



**JOURNAL OF TECHNICAL UNIVERSITY OF MOLDOVA
AND MOLDAVIAN ENGINEERING ASSOCIATION**

MERIDIAN INGINERESC

**Technical and applied scientific publication founded in
9 February 1995**

**2
2017**

**Typesetting and desktop publishing:
Dulgheru Valeriu**

**Cover: Podborschi V.
Trifan N.**

ISSN 1683-853X

Published by Technical University of Moldova

C O N T E N T

	<i>Abstract.....</i>	3
<i>Băjenescu Titu-Marius I., Bâzu M. I.</i>	<i>Failure analysis in development, manufacturing and utilization of a new electronic product.....</i>	11
<i>Nedashkivskiy O., Semenko A.</i>	<i>Precise method of balancing passive optical networks with irregular splitter with two or more outputs.....</i>	18
<i>Gara A., Gara An.</i>	<i>Features of carbonating hardening of lightweight concrete.....</i>	22
<i>Vârovoi V., Korobko O., Zavoloka M., Koşurubenko O.</i>	<i>Structural material science.....</i>	26
<i>Radomska A. M.</i>	<i>Modern view on the problem of interaction of art education and ethnic culture.....</i>	31
<i>Radomskiy O. M.</i>	<i>Principles of mobile walking robot control in scope of technical monitoring tasks.....</i>	36
<i>Vlasenco A.</i>	<i>Study of cartographic projections for pan-European representations.....</i>	40
<i>Dulgheru V., Dumitrescu C., Rădoi R.</i>	<i>Some aspects of increasing of wind turbine conversion efficiency.....</i>	49
<i>Boaghi E.</i>	<i>Respiration of unshelled walnuts (<i>juglans regia l</i>) and walnut kernel.....</i>	54
<i>Ghencea C.</i>	<i>Perception and creativity assessments in graphic design.....</i>	57
<i>Korotun I.</i>	<i>Architecture of the Armenian Church of Holy Apostles Peter and Paul in Chernivtsi.....</i>	66
<i>Antoshchuk T.</i>	<i>Romanticism in architecture of constructions and buildings of northern Bukovina in XIX – beginning of the 20th century.....</i>	70
<i>Dulgheru V.</i>	<i>Creativity in groups: why brainstorming doesn't work.....</i>	75
<i>Manolea Gh.</i>	<i>Personalities from the meridians of the scientific universe.....</i>	78

REZUMATE

Titu-Marius I. Băjenescu, M. I. Băzu. **Analiza defecțiunilor în dezvoltarea, fabricarea și utilizarea unui nou produs electronic.** Inițial, analiza defecțiilor (AD) a fost dezvoltată ca o metodă auxiliară de cercetare a fiabilității, fiind utilizată pentru identificarea mecanismelor de defectare. Noua abordare în probleme de fiabilitate, bazată pe principiile ingineriei concurente, spune că toți specialiștii care contribuie la fabricarea unui produs fiabil (proiectanți, ingineri de test, ingineri fiabiliști, specialiști în marketing) trebuie să participe, chiar din faza de proiectare și, de asemenea, pe tot parcursul ciclului de dezvoltare a produsului.

Nedashkivskiy O., Semenko A. **Metoda precisă de echilibrare a rețelelor optice pasive cu splitter neregulat cu două sau mai multe ieșiri.** În această lucrare sunt prezentate problematica implementării rețelelor pasive de acces optic, cum ar fi echilibrarea rețelei. Acest model utilizează un splitter optic pasiv cu o intrare și două sau trei ieșiri. Bazându-se pe ecuațiile și calculele obținute, este sugerat un singur model matematic universal, care permite despărțitori de echilibrare cu orice număr de porturi de ieșire.

Gara A., Gara An. **Specificul prizei betonului cu conținut de cheramzit în condițiile carbonatării.** Au fost determinate caracteristicile elementelor din beton cu conținut de cheramzit în condițiile întăririi în rezultatul carbonatării. Intensificarea procesului de carbonatare a betonului este posibilă în betoanele cu o structură optimală, un dozaj a compușilor bine definit și prin scăderea conținutului de apă în beton. Au fost studiate caracteristicile betonului în perioada timpurie după carbonatare.

Vârovoi V., Korobko, O., Zavoloka, M., Koșturubenko, O. **Știința materialelor structurale.** Este propusă prezentarea obiectelor sisteme în formă de modele.

Mecanismul de formare a structurilor la nivelul la care predomină forțele de greutate diferă de mecanismele de formare a structurii nivelului, la care domină forțele de interacțiune între particule. Existența autonomă relativă a diferitor nivele spațiale presupune o realizare spontană a evenimentelor, interacțiunea căror asigură integritatea și funcționarea sigură a construcției-sisteme.

Radomska A. M. **Viziunea modernă asupra problemei educației artistice și a culturii etnice.** Articolul se concentrează pe problemele interacțiunii active între individ și societate în domeniul culturii și al educației artistice. Autorul articolului analizează poziția etno-culturală a studenților din facultăți de arta grafică, în contextul lumii proceselor globale în societatea modernă. Din punct de vedere al pedagogiei poziția etnoculturală este examinată de autor ca o construcție, legată indisolubil cu persoana și capabilă să se transforme în legătură cu dezvoltarea ei. Din punct de vedere al pedagogicii autorul studiază poziția etnoculturală a studenților ca o schemă legată de persoană și capabilă să se transforme în legătură cu dezvoltarea ei.

Radomskiy O. M. **Principiile de control al robotului mobil de mers pe jos în domeniul sarcinilor tehnice de monitorizare.** Articolul examinează caracteristicile unui robot de mers pe jos care a fost creat pentru a rezolva problemele de control, gestionare și monitorizare a obiectelor la distanță. Propusă de schema de mișcare cinematică a autorului pentru dispozitivul cu un corp mobil poate reduce semnificativ costurile de energie atunci când conduceți și robotul de mers pe jos. Autorul prezintă robotului de mers pe jos un circuit pentru controlul servo-sistemului prin utilizarea unor impulsuri modulate în impulsuri. Sistemul de control calculează relațiile pentru servomecanisme utilizând presetarea prestabilă a mișcărilor robotului și apoi recuperează datele de la senzori.

Utilizarea datelor senzorialor Regulator Unități actualizează valorile pentru controlul servo. Sistemul de control include unitate de calcul, șapte servomecanisme, accelerometru cu trei axe și cameră mișcătoare care funcționează într-o gamă optică vizibilă. Structura generală a sistemului de control al robotului, propusă de autor, poate fi utilizată pentru a studia o varietate de caracteristici de performanță a vehiculelor existente și viitoare de tip similar.

Vlasenco A. Studiul proiecțiilor cartografice pentru reprezentările pan-Europene. Lucrarea prezintă un studiu ale principalelor caracteristici ale proiecțiilor cartografice, recomandate de către Comisia Europeană pentru adoptarea lor la planificarea spațială a politicii de integrare și evaluare a statelor care sunt candidate și care sunt integrate în Uniunea Europeană. S-au studiat proiecțiile propuse și posibilitățile de reprezentare a teritoriului Republicii Moldova în aceste proiecții, din punct de vedere al poziției geografice și al nivelului de deformații produse de aceste proiecții.

Dulgheru V., Dumitrescu C. Unele aspecte ale creșterii a eficienței conversiei turbinelor eoliene. Instalațiile eoliene mondene se vor dubla aproape în următorii cinci ani, în condițiile în care prețurile continuă să scadă, iar țările dezvoltă energie regenerabilă pentru a se conforma obiectivelor de reducere a emisiilor, potrivit studiului publicat în publicația emblematică "Global Wind Energy Council" (GWEC). Se observă că un obiect de studiu important în planul majorării puterii unei turbine devine pala. În același context în continuare autorii vin cu o idee originală de majorare a puterii turbinei eoliene prin instalarea sub un anumit unghi în aval a palei în butucul rotorului. În lucrare se prezintă o soluție tehnică de majorare a puterii turbine eoliene și eficienței de conversie.

Boaghi E. Respirația nucilor de nuci (juglans regia l) și a kernelului de nuc. În

acest experiment s-a studiat intensitatea respirației fructelor de nuci (*Juglans Regia L.*). Scopul cercetării a fost de a discuta schimbările de calitate ale nucilor la păstrare. Rezultatele obținute au arătat că, în timpul depozitării inițiale (15 zile), intensitatea respirației nucilor proaspete a prezentat o scădere bruscă, apoi scăzută, stabilizându-se ulterior. Au existat diferențe evidente între intensitatea respirației nucilor în coajă și a miezului de nuci. S-a studiat influența temperaturii de depozitare asupra intensității respirației nucilor și s-a stabilit că aceasta crește încet odată cu creșterea temperaturii de la 4 la 20°C.

Ghencea C. Percepția și evaluarea creativității în designul grafic. În articol se prezintă rezultatele unui studiu complex privind evaluarea creativității designului grafic. Abordarea adoptată urmărește să identifice variațiile părerilor pentru a distinge factorii care influențează criteriile luate în considerare de respondenți în funcție de mediul lor profesional în domeniul designului grafic (directori de artă, designeri, studenți de design grafic, profesori de artă și publicul țintă) și de nivelul lor de experiență (1-2 ani, 3-5 ani, 5-10 ani și fără experiență profesională).

Korotun I. Arhitectura bisericii armene a Sfântului Apostol Petru și Pavel din Cernăuți. Lucrarea cuprinde istoria structurii și a caracteristicilor arhitecturii obiectului patrimoniului cultural - biserica armeană din Cernăuți.

Antoshchuk T. Romantismul în arhitectura construcțiilor și a clădirilor din nordul Bucovinei în XIX - începutul secolului XX. Articolul se referă la apariția și aplicarea tendințelor și variațiilor romantismului ca mișcare ideologică a artei europene, precum și unele la aspecte ale manifestărilor sale naționale în arhitectura clădirilor și structurilor pe teritoriul Bucovinei de Nord.

ABSTRACT***Băjenescu T.M.I., Băzu M. I. Failure analysis in development, manufacturing and utilization of a new electronic product.***

Initially, failure analysis (FA) was developed as an auxiliary method of reliability research, being used for identifying the failure mechanisms. The new approach in reliability issues, based on the principles of concurrent engineering, say that all the specialists concurring to the fabrication of a reliable product (designers, testing engineers, reliability engineers, marketing specialists) have to participate even from the design phase, and also during the whole cycle of product development.

Nedashkivskiy O., Semenko A., Precise method of balancing passive optical networks with irregular splitter with two or more outputs.

In this work the issue of implementation of passive optical access networks, such as balancing the network, are presented. This model uses passive optical splitter with one input and two or three outputs. Based on the obtained equations and calculations a single universal mathematical model is suggested, which allows balancing splitters with any number of output ports.

Gara A., Gara An. Features of carbonating hardening of lightweight concrete.

The work is devoted to research of the parameters of expanded clay lightweight concrete technology by using the carbonation hardening that allows to maximally intensify the process of carbonization using such methods: decreasing the total water content in the system; applying optimal structure and formula concrete compositions; processing the products in carbon dioxide environment. The mechanism of structure formation of concrete compositions in conditions of artificial carbonation was studied. And it was formulated the basic techniques of rational intensification of the hardening process.

Vyrovoy V., Korobko O., Zavoloka M., Kotsiurubenko O. Structural material science.

The objects-systems are offered to be present in the form of models. The mechanism of structure formation on the level where gravity prevails differs from mechanism of structure formation at the level where forces of interparticle interactions dominate. Rather independent coexistence of various solid levels assumes spontaneous realization of various events interaction which provides a wholeness and safe functioning of a construction-system.

Radomska A. M. Modern view on the problem of interaction of art education and ethnic culture.

The article focuses on the problems of the active interaction between the individual and society in the sphere of artistic culture and education. The author of the article examines the ethno-cultural position of students of is art-graphic faculties in the context of the world of global processes in the modern society. In terms of pedagogy ethnocultural position is regarded as the author of the design is inextricably linked with the personality and the ability to transform in connection with its development.

O. M. Radomskyi Principles of mobile walking robot control in scope of technical monitoring tasks.

The article examines the characteristics of a walking robot that was created to solve the problems of control, management and monitoring of remote objects. Proposed by the author kinematic motion scheme for the device with a movable body can significantly reduce energy costs when driving and the walking robot. The author presents for the walking robot a circuit for controlling the servo-system through the use of pulse-width-modulated impulses. Control system computes relations for servos using default preset of the robot motions, and then retrieves data from sensors. Using sensors data Regulator Unit updates values

for servos control. Control system includes computing unit, seven servos, three-axis accelerometer and moving camera operating in a visible optical range. The overall structure of the robot control system, proposed by the author can be used to study a variety of performance characteristics of existing and future vehicles of a similar type.

Vlasenco A. Study of cartographic projections for pan-European representations. The work presents a study of the main characteristics of cartographic projections, recommended by the European Commission for their adoption in the spatial planning of the integration and evaluation policy of the candidate countries that are integrated into the European Union. The proposed projections and the possibilities of representing the territory of the Republic of Moldova in these projections were studied, in terms of geographic position and the level of deformations produced by these projections.

Dulgheru V., Dumitrescu C., Rădoi R. Some aspects of increasing of wind turbine conversion efficiency. Global wind power installations will nearly double in the next five years as prices continue to fall and countries develop renewable energy to comply with emissions reduction targets, according to research published in Global Wind Energy Council (GWEC) flagship publication. It is noticed that an important study object in the plan to increase the power of a turbine becomes blade. In the same context, the authors still come up with an original idea of increasing wind turbine power by installing below a certain downstream angle of the blade in the rotor bush. The paper presents a technical solution for increasing wind turbine power and conversion efficiency.

Boaghi E. Respiration of unshelled walnuts (*Juglans regia* l) and walnut kernel. In this experiment the respiratory rates of nuts in

English walnut (*Juglans Regia* L.) were studied. The purpose of this research was to discuss the walnut quality changes during storage. Obtained results indicated that, during the initial storage(15 d), the respiration rate of fresh walnut showed a sharp downtrend, then low and stabilized. There were obvious differences between respiration rate of unshelled walnuts and kernel. It has been studied the influence of storage temperature on walnut respiration intensity and it was established that it increases slowly with increasing temperature from 4 to 20⁰C.

Ghencea C. Perception and creativity assessments in graphic design. The article presents the results of a comprehensive study on the creativity assessments in graphic design. It aims to identify factors that exert an influence on the judgments of creative design. It develops a multiple feedback approach by exploring assessments made by judges with different professional backgrounds in graphic design area (art directors, designers, graphic design students, art teachers and targeted audience) and their levels of experience in design (1-2 years, 3-5 years, 5-10 years and no professional experience).

Corotun I. Architecture of the Armenian Church of Holy Apostles Peter and Paul in Chernivtsi. The article present the history of structure and features of architecture of the object of cultural heritage – Armenian church in Chernivtsi.

Antoshchuk T. Romanticism in architecture of constructions and buildings of northern Bukovina in XIX – beginning of the 20th century. The article relates with the occurrence, application of trends and variations of Romanticism as an ideological movement of European art, as well as some aspects of its national manifestations in the architecture of buildings and structures on the territory of Northern Bukovina.

SOMMAIRE

Băjenescu Titu-Marius I., Băzu M. I. Analyse de l'échec dans le développement, la fabrication et l'utilisation d'un nouveau produit électronique. Initialement, l'analyse des défaillances (AD) a été développée comme une méthode auxiliaire de recherche sur la fiabilité, utilisée pour identifier les mécanismes des défaillances. La nouvelle approche des problèmes de fiabilité, basée sur les principes de l'ingénierie concurrente, indique que tous les spécialistes qui concourent à la fabrication d'un produit fiable (designers, ingénieurs de test, ingénieurs de fiabilité, spécialistes du marketing) doivent participer, même à partir de la phase de conception et également pendant tout le cycle de développement du produit.

Nedashkivskiy O., Semenko A. Méthode précise d'équilibrage des réseaux optiques passifs avec répartiteur irrégulier avec deux sorties ou plus. Dans ce travail, la question de la mise en œuvre des réseaux d'accès optiques passifs, tels que l'équilibrage du réseau, sont présentées. Ce modèle utilise un diviseur optique passif avec une entrée et deux ou trois sorties. Sur la base des équations obtenues et des calculs effectués, il est proposé un unique modèle mathématique universel qui permet d'équilibrer les répartiteurs avec n'importe quel nombre de ports de sortie.

Gara A., Gara An. Le réglage spécifique du béton contenant ceramsite sous carbonisation. Ils ont été déterminés les caractéristiques du béton contenant le ceramsite en termes de renforcement à la suite de la carbonatation. L'intensification du processus de carbonatation du béton est possible dans le béton avec la structure optimale, une dose bien définie des composés et la diminution de la teneur en l'eau dans le béton. Ils ont étudié les propriétés du béton dans la première période après carbonatation.

Vyrovoy V., Korobko O., Zavaloka M., Kotsiurubenko O. La science des matériaux

structurale. Être proposé la structure des objets-systèmes en forme des modèles. Le mécanisme de la formation de la structure au niveau, sur qui prédominent les forces de la pesanteur, se distingue des mécanismes de la formation de la structure du niveau, sur qui dominant les forces de la coopération inter partielle. La coexistence assez autonome des divers niveaux spatiaux suppose la réalisation spontanée des événements, la coopération de qui assure l'intégrité et le fonctionnement sûr de la construction-système.

Radomska A.M. La vision moderne sur le problème de l'éducation artistique et de la culture ethnique. L'article se concentre sur les problèmes de l'interaction active entre l'individu et la société dans le domaine de la culture artistique et de l'éducation. L'auteur de l'article examine la position ethnoculturelle des étudiants des facultés d'art graphique dans le contexte du monde des processus globaux dans la société moderne. En termes de pédagogie, la position ethnoculturelle est considérée comme l'auteur de la conception est inextricablement liée à la personnalité et la capacité de transformer en relation avec son développement.

Radomsky A.N. Les principes du contrôle du robot marchant mobile. Sur l'article on examine les caractéristiques d'un robot marchant qui a été créé pour résoudre des problèmes du contrôle, de la gestion et de la surveillance des objets distants. Le schéma cinématique du mouvement proposé par l'auteur pour l'appareil avec un corps mobile permet de réduire la consommation d'énergie pendant le fonctionnement actif et la locomotion du robot marchant. L'auteur présente le schéma de contrôle du système d'actionneurs asservis sur la base de l'utilisation des impulsions latitudino-modulée. Le système de contrôle calcule des relations pour actionneur asservi utilisant la combinaison des réglages pré-réglés des mouvements du robot par défaut, puis il tire l'information du capteur. Avec l'aide des

capteurs d'acquisitions on actualise des paramètres pour contrôler des servos. La structure générale du système du contrôle du robot mobile, proposé par l'auteur peut être utilisé pour étudier une variété de caractéristiques fonctionnelles des véhicules existants et perspectifs d'un type similaire.

Vlasenco A. L'étude des projections cartographiques pour les représentations pan-Européenne. Cet article présente une étude des principales caractéristiques des projections cartographiques, recommandées par la Commission Européenne pour leur adoption l'aménagement du territoire la politique d'intégration et d'évaluation des pays candidats et qui sont intégrés dans l'Union Européenne. Ont été étudié les projections proposées et les possibilités de représentation du territoire Moldavie dans ces projections, en termes de localisation géographique et le niveau de déformation de ces projections.

Dulgheru V., Dumitrescu C., Rădoi R. Quelques aspects de l'augmentation de l'efficacité de conversion de l'éolienne. Les installations éoliennes mondiales vont presque doubler au cours des cinq prochaines années, alors que les prix continuent de baisser et que les pays développent des énergies renouvelables pour se conformer aux objectifs de réduction des émissions, selon une étude publiée dans la publication phare du Global Wind Energy Council (GWEC). On remarque qu'un objet d'étude important dans le plan d'augmenter la puissance d'une turbine devient le lame. Dans le même contexte, les auteurs proposent encore une idée originale de l'augmentation de la puissance des éoliennes en installant sous un certain angle aval de la lame dans la douille du rotor. L'article présente une solution technique pour augmenter l'efficacité de la puissance et de la conversion des éoliennes.

Boaghi E. Respiration des noix sans écrou (juglans regia l) et du noyau de noix. Dans cette expérience, les taux respiratoires de noix en noyer anglais (Juglans Regia L.) ont été

étudiés. Le but de cette recherche était de discuter des changements de qualité du noyer qui mangent le stockage. Les résultats obtenus indiquent que pendant le stockage initial (15d), le taux de respiration du noyer frais a montré une forte tendance à la baisse, puis faible et stabilisé. Il y avait des différences évidentes entre le taux de respiration des noix sans écrou et du noyau. On a étudié l'influence de la température de stockage sur l'intensité de la respiration des noix et il a été établi qu'elle augmente lentement avec une température croissante de 4 à 200 ° C.

Ghencea C. Perception et évaluation de la créativité dans le design graphique. L'article présente les résultats d'une étude approfondie sur l'évaluation de la créativité dans le domaine du design graphique. L'approche adoptée vise à explorer les variations de jugements afin d'identifier les facteurs influant sur les critères qui sont pris en considération par les juges en fonction de leur parcours professionnel (directeurs artistiques, designers, enseignants en art et public visé) et le niveau d'expertise en design (1-2 ans, 3-5 ans, 5-10 ans et aucune expérience professionnelle).

Corotun I. Architecture de l'Église arménienne des saints apôtres Pierre et Paul à Chernivtsi. L'article présent l'histoire de la structure et des caractéristiques de l'architecture de l'objet du patrimoine culturel - Église arménienne à Chernivtsi.

Antoshchuk T. Romantisme dans l'architecture des constructions et des bâtiments de la Bukovine du nord au XIX^e siècle du début du XX^e siècle. L'article se rapporte à l'apparition et l'application des tendances et des variations du romantisme en tant que mouvement idéologique de l'art européen, ainsi que certains aspects de ses manifestations nationales dans l'architecture des bâtiments et des structures sur le territoire de Bukovine du Nord.

REZUME

Бэженеску Т. М. I., Vâzu M. I. Анализ отказов при разработке, изготовлении и использовании нового электронного продукта. Первоначально анализ отказов (FA) был разработан как вспомогательный метод исследования надежности, который используется для идентификации механизмов отказа. Новый подход к вопросам надежности, основанный на принципах параллельной инженерии, говорит о том, что все специалисты, соглашающиеся на изготовление надежного продукта (дизайнеры, инженеры по тестированию, инженеры по надежности, специалисты по маркетингу), должны участвовать даже на этапе проектирования и Также в течение всего цикла разработки продукта.

Недашковский А. Л., Семенко А.И. Точные методы балансировки пассивных оптических сетей с неравномерными разветвителями с двумя и более выходами. В работе рассмотрены вопросы внедрения пассивных оптических сетей доступа, а именно балансировка ветвей сети. При этом использованы модели пассивных оптических разветвителей с одним входом и двумя или тремя выходами. На основе полученных уравнений и выполненных расчетов предложена единая универсальная математическая модель, позволяющая осуществлять балансировку разветвителей с любым количеством выходных портов.

Гара А., Гара Ан. Особенности карбонизационного твердения керамзитобетона. Отработаны параметры технологии керамзитобетонных изделий с применением карбонизационного твердения, позволяющие максимально интенсифицировать процесс карбонизации путем снижения общего водосодержания системы, применения бетонных смесей оптимальной структуры и рецептуры, обработки изделий в среде углекислого газа по оптимальным режимам. Исследованы свойства бетона в раннем возрасте после карбонизации.

Выровой В., Коробко О., Заволока М., Коцюрубенко О. Структурное материаловедение. Предложено структуру

объектов-систем представлять в виде моделей. Механизм образования структуры на уровне, на котором преобладают силы тяжести, отличается от механизмов формирования структуры уровня, на котором доминируют силы межчастичного взаимодействия. Относительно автономное сосуществование различных пространственных уровней предполагает спонтанную реализацию событий, взаимодействие которых обеспечивает целостность и безопасное функционирование конструкции-системы.

Радомская А. М. Современный взгляд на проблему взаимодействия художественного образования и этнической культуры. В статье сделан акцент на проблемах активного взаимодействия личности и общества в сфере художественной культуры и образования. Автором статьи рассматривается этнокультурная позиция студентов художественно-графических факультетов в контексте мировых глобальных процессов в современном обществе. С точки зрения педагогики этнокультурная позиция рассматривается автором как конструкция, неразрывно связанная с личностью и способная трансформироваться в связи с её развитием. С точки зрения педагогики автор изучает этнокультурную позицию студентов как схему связанную с личностью и способную трансформироваться в связи с её развитием.

Радомский А. Н. Принципы управления мобильным шагающим роботом. В статье рассматриваются характеристики шагающего робота, созданного для решения проблем контроля, управления и мониторинга удаленных объектов. Предложенная автором статьи кинематическая схема движения для аппарата с подвижным корпусом позволяет снизить затраты энергии во время активной работы и передвижения шагающего робота. Автор представляет схему управления системой сервоприводов на основе использования широтно-модулированных импульсов. Система управления вычисляет соотношения для сервоприводов, используя

по умолчанию набор предустановленных настроек движений робота, а затем извлекает данные из датчиков. С помощью датчиков данных обновляются параметры для управления сервоприводов. Общая структура системы управления мобильным роботом, предложенная автором статьи может быть использована для исследования различных эксплуатационных характеристик существующих и перспективных транспортных средств аналогичного типа.

Власенко А. **Исследование картографических проекций для общеевропейских представлений.** Статья представляет исследование основных особенностей картографических проекций, рекомендованные Европейской Комиссией для их принятия политики пространственного планирования интеграции и оценка стран, которые являются кандидатами и которые интегрированы в Европейском Союзе. Были изучены предложенные проекции и возможности представлении Молдавской территории в этих проекции, с точки зрения географического расположения и уровня деформации от этих проекции.

Дулгеру В., Думитреску С., Рэдой Р. **Некоторые аспекты повышения эффективности конверсии ветровой турбины.** Согласно данным исследований, опубликованных в главном издании Глобального совета по ветроэнергетике (GWEC), глобальные ветроэнергетические установки почти удвоятся в ближайшие пять лет, поскольку цены продолжают падать, а страны разрабатывают системы конверсии возобновляемых источников энергии для сокращения выбросов. Замечено, что важным объектом исследования в плане увеличения мощности турбины становится лопасть. В этом контексте авторы придумывают оригинальные идеи увеличения мощности ветровых турбин. В работе представлено техническое решение для увеличения мощности ветровых турбин и эффективности преобразования ветровой энергии.

Боаги Е. **Дыхание неочищенных грецких орехов (*Juglans regia* L) и ядра грецкого**

ореха. В данной работе изучена интенсивность дыхания плодов грецкого ореха (*Juglans Regia* L.). Цель исследования заключалась в обсуждении изменений качества грецких орехов во время хранения. Результаты показали, что в ходе первоначального хранения (первые 15 дней), интенсивность дыхания свежих плодов представлены резким падением, а затем медленным снижением до дальнейшей стабилизации. Были очевидные различия в интенсивности дыхания грецких орехов в скорлупе и очищенных. Было изучено влияние температуры хранения на интенсивность дыхания орехов и установлен медленный рост дыхания с увеличением температуры от 4 до 20 °C.

Ghencea С. **Восприятие и оценка творчества в графическом дизайне.** В статье представлены результаты комплексного исследования по оценке творчества в области графического дизайна. Используемый подход заключается в изучении вариаций в суждениях с целью выявления факторов, влияющих на критерии, которые судьи принимают во внимание в контексте своего профессионального опыта (арт-директора, дизайнеры, преподаватели искусства и целевая аудитория) и уровень экспертизы в дизайне (1-2 года, 3-5 лет, 5-10 лет и без профессионального опыта).

Коротун И. **Архитектура Армянской церкви святых апостолов Петра и Павла в Черновцах.** В данной статье излагаются история сооружения и особенности архитектуры объекта культурного наследия национального значения – армянской церкви в Черновцах.

Антощук Т. **Романтизм в архитектуре сооружений и зданий северной Буковины в XIX - начале XX века.** Статья связана с появлением и применением тенденций и вариаций романтизма как идеологическое движение европейского искусства, а также с некоторыми аспектами его национальных проявлений в архитектуре зданий и сооружений на территории Северной Буковины.

FAILURE ANALYSIS IN DEVELOPMENT, MANUFACTURING, AND UTILIZATION OF A NEW ELECTRONIC PRODUCT

¹*Titu-Marius I. Băjenescu, univ. prof. eng.,* ²*Marius I. Băzu, univ. prof. Eng*
¹*Switzerland,* ²*Romania*

1. INTRODUCTION

Failure Analysis (FA) is the process of determining the cause of failure, collecting and analysing data and developing conclusions to eliminate the failure mechanism (FM) causing the specific device or system failures. FA is the scientific method for identifying the cause that does not allow to a product to fulfil, during operation, the required function; in other words, making the device to fail. The goal of FA is to determine the root cause of a failure or parameter excursion so that corrective action can be taken. Understanding the cause of the part failure allows for effective corrective action and the prevention of future occurrences. When electronic parts fail, it's important to understand why they failed. Effective root cause analysis of part failures is required to assure proper corrective action can be implemented to prevent reoccurrence. Determination of root cause is also important for each high reliability system.

How did you learn FA? You took your background in physics, electrical engineering, biology, chemical engineering, or chemistry, and were thrown into the laboratory for your on-the-job-training. You read abundantly specialized international journals, attended tutorials, and found two or three good books, updated the field for leading edge techniques, retaining the tried and new methods, gaining a common understanding of the basic physics and electronics of the chips to be analysed. The major changes of the last decade is that the deep submicron technologies got deeper; from 0.25 μm to 90 and 65 nm technologies; and that brought not only small feature size and huge numbers of devices on a die, but new materials. Copper, low-k and high-k dielectrics, white LEDs based on phosphor conversion, and SOI or SoC are some of the examples of rapid challenge to failure analysts.

Imaging techniques had to respond to the challenge of observing materials whose minimum features were smaller than the shortest wavelength of visible light.

FA is now visibly a science requiring speciality teams.

How does an experienced FA engineer crack a tough analysis? What makes the difference between a new engineer's FA approach and the seasoned, effective analysis method of a veteran? Can our industry capture a formulation of correct FA methodology to accelerate the development of new engineers?

Electronics is so pervasive and necessary today that virtually every product either contains an electronic module or interfaces with one¹.

Today, for a FA, we have to analyse not only discrete passive components, but a great range of ultra-high density ICs too, with a huge design complexity that exceeds 500 millions gates and a great variety of technologies (bipolar silicon, CMOS, BiCMOS, GaN, SiC, complex heterojunction structures and microelectromechanical systems). That is why the today's analyst faces complex equipments sets (curve tracer, optical microscope, decapsulation tools, X-ray and acoustic microscopy, electron and/or optical and/or focused ion beam tools, thermal detection techniques, the scanning probe atomic force microscope, surface science tools, a great variety of electrical testing hardware etc.) that are necessary to realize a spatial and complex failure analysis. One sees that FA is a highly technical activity with increasingly complex, sophisticated and costly specialized equipments. It is very difficult to realize a balance between customer satisfaction, cost-effectiveness and future challenges. Very oft the analyst must make with a Today, in the domain of electronic components, it is almost impossible to conceive a serious investigation into the reliability of a product or process without FA. The idea that failure acceleration by various stress factors (the key to accelerated testing) could be modelled only for the population affected by the same failure mechanisms (FM) greatly promoted FA

¹ The merits and capabilities of solid-state semiconductor materials were discovered, developed and commercialized within the relatively short span of 60 years. Primarily driven by the requirements of the aerospace industry, the constantly increasing payloads of electronics demanded that miniaturization, reduced power consumption, and increased reliability of onboard navigation, weapons control, and communication equipment be pursued.

as the only way to segregate such a population damaged by specific FMs.

Moreover, the simple statistical approach in reliability, which was the dominant one for years, is no longer sufficient. The physics-of-failure (PoF) approach is the only one accepted at world level, being the solution for continuously improving the reliability of the materials, devices and processes. Even for the modelling of FMs, the well-known models based on distributions like Weibull or Lognormal have today been replaced by analytical models that are elaborated based on an accurate description of the physical or chemical phenomena responsible for degradation or failure of electronic components and materials.

In FA, a large range of methods are now used, from (classical) visual inspection to expensive and modern methods such as transmission electron microscopy, secondary ion mass spectroscopy and so on.

2. MANUFACTURING

Manufacturing is concerned with everything necessary to produce a product; this includes all of the realization processes, and those affected beyond, such as sales, service, recycling and so on. By definition, any product has to be producible; however, there are degrees of ease or difficulty of manufacturability. These are caused by the difficulties of replicating the design, the effectiveness of the prototyping process to uncover problems, and the efficiencies of the manufacturing process. A producible design considers all of the factors that can affect how component parts are fabricated and assembled, how subsystems are fitted together, and overall product performance.

All products have a degree of functionality. How well products perform their intended functions depends – to a large extent – on how close the production version is to the original design and/or final design intent, based on the development experience with a prototype. The potential accuracy of the design is also important. Manufacturing is usually based on a sequential occurrence of events, specified so that previous steps will provide a robust foundation and path for succeeding stages.

Within the zero defects philosophy, different degrees of fault identification and tolerance must be established. This will allow design trade-offs to be made so that a minimum fault tolerance can be maintained without adversely affecting short- and long-term reliability, certain trade-offs have to be made.

Within airframe manufacturing cycle, every fabrication, inspection, and assembly station has supplier-customer interfaces, both of which have to sign off on the process accuracy and functional performance. There other systems helping this process, among them relational databases, which contain all product information, performance standards, process capabilities and material specifications. Updated continuously and instantly, these databases allow for continuous process improvement. Outside suppliers are also part of this manufacturing quality system. Industry quality standards are utilized so that common terminology and testing methods conform to worldwide requirements, resulting in completely integrated manufacturing.

3. FA TECHNIQUES

The basic flow for effective part FA starts before the component is removed from the board. Upon completion of the board troubleshooting and fault isolation process, the cognizant FA engineer should review the troubleshooting results while the part is still on the board witnessing any in-situ part measurements (for later verification in the FA lab) and noting any anomalies that exist on the board which may potentially have contributed to the part failure. Prior to removing a part from the board, it is also recommended to photograph the part as installed for future reference. Photos should be taken from various angles to capture the details of the installation, such as the solder attachment. In addition, contacting the vendor before removing high value parts is advised. Reviewing the failure data with the vendor can often identify external interfaces as the culprit rather than the suspected part. As some devices can cost many thousands of Euros to replace, it is highly recommended that all resources available be used prior to replacing them.

ICs are the central component to be analyzed. The manufacturing of silicon-based circuits is the central theme of this analysis. Other components in the typical electronic system (output, display, storage, input transfer, and power) are considered to be performing functions that are peripheral to the IC.

The failure analyst should also be consulted on the safest means for removing the part to preserve it to the greatest extent possible. Once the part is removed for FA, three basic processes should be followed:

- Electrical testing and part characterization. (test / characterize over temperature; curve tracer I-V check of inputs).

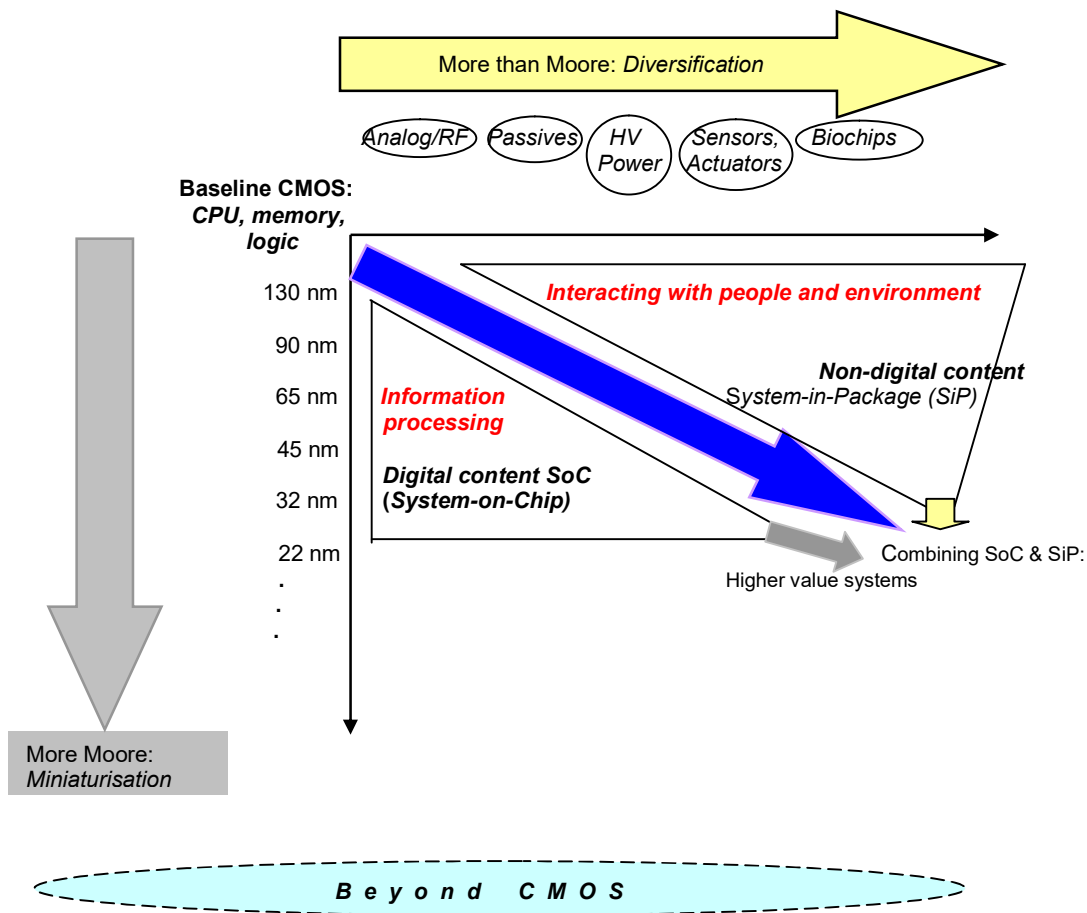


Figure 1. More Moore and more than Moore [Source: ITRS, ExecSum (2005)]

Non-invasive tests [external microscopic examination / photo fine and gross leak; vacuum bake (non-hermetic parts); X-ray; particle impact noise detector (PIND); X-ray fluorescence (XRF); scanning acoustic microscope (SAM); C mode-SAM (CSAM)].

- Invasive tests (lid removal / decapsulating; die examination; die probing; infrared microscopic examination; liquid crystal; cross-sectioning; scanning acoustic microscope (SEM); energy dispersive X-ray spectroscope (EDS); focused ion beam (FIB); Auger; secondary mass ion spectroscope (SIMS); Fourier transform infrared spectroscope (FTIR); transmission electron microscope (TEM); scanning transmission electron microscope (STEM).

4. STATE OF THE ART; FUTURE TRENDS

At component level, a broad definition of FA includes: collection of background data, visual

examination, chemical analysis, mechanical properties, macroscopic examination, metallographic examination, micro-hardness, scanning electron microscopy (SEM) analysis, microprobe, residual stresses and phases, simulation / tests, summary of findings, preservation of evidence, formulation of one or more hypotheses, development of test methodologies, implementation of tests/collection of data, review of results and revision of hypotheses. Each time, the customer will be notified.

- First, the causes of a failure can be classified according to the phase of a product's life cycle in which they arise – design, materials processing, component manufacturing or service environment and operating conditions. Then two main areas of FA enable fast chip-level circuit isolation, circuit editing for quick diagnostic and problem-solving, helping bring forward semiconductor development: Physical inspection, represented by three important tools: SEM,

- emission microscopy and transmission electron microscopy (TEM).

- Electrical localisation, executed mainly with liquid crystal analysis (LCA), photo electron microscopy (PEM) and Focused Ion Beam (FIB). The package global localisation tool infra-red lock-in thermography (IR-LIT) became widely available in 2005 and is the most popular tool for global localisation for complex packages, such as system-in-package (SiP) and system-on-chip (SoC). Today the tool support for SoC development is X-ray CT, due to a significant resolution and speed improvement. FA has given and gives a continuous contribution to technological innovation in the whole history of semiconductor development.

Over the last few years, the increased complexity of devices has scaled the difficulty in performing FA. Higher integration has led to smaller geometry and better wire-to-cell ratios, thus increasing the complexity of the design. These changes have reduced the effectiveness of most of the current FA techniques; over the past few years, a variety of techniques and tools, such as electron-beam (E-beam) probers, FIB, enhanced imaging SEM to determine the defects at wafer level. All these tools improve FA capabilities, but at substantial cost, running into hundreds of thousands of dollars. Some other examples of new techniques are given below:

- A strategy was derived for FA in random logic devices (such as microprocessors and other VLSI chips) where the electrical scheme is not known. This strategy is based on the use of a test tool composed of an SEM allied to a voltage contrast, an exerciser, an image processing system and a control and data processing system [1].

- Three new FA techniques for ICs have been developed recently using localised photon probing with a scanning optical microscope (SOM) [2]. The first two are light-induced voltage alteration (LIVA) imaging techniques that (i) localise open-circuited and damaged junctions and (ii) image transistor logic states. The third technique uses the SOM to control logic states optically from the IC backside. LIVA images are produced by monitoring the voltage fluctuations of a constant current power supply as a laser beam is scanned over the IC. High selectivity for localising defects has been demonstrated using the LIVA approach. Application of the two LIVA-based techniques to backside FA has been demonstrated using an infrared laser source.

- It is critical to develop improved analysis techniques that are easier to use, less damaging, more sensitive and provide better spatial resolution. One example is 'passive' techniques, which are non-invasive, in the sense that the normal operation of the IC provides the information or energy being measured. Recently, dynamic photoelectric laser-stimulation techniques were applied to mixed-mode ICs, where the major difficulty is their considerable intrinsic sensitivity [3]. Indeed, the analogue circuitry is more sensitive than the digital circuitry since a slight change in an electrical parameter can trigger a functionality failure. This property limits the defect localisation because of the complex interpretation of the results: the laser-stimulation mapping. In this case, dynamic laser-stimulation mapping is coupled with photoelectric impact simulations run on a previously analysed structure. The goal is to predict and interpret the laser-sensitivity mapping and to isolate the defective areas in the analogue devices.

- A technique used for decapsulating the device for FA is the ultra-short-pulse laser-ablation-based backside sample-preparation method [4]. This technique is contactless, non-thermal, precise, repetitive and adapted to each type of material present in IC packages. However, it can create thermal contribution to technological innovation in the whole history of semiconductor development.

In the horizontal axis of Figure 1, applications drive the development of new technologies and its diversification. In the vertical axis, Moore's law predicts the exponential growth of number of transistors that can be placed inexpensively on an integrated chip. It is drives the rapid scaling down of gate width towards 22 nm and beyond. For future applications, higher value systems are expected with a form of SoC and SiP (System in Package), as result of the combination of the two. More Moore pushes the industry towards miniaturisation (left down of the Figure 1). More than Moore is the clear message that summarized the broad diversification in semiconductor applications. From analog/RF, passives, high voltage/power, sensors, to bio chips (the second horizontal line of Figure 1), the IC devices are exposing to harsher environment. The FA challenge is multiplied by the chip challenges (System-on-Chip SoC) and the package challenges (System-in-Package SiP). "Assembly and packaging are limiting factors in both cost and performance for electronic systems" states the latest version of the International Technology Roadmap for Semiconductors (ITRS). The resulting consequence: in next years, the FA will be extended to broader

aspects such as: design for analysis (or design for test), physical limit – tools for chip, tools for package, chip-package co-design, and organizational issues like FA cost, FA cycle time etc.

Chip sizes will stay constant over the next 10 years, but power will rise, accompanied by a drop in core voltage and no increase in allowed-junction temperature (except in harsh environments where operating temperatures will also increase). Pin count is expected to possibly double for the cost-performance market. While the thin gate oxide structures are very fragile, two new families of tools have emerged to facilitate probing such small components, Atomic Force Microscope (AFM) probe technology, and in-chamber scanning electron microscopy (SEM) or Focused Ion Beam (FIB) probe technology.

RIL (Resistive Interconnect Localisation) is a newer technique which can identify via anomalies functionally using induced thermal gradients to the metal but does not address how to uniformly inject the thermal energy required in the silicon to analyse timing design deficiencies and other defects.

With SIFT (Stimulus Induced Fault Testing), numerous stimuli will be used to identify speed, fault, and parametric differences in silicon. The heart of this technique [5] revolves around intentionally disturbing devices with external stimuli and comparing the test criteria to reference parts or timing/voltage sensitivities. Synchronous interfacing is possible to any tester without any wiring or program changes.

In paper [4], backside preparation examples are presented on a conventional DIL plastic package, a TSOP plastic package with an oversized silicon die, and on a DIL ceramic package.

Laser ablation is a recent pre-decapsulation technique, which is used for sample preparation in FA. This process works with speed and accuracy. These are key parameters for getting successful observation and defect localisation. This can be used to have a precise opening on the die. However, this technique can create thermal stresses to the device. In order to minimize this stress, paper [5] has investigated methods for controlling the thermal effect of the laser on the component. This paper presents the experimental setup and the study of an electrical artefact that influences the interpretation of the thermal data.

As new technologies in the electronic environment develop from 2D ICs to 3D complex packages, it becomes necessary to find new techniques to detect and localize the different kinds of failures. A solution to localize defects for SiP devices is to measure the magnetic field that is generated by the current owing through the device, with a magnetic microscope (Magma C20) and comparing it with several simulated faults in order to choose the most probable one [6].

The new FA requirements put a high demand on the inspection tools with regard to accuracy and resolution. The resolution of single-beam FIB instruments is not sufficient anymore to deal with the necessary accuracy. To overcome this problem, the FIB tool must be combined with a high-resolution SEM that is used to monitor the FIB work on a nanometre scale. These integrated CrossBeam tools [7] enable the observation and direct control of the FIB operation in real time. The CrossBeam tools combine the imaging and analytical capabilities of a high-resolution field emission SEM (FESEM) with a high-performance FIB column into one integrated instrument. In the case of the CrossBeam tool, the final lens of the FESEM is designed as a magnetic/electrostatic compound lens. This layout has the advantage of no magnetic field interfering with the ion beam, and the FESEM can be operated at nanometre resolution during the ion milling process. This layout allows full control over the total process and gives an excellent endpoint detection and cut localization for defect review and FA [7].

5. FAILURE MODES

Electronic components have a wide range of failure modes. These can be classified in various ways, such as by time or cause. Failures can be externally utility generated, *in-situ* facility or locally generated by other nearby equipment or machinery, or internally generated from other related components in the circuitry. They can be caused by excess temperature, excess current or voltage, ionizing radiation, mechanical shock, stress or impact, parasitic structures, and many other causes. They can happen in an instant or take time to manifest. They can happen in storage, on manufacturing, in handling, packaging, shipping, installation, or during maintenance. In some electronic semiconductor devices, such as LEDs, problems in the device package may cause failures due to contamination, mechanical stress of the device or open or short circuits.

Failures most commonly occur at near the beginning and near the ending of the lifetime of the parts, resulting in the bathtub curve graph of failure rates. Burn-in procedures are used to detect early failures.

Analysis of the statistical properties of failures can give guidance in designs to establish a given level of reliability. For example, power-handling may be greatly derated to obtain adequate service life; a part intended to run for years has different reliability requirements than a part intended to run for 6 months or a year.

A sudden fail-open fault in an inductive circuit can cause multiple secondary failures. A broken metallization [printed circuit board (PCBA)] may cause secondary overvoltage damage. Thermal pads, vias, and metalized plans can add capacitance and discharge paths to ground. Thermal runaway can cause sudden failures including melting, fire or explosions. Paint can add high resistance to paths needing electrical continuity. Any fault effects can be cumulative or systemic where circuits feed other circuits.

6. FAILURE MECHANISMS

From a technical perspective, failure can be defined as the cessation of function or usefulness. FA is the process of investigating such a failure. Basically, FA is analysing the failure modes (FMo) with the aim to identify the failure mechanisms, by using optical, electrical, physical, and chemical analysis techniques.

Reliability is built into the device at the design and manufacturing process stages. In most practical cases, the final damage quite rarely reveals a direct physical FM; often the original cause (or complete scenario of failure) is hidden by secondary post damage processes. On the other side, it is impossible to eradicate failures during the manufacturing process and at field use. Therefore, FA must be performed to provide timely information to prevent the recurrence of similar failures. Or, wafer fabrication and assembly process involves numerous steps using various types of materials. This, combined with the fact that devices are used in a variety of environments, requires a wide range of knowledge about the design and manufacturing processes. This explains why FA of semiconductor device is becoming increasingly difficult as VLSI technology evolves toward smaller features and semiconductor device structures become more

complex. Since it is usually not possible to repair faulty component devices in a VLSI, each device in a chip can become a single point of failure unless some redundancy is introduced. Therefore, VLSIs have to be designed based on the characteristics of worst devices rather than those of average devices. Even if a chip is equipped with some redundant devices, today's scale of integration is becoming so high, that the yield requirement is still very severe. The final chip yield is governed by the device yield.

CONCLUSION

Going further from microsystems, another challenge for FA comes from a new domain, called nanotechnology. Here everything is new and the FMs for nanomaterials, which are different from those of the same materials at micro level, have to be studied. Supplementary issues are induced by using organic materials, which is a new trend in this field. Also, at nano level, new techniques for FA have to be created [8]. As one can see, nano-reliability (studying the reliability of nano-devices) offers a huge range of subjects for FA. The near future will show an important step forward in this field.

In conclusion, it is both easy and difficult to predict the future evolution of FA. Easy, because everyone working in this domain can see the current trend. Now the FA is still in a 'romantic' period, with fabulous pictures or smart figures smashing the customers, convinced by such a 'scientific' approach. Seldom, these users of electronic components do understand the essence of the FA procedure, because the logic is frequently missing. But this situation is only a temporary one. Very soon, the procedures for executing FA will be stabilized and standardized, allowing to any user of an electronic component to verify the reliability of the purchased product [9].

But it is also difficult to predict the evolution of FA, because the continuous progress in microelectronics and microtechnology makes almost impossible to foresee with maximum accuracy the types of electronic components that will be most successful on the market. And the FA must serve this development, being one step ahead and furnishing to the manufacturers the necessary tools for their researches. However, with sufficiently high probability one may say that the nanodevices (or even nanosystems) will become a reality in the next five years, so we have to be prepared to go deeper inside the matter, with more and more expensive investigation tools.

References

1. **Bergher L. et al.** *Towards Automatic Failure Analysis of Complex ICs Through E-Beam Testing. Proc. of International Test Conference; Testing's Impact on Design and Technology, Cat. No. 86CH2339-0, Washington, DC, USA, 1986.*
2. **Cole Jr. E. I. et al.** *Novel Failure Analysis Techniques Using Photon Probing With a Scanning Optical Microscope. Proc. of Annual IEEE Reliability Physics Symp., 1994, pp. 388-398.*
3. **Sienkiewicz M. et al.** *Failure Analysis Enhancement by Evaluating the Photoelectric Laser Stimulation Impact on Mixed-Mode ICs. Microelectronics Reliability, Vol. 48, Issues 8-9, August-September 2008, pp. 1529-1532.*
4. **Beaudoin F. et al.** *New Non-Destructive Laser Ablation Based Backside Sample Preparation Method. Microelectronics Reliability, Vol. 40, Issues 8-10, August-October 2000, pp. 1425-1429.*
5. **Aubert A. L., Dantas de Morais, Rebrassé J.-P.** *Laser Decapsulation of Plastic Packages for Failure Analysis: Process control and artefact investigations. 19th European Symposium on Reliability of Electron Devices, Failure Physics and Analysis (ESREF 2008); Microelectronics Reliability, Vol. 48, Issues 8-9, August-September 2008, pp. 1144-1148.*
6. **Colvin J.** *Functional Failure Analysis by Induced Stimulus. Proc. ISTFA, 2002, pp. 623-630. <http://www.fainstruments.com/PDF/sift2.PDF>*
7. **Infante F.** *Failure Analysis for System in Package Devices Using Magnetic Microscopy, Ph. D. Thesis, CNES, 2007. http://www.tesionline.com/intl/pdfpublicview.jsp?url=../_PDF/22186/22186p.pdf*
8. **Gnauck P., Boit C.** *Failure Analysis and Defect Review for the 45 nm Node Using Extended Accuracy of the CrossBeam Technology. [http://www.zeiss.de/C1256E4600307C70/EmbedTitelIntern/FailureAnalysisandDefectReviewCrossBeamTechnology/\\$File/2q05em01.pdf](http://www.zeiss.de/C1256E4600307C70/EmbedTitelIntern/FailureAnalysisandDefectReviewCrossBeamTechnology/$File/2q05em01.pdf)*
9. **Jeng S.-L., Lu J.-C., Wang K.** *A Review of Reliability Research on Nanotechnology. IEEE Trans. on Reliability, Vol. 56, No. 3, September 2007, pp. 401-410.*
10. **Bâzu M., Băjenescu T.-M.** *Failure Analysis - A practical Guide for Manufacturers of Electronic Components and Systems, John Wiley & Sons, Chichester and New York, 2011.*
11. **Alers G. B. et al.** *Stress Migration and the Mechanical Properties of Copper. Proc. of 43rd Annual Reliab. Physics Symp., April 17-21, 2005, pp. 424-426.*
12. **Lin M. H. et al.** *Copper Interconnect Electromigration Behavior in Various Structures and Lifetime Improvement by Cap/Dielectric Interface Treatment. Microelectron. Reliab., 45(7-8), pp. 1061-1078.*
13. **Wenbin Z. et al.** *W-Plug via Electromigration in CMOS Process. J. Semiconduct. 30(5) 2009, pp. 056001-056004.*
14. **Yokogawa S. et al.** *Analysis of Al Doping Effects on Resistivity and Electromigration of Copper Interconnects," IEEE Trans. Device Mtaer. Reliab., 8(1)2008, pp. 216-221.*

PRECISE METHOD OF BALANCING PASSIVE OPTICAL NETWORKS WITH IRREGULAR SPLITTER WITH TWO OR MORE OUTPUTS

Oleksiy Nedashkivskiy, Anatoly Semenko, prof.
State University of Telecommunications, Kyiv, Ukraine

1. INTRODUCTION

Recent advances in fiber optic technology, in particular in the field of passive optical networks (PON - Passive Optical Network), open opportunities to cover broadband Internet services and other telecommunications services. Today, there are several generations of PON [1, 2, 3, 4] speeds up to 10 Gbit/s per PON-tree. Many articles and materials devoted to problems of implementation of such networks [5, 6, 7, 8, 9, 10, 11]. Thus, the problem of balancing the branches of PON-tree, more or less accurately solved only splitters type 1: 2 (one input - two outputs), which built the corresponding two-dimensional table [7, 8, 9], and the solution to the problem boils down to a simple search from a list of possible values. These tables for splitters with three or more outputs do not build because following table for splitter with three outputs are three-dimensional! For four outputs splitters they are four- dimensional tables, etc. As a result, designed and calculated PON often negates the potential for passive optical networks because network topology approach the "star" instead of "tree" or "bus". In this no economy of fibers, increased requirements for automatic gain control, reduced maximum range of PON-tree that together leads to reduction of technical and economic efficiency of PON.

So the search for analytical solutions to the problem of balancing passive optical network is scientific problem. But advances in the manufacture of passive optical splitters, couplers that can make increments dividing the input power at 1% make finding solution relevant and timely.

2. BALANCING PON BRANCHES BY 1:2 SPLITTERS

Consider the model of optical splitter 1:2 with a scheme of connection of two remote users with relevant optical network terminals (ONT - Optical Network Terminal): ONT1 and ONT2 (Figure 1).

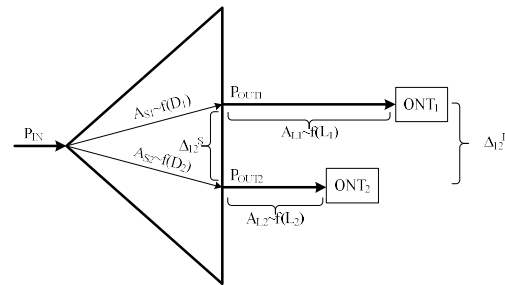


Figure 1. Model of optical splitter 1:2.

In general, subscribers are in different places, that is, the length of individual optical fibers, the number and characteristics of connectors and welding points are different. This leads to losses $A_{L_i} \sim f(L_i)$, that are made by individual optical paths in areas from splitter to the ONT are not equal. So there is a difference ONT of optical power levels of signals in ONT inputs:

$$\Delta_{12}^L = A_{L1} - A_{L2} \tag{1}$$

where: A_{L1} , A_{L2} - individual total loss of the optical path for ONT₁ and ONT₂, respectively;

Δ_{12}^L - the difference between power levels of optical signals between ONT₁ and ONT₂.

For maximum efficiency (range, reliability, stability, error rate) of PON networks it is need to provide the same power level at the inputs of all ONT's, and this can be done with unequal distribution of power between the splitter outputs.

The scheme (Figure 1) shows that the losses of optical splitter depends on the rate of capacity, which is displayed in the corresponding output, while the outputs of the splitter can be such a difference of insertion loss Δ_{12}^S that will offset the inequality of power levels of optical signals Δ_{12}^L , taken with a minus sign:

$$\begin{aligned} \Delta_{12}^S &= A_{S1} - A_{S2} = \\ &= -\Delta_{12}^L = -(A_{L1} - A_{L2}) = A_{L2} - A_{L1} \end{aligned} \tag{2}$$

where: A_{S1} , A_{S2} - optical splitters loss towards outputs OUT_1 and OUT_2 ;

Δ_{12}^S - difference of insertion loss between ONT_1 and ONT_2 due to the irregular distribution of input power PIN.

It is known [9] that the losses being made by optical couplers of any type may be approximated by:

$$A_{Si} = 10 \lg\left(\frac{100\%}{D_i\%}\right) + \log(N-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100\%}{D_i\%}\right), \quad (3)$$

where: A_{Si} - optical splitters loss towards outputs i ;

D_i - percentage of power transmitted from the splitter input in the direction of the output i ;

N - number of splitter output.

Then, with (1), (2), (3) and the fact that the sum of all D_i is 100%:

$$\sum_{i=1}^N D_i, \quad (4)$$

we can write the following system of equations:

$$\begin{cases} \Delta_{12}^S = A_{L2} - A_{L1} \\ D_1 + D_2 = 100 \\ A_{S1} = 10 \lg\left(\frac{100}{D_1}\right) + \log(2-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_1}\right) \\ A_{S2} = 10 \lg\left(\frac{100}{D_2}\right) + \log(2-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_2}\right) \end{cases} \quad (5)$$

Substituting the third and fourth equation of (5) in the first, which takes the form:

$$\Delta_{12}^S = 11.5 \lg\left(\frac{D_1}{D_2}\right). \quad (6)$$

From the second equation of (5) terms D_1 and substitute it in (6), we obtain:

$$\Delta_{12}^S = 11.5 \lg\left(\frac{100-D_2}{D_2}\right). \quad (7)$$

Result of (7) will be:

$$D_2 = \frac{100}{1 + 10^{\frac{\Delta_{12}^S}{11.5}}} \quad (8)$$

Finally for D_1 and D_2 :

$$\begin{cases} D_1 = \frac{100}{1 + 10^{\frac{-\Delta_{12}^S}{11.5}}} \\ D_2 = \frac{100}{1 + 10^{\frac{\Delta_{12}^S}{11.5}}} \end{cases} \quad (9)$$

Analyzing the expression (9) it is possible to simplify it form. Thus, if the exponent $-\Delta_{12}^S$ substitute by Δ_{21}^S , where the difference is taken in the opposite direction and one's in the denominator of the first and second equation of (9) replace by the relevant expressions $10^{\frac{\Delta_{11}^S}{11.5}}$ and $10^{\frac{\Delta_{22}^S}{11.5}}$ we get:

$$\begin{cases} D_1 = \frac{100}{10^{\frac{\Delta_{11}^S}{11.5}} + 10^{\frac{\Delta_{21}^S}{11.5}}} \\ D_2 = \frac{100}{10^{\frac{\Delta_{22}^S}{11.5}} + 10^{\frac{\Delta_{12}^S}{11.5}}} \end{cases} \quad (10)$$

Next, change the order of summation in the second equation of (10):

$$\begin{cases} D_1 = \frac{100}{10^{\frac{\Delta_{11}^S}{11.5}} + 10^{\frac{\Delta_{21}^S}{11.5}}} \\ D_2 = \frac{100}{10^{\frac{\Delta_{12}^S}{11.5}} + 10^{\frac{\Delta_{22}^S}{11.5}}} \end{cases} \quad (11)$$

Which shows that the overall solution can finally be written as:

$$\begin{cases} D_i = \frac{100}{\sum_{n=1}^2 10^{\frac{\Delta_{in}^S}{11.5}}} \\ i = 1 \dots 2 \end{cases} \quad (12)$$

3. BALANCING PON BRANCHES BY 1:3 SPLITTERS

Consider the model of optical splitter 1:3 with a scheme of connection of three remote users with relevant ONT_1 , ONT_2 and ONT_3 .

In general, subscribers are in different places, so on the ONT inputs there is not one, like in splitters 1:2, but three difference power levels of optical signals that can described as:

$$\begin{cases} \Delta_{12}^L = A_{L1} - A_{L2} \\ \Delta_{23}^L = A_{L2} - A_{L3} \\ \Delta_{13}^L = A_{L1} - A_{L3} \end{cases} \quad (13)$$

where: A_{L1} , A_{L2} , A_{L3} - individual total loss of the optical path for ONT_1 , ONT_2 and ONT_3 , respectively;

Δ_{12}^L - the difference between power levels of optical signals between ONT_1 and ONT_2 ;

Δ_{23}^L - the difference between power levels of optical signals between ONT_2 and ONT_3 ;

Δ_{13}^L - the difference between power levels of optical signals between ONT_1 and ONT_3 .

The scheme (Figure 2) shows that the losses of optical splitter depends on the rate of capacity, which is displayed in the corresponding output, while the outputs of the splitter can be such a difference of insertion loss Δ_{12}^S , Δ_{23}^S , Δ_{13}^S , that will offset the inequality of power levels of optical signals Δ_{12}^L , Δ_{23}^L , Δ_{13}^L , taken with a minus sign:

$$\begin{cases} \Delta_{12}^S = A_{S1} - A_{S2} = -\Delta_{12}^L = -(A_{L1} - A_{L2}) = A_{L2} - A_{L1} \\ \Delta_{23}^S = A_{S2} - A_{S3} = -\Delta_{23}^L = -(A_{L2} - A_{L3}) = A_{L3} - A_{L2} \\ \Delta_{13}^S = A_{S1} - A_{S3} = -\Delta_{13}^L = -(A_{L1} - A_{L3}) = A_{L3} - A_{L1} \end{cases} \cdot (14)$$

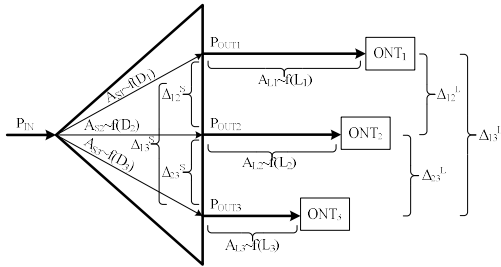


Figure 2. Model of optical splitter 1:3.

where: A_{S1} , A_{S2} , A_{S3} - optical splitters loss towards outputs OUT_1 , OUT_2 and OUT_3 respectively;

Δ_{12}^S - difference of insertion loss between ONT_1 and ONT_2 due to the irregular distribution of input power PIN ;

Δ_{23}^S - difference of insertion loss between ONT_2 and ONT_3 due to the irregular distribution of input power PIN ;

Δ_{13}^S - difference of insertion loss between ONT_1 and ONT_3 due to the irregular distribution of input power PIN .

Then, with (13), (14), (3) and (4) we can write the following system of equations:

$$\begin{cases} \Delta_{12}^S = A_{L2} - A_{L1} \\ \Delta_{23}^S = A_{L3} - A_{L2} \\ \Delta_{13}^S = A_{L3} - A_{L1} \\ D_1 + D_2 + D_3 = 100 \\ A_{S1} = 10 \lg\left(\frac{100}{D_1}\right) + \log(3-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_1}\right) \\ A_{S2} = 10 \lg\left(\frac{100}{D_2}\right) + \log(3-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_2}\right) \\ A_{S3} = 10 \lg\left(\frac{100}{D_3}\right) + \log(3-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_3}\right) \end{cases} (15)$$

Substitute fifth and sixth equation of (15) in the first equation, sixth and seventh in the second and fifth and seventh in the third and after transformations we obtain:

$$\begin{cases} \Delta_{12}^S = 11.5 \lg \frac{D_1}{D_2} \\ \Delta_{23}^S = 11.5 \lg \frac{D_2}{D_3} \\ \Delta_{13}^S = 11.5 \lg \frac{D_1}{D_3} \\ D_1 + D_2 + D_3 = 100 \\ A_{S1} = 10 \lg\left(\frac{100}{D_1}\right) + \log(3-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_1}\right) \\ A_{S2} = 10 \lg\left(\frac{100}{D_2}\right) + \log(3-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_2}\right) \\ A_{S3} = 10 \lg\left(\frac{100}{D_3}\right) + \log(3-1) \cdot 0.4 + 0.2 + 1.5 \lg\left(\frac{100}{D_3}\right) \end{cases} (16)$$

Result of (16) will be:

$$\begin{cases} D_1 = \frac{100}{1 + 10^{\frac{-\Delta_{12}^S}{11.5}} + 10^{\frac{-\Delta_{13}^S}{11.5}}} \\ D_2 = \frac{100}{1 + 10^{\frac{\Delta_{12}^S}{11.5}} + 10^{\frac{-\Delta_{23}^S}{11.5}}} \\ D_3 = \frac{100}{1 + 10^{\frac{\Delta_{13}^S}{11.5}} + 10^{\frac{\Delta_{23}^S}{11.5}}} \end{cases} (17)$$

Analyzing the expression (17) it is possible to simplify it form. Thus, if the exponent $-\Delta_{12}^S$, $-\Delta_{13}^S$, $-\Delta_{23}^S$ substitute by Δ_{21}^S , Δ_{31}^S , Δ_{32}^S , where the difference is taken in the opposite direction and one's in the denominator of the first, second and third equation of (9) replace by the relevant expressions $10^{\frac{\Delta_{11}^S}{11.5}}$, $10^{\frac{\Delta_{22}^S}{11.5}}$ and $10^{\frac{\Delta_{11}^S}{11.5}}$ we get:

$$\begin{cases} D_1 = \frac{100}{10^{\frac{\Delta_{11}^S}{11.5}} + 10^{\frac{\Delta_{21}^S}{11.5}} + 10^{\frac{\Delta_{31}^S}{11.5}}} \\ D_2 = \frac{100}{10^{\frac{\Delta_{22}^S}{11.5}} + 10^{\frac{\Delta_{12}^S}{11.5}} + 10^{\frac{\Delta_{32}^S}{11.5}}} \\ D_3 = \frac{100}{10^{\frac{\Delta_{33}^S}{11.5}} + 10^{\frac{\Delta_{13}^S}{11.5}} + 10^{\frac{\Delta_{23}^S}{11.5}}} \end{cases} \quad (18)$$

Further, changing the order of summation in the second and third equations of system (18), similar to the formula (12), finally we get a compact form of solution for determine the rate of distribution of power between the outputs of splitters 1:3 for precise balancing of PON branches:

$$\begin{cases} D_i = \frac{100}{\sum_{n=1}^3 10^{\frac{\Delta_{ni}^S}{11.5}}} \\ i = 1 \dots 3 \end{cases} \quad (19)$$

4. BALANCING EQUATION OF PON BRANCHES BY SPLITTERS OF GENERAL TYPE 1:N

Comparing (12) and (19) shows that they have the same form exactly the number of outputs of optical splitter, that is the type of splitter.

Thus it can be argued that for precise balancing of optical splitters 1:N (Figure 3), where N is a positive integer and is equal to the number of outputs, can be used one compact general formula:

$$\begin{cases} D_i = \frac{100}{\sum_{n=1}^N 10^{\frac{\Delta_{ni}^S}{11.5}}} \\ i = 1 \dots N \end{cases} \quad (20)$$

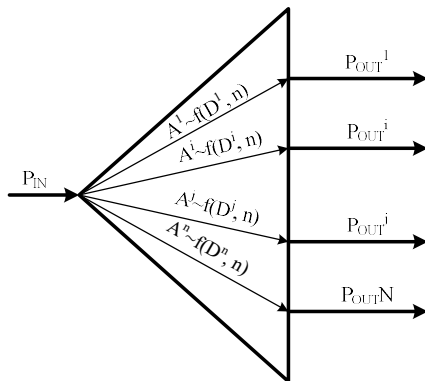


Figure 3. Model of optical splitter 1:N

5. CONCLUSION

1. The mathematical model of PON of complex structure can be used while implementing passive optical access networks and cable TV networks, where the physical processes in the couplers and splitters are very similar.

2. By using precise analytical solution of the problem of balancing make it possible in practice to approach the maximum theoretical advantages inherent in the PON technology.

References

1. ITU-T Rec. G.983.1. Broadband Optical Access Systems based on Passive Optical Networks (PON), 10/1998.
2. ITU-T Rec. G.983.3. A broadband optical access system with increased service capability by wavelength allocation, 03/2001.
3. ITU-T Rec. G.984.3. Gigabit Capable Passive Optical Networks (G-PON): Transmission Convergence Layer Specification, 10/2003.
4. ITU-T Rec. G.987.10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms, 06/2012.
5. Sklyarov A.K. Optical fiber network and communication systems. St. Petersburg., 2010, p. 272.
6. Rusakov E.A. Designing of access network base on PON technology. Ekaterinburg, 2015, p. 40.
7. Glushchenko D.B., Uryadov V.N. PON optical budget calculation with uniform splitter. Modern means of communication: materials XV Intern. Scientific-techn. Conf., 28-30 Sept. 2010, Minsk, Republic of Rep. Belarus. - Minsk: VGKS, 2010. – p. 28.
8. Glushchenko D.B., Uryadov V.N. PON optical budget calculation with ununiform splitters. Modern means of communication: materials XV Intern. Scientific-techn. Conf., 28-30 Sept. 2010, Minsk, Republic of Rep. Belarus. Minsk: VGKS, 2010. p.29.
9. Glushchenko D.B., Uryadov V.N. Methods for estimating the budget based on the application of technical solutions using a component of passive optical networks. Communications Networks, No. 2 (108), 2011, pp. 43-45.
10. Petrenko I.I., Ubaidullaev R.R. Passive Optical Networks PON, Part 1. Architecture and Standards. Lightwave russian edition No. 1 2004, pp. 22-28.
11. Ubaidullaev R.R. Fiber-optic networks. Eco-Trends, Moscow, 2001, p. 267.

Recommended for publication: 15.03.2017.

FEATURES OF CARBONATING HARDENING OF LIGHTWEIGHT CONCRETE

*Alexandr A. Gara, PhD. Eng., Prof., Anatoliy A. Gara, PhD. Eng.
Odessa State Academy of Civil Engineering and Architecture*

INTRODUCTION

The task of the concrete hardening acceleration becomes very important in developing of the saving technologies of the concrete products.

The maximum speed of the concrete hardening can be obtained by treatment compositions in carbon dioxide[1].

The continuous process of the carbonization gives an opportunity to make the material with specified properties. To achieve this effect it is necessary to optimize the recipe and the processing modes.

The purpose of the work is to develop a rational technological methods and parameters of the expanded clay lightweight concrete products processing in carbon dioxide that allows getting the material with specified physical and technical properties with minimal duration of hardening.

1. PROBLEM FORMULATION

The increased initial strength of the concrete is connected with acceleration of the hardening process of the cement in the very early period. Slowing the rate of hydration of binders can be explained by formation of a colloidal dispersion of the hydration shells around the grains. The reasons of formation of such shells are the small diffusion coefficients hydrate neoplasms and the supersaturation in the boundary layer that prevents the dissolution of the new cement portions and slows down its hydration and hardening. The supersaturation of the liquid phase of the cement paste is caused by the calcium hydroxide. Thus the acceleration the formation of a new phase and the reduction in the degree of supersaturation can be obtained by using the reaction of compound of calcium oxide with carbon dioxide. The carbon dioxide transforms a stand-lime to practically insoluble calcium carbonate. At the beginning the crystals of such calcium carbonate turn to crystallization basis and then give an additional bond to strengthen the cement stone.

In theory all calcium-containing components of the cement stone are capable of carbonation. The only exception is the compounds that include CaSO_4 . The reaction of CO_2 with Ca(OH)_2 proceeds with the evolution of the one mole of water. In a result the humid state of the material can be changed. In that case the favorable will be an exothermic effect that causes intense drying of the system. On the other hand, by carbonation hardening the water will be mostly the environment in which takes place the dissolution of the initial binder phase and their transportation to a reaction zone. The water becomes the main structural part of the emerging neoplasms only when the water carbonates formed. The neoplasms mostly were formed in a reaction zone that located at a distance from the surface of the dissolving starting material. The neoplasms can also be formed in a close proximity to the surface of the dissolving starting material if the humidity of the carbonized samples will be decreased noticeably. As a result that will block further reaction passing and the process will slow down strongly.

Along with hydrates carbonization can take place the "Carbonate" dissolution of the starting materials [1]. This is due to the fact that the irreversible transfer of Ca(OH)_2 to CaCO_3 disturbs the dynamic balance between the initial phase and the solute in Ca^{2+} ions that leads to the intensive dissolution. The selective dissolution and carbonization of the separate component parts of cement occur in the downstream row that matches to the downlink solubility and hydrated oxides of compounds. At first the calcium hydroxide enters into the reaction and after that the hydrated calcium oxide compounds enters too. In addition to reactions described above the calcium Hydrosilicates polymerization can also take place when CO_2 effect on cement paste. That leads to the insoluble polysilicate formation [2].

During carbonation hardening the changes in a moisture state of the material can slow down the carbonization process. In connection to this it is necessary to work out the technological methods that will reduce the water content of concrete compound on the stage of its preparation and that

will provide the excess water extraction from the cement matrix during the hardening. Moreover for the efficient continuous flow of carbonation reaction it is necessary to make an optimally developed structure of the compacted concrete compound. Such structure will provide the bulk diffusion of carbon dioxide into the product and connected to this volumetric change of neoplasms on the one hand and the mudding of the pore structure with neoplasms as a result of the local bulk increase of the solid phase during the carbonization process on the other hand.

All this actions and the optimization of the binder composition and the processing modes have to provide efficiency of the carbonization process of the product that allows obtaining the material with specified mechanical and physical properties while dramatically reducing the production cycle.

2. RESEARCH METHODOLOGY

The experimental device was built to carry out artificial carbonization of control samples and concrete samples. This experimental device consists of autoclave, vacuum pump, Carbon dioxide cylinders with reducers, control devices and pressure hoses. The device made it possible to carbonize up to 18 cube samples with an edge of 100 mm according to a given regime at the same time. Freshly molded concrete samples were previously subjected to evacuation to a vacuum of 0.085 ... 0.095 MPa. As a result, a porous capillary system was created in the samples under vacuum. After that carbon dioxide gas was supplied stepwise to the required excess pressure. The device allows to carry out the carbonization modes at excess pressure up to 1.5 MPa for a predetermined time interval.

In the studies, a complex of physicochemical and optical methods was used, including differential-thermal and X-ray diffraction analyzes, as well as electron microscopy in the studies.

During the optimization of prescription and technological conditions for the production of carbonized expanded clay concrete, mathematical methods of experiment planning were used. An experimental plans of the second order, close to the D-optimal one were used.

3. RESULTS AND DISCUSSION

The optimization of the recipe and technological parameters of the carbonized

expanded clay lightweight concrete included: working out an economical concrete compositions, working out the optimal carbonization modes, researching the possibility to intensify the carbonization process by inserting a binder into the composition (milled limestone) and by decreasing the total water content of the concrete mixture.

The carbonization process can be activated by intensive introduction of gas reagent into the reaction zone. That can be achieved by using carbonization regimes with preliminary vacuuming and subsequent filing of carbon dioxide under pressure. The vacuuming of freshly made concrete provides the creation of rarefaction in capillary-porous system. After that the carbon dioxide pressure drop in the initial period provides the vacuum removal, effective self-consumption of the reagent and the intensification of the carbonization process.

The process of "carbonate" dissolution of initial cement minerals accelerates proportionally to concentration of the carbon dioxide in reaction zone. That's why the use of regimes with CO₂ overpressure allows to rule the structuring process of cement compositions. At the same time carbonization of the product under the pressure leads to creation of the high saturations in the system and to local increase of the solid phase bulk. That entails the emergence of a significant internal tension and the development of destructive processes in the concrete structure. In this circumstances the use of stepwise pressure rise of CO₂ to the desired value allows to eliminate destructive processes that take place while the single-stage carbonization. It was established experimentally that the use of stepwise pressure rise of CO₂ allows to increase the demoulding strength of the expanded clay lightweight concrete in 10...30 percent [3].

It was found the an efficient replacement of 20...30 percent of the cement on the milled limestone without changing the physical and mechanical properties of the material [4]. While the carbonization hardening the basic component of the crystal structure is the calcite. The results of the X-ray examination and the differential thermal studies of the cement stone confirmed that. A massive morphological changes arise under the CO₂ effect in the cement matrix. The increase of the pressure, processing time and temperature leads to the matrix compaction and to the reduction of micropores and microcapillaries as compared with untreated samples. The flat, plate-like structures (inherent in portland lime stone) and thin needle-like crystals of ettringite are absent. Instead of them there are

rounded, densely arranged round crystals without any pores and the crystals in the structure of treated samples.

In connection to aforesaid it is obviously that crystallization of neoplasm occurs at the surface of carbonates grains. As a result such carbonates grains accrete with a fused between well-developed crystals of a new phase. The electron microscopic analysis confirmed the lasting nature of accretion between a carbonate rock and a secondary calcite generation. That leads to the structure hardening. The carbonate rock serves as a substrate. That occurs thanks to the proximity of crystallographic cells.

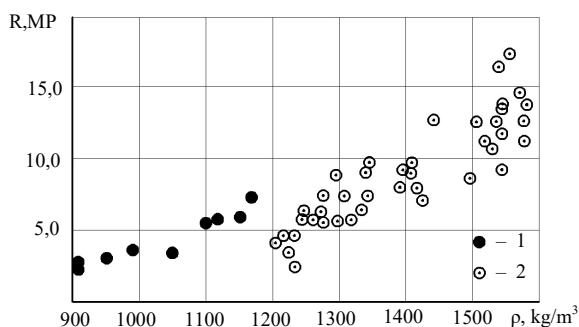


Figure 1. The relationship between the demoulding strength and the density of the carbonized keramsit:

- 1 – concrete based on expanded clay aggregate gravel ($\rho_{bulk.} = 450 \text{ kg/m}^3$);
- 2 – concrete based on expanded clay aggregate gravel ($\rho_{bulk.} = 720 \text{ kg/m}^3$).

In conditions of carbonization hardening the super plasticizer addition introduction into the concrete mix provides technological concrete mixtures with low water content. After the cement mixture compaction the dehydration of cement mixture occurs as a result of self evacuation. In this case the capillaries are exempted from moisture and become gas-proof. The volume of solid increase during the process of binding up CO_2 by hydrolysis products of cement minerals. That process is accompanied by pore structure mudding and leads to the increase of concrete strength.

The increased CO_2 concentration effects on initial concrete strength noticeably in the reaction zone [5]. The increase of the amount of CO_2 pressure from 0,6 to 1,2 MPa leads to increase of the CO_2 concentration and as a result to increase of the concrete strength in one hour after the carbonization of 25...60 percent. The increase of the duration of treatment from 30 to 60 minutes leads to increasing concrete strength of 5...20 percent. The influence of carbonization regimes on

the concrete strength is equalized with increasing concrete age. As a result the strength of the same dense concrete can vary widely after the carbonization (Fig.1).

The four tested lightweight aggregate compositions were selected for researching the growth of the kinetic strength during the time. All compositions have different consumption and composition of the binder.

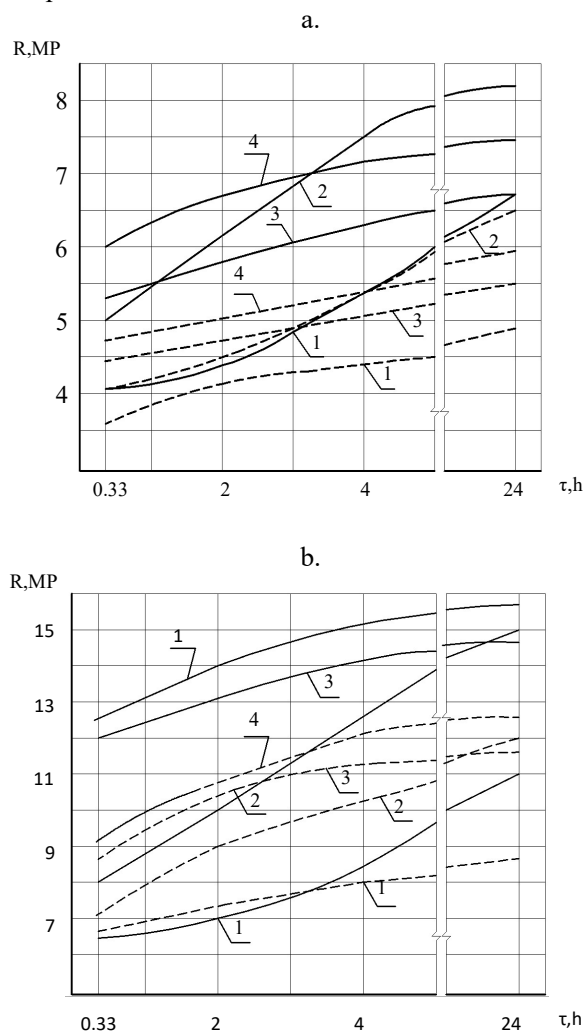


Figure 2. The growth of expanded clay lightweight concrete strength in early age after the carbonization (a – compositions 1 and 2; b – compositions 3 and 4):

- 1 – carbonization by regime: $R_c = 0,6 \text{ MPa}$, $\tau_c = 20 \text{ min}$;
- 2 – carbonization by regime: $R_c = 0,6 \text{ MPa}$, $\tau_c = 40 \text{ min}$;
- 3 – carbonization by regime: $R_c = 1,2 \text{ MPa}$, $\tau_c = 20 \text{ min}$;
- 4 – carbonization by regime: $R_c = 1,2 \text{ MPa}$, $\tau_c = 40 \text{ min}$;

The analysis of strength changes of expanded clay lightweight concrete in early age (20 min, 2 hours, 4 hours, 24 hours after carbonization) showed the maximal demoulding strength after applying the carbonization regimes with the maximal CO₂ concentration and pressure value in the reaction zone. After applying the carbonization regimes with pressure value 1,2 MPa and carbonization time 20...40 min the demoulding strength were 70...75 percent from the one after 28 days (Fig. 2 a, b).

The decreasing of the CO₂ concentration by applying carbonization regimes with pressure value 0.6 MPa provides reaching 50...60 percent of the concrete strength from the ones after 28 days for concrete classes B5-B7,5 (compositions 1 and 2) and 34...45 percent of the concrete strength for concrete classes B10-B15 (compositions 3 and 4).

The use of porous sands in structurally-insulated concretes leads to producing the products with a residual moisture above permissible. During the carbonization process the free water is released with exothermic effect as a result of the chemical interaction of carbon dioxide and hydration and hydrolysis products of binder minerals. In consequence of this after the demoulding the residual moisture of the expanded clay lightweight concrete was 9,4-13,5 percent for concretes with 920...1000 kg/m³ density and 10,6...13,1 percent for concretes with 1200...1550 kg/m³ density. The injection of the superplasticizer allows to reduce the residual moisture by 0,5...3,5 percent depending on concrete composition.

4. CONCLUSIONS

1. It had been studied the mechanism of structuring of the cement compositions in conditions of artificial carbonization. And the main rational methods of intensification of hardening process were found.

2. It had been offered the rational technological parameters and formulas of carbonization technology of the lightweight aggregate concrete wall products:

- the effective replacement of 30 percent of cement by milled limestone without changing the level of indexes of physical and mechanical properties of the material;
- the optimal granulometry of porous fillers;
- the optimal carbonization regimes that use the preliminary mixture vacuuming and the step processing mode in carbon dioxide.

3. The maximal demoulding strength had been provided under carbonization regimes with a maximal CO₂ concentration in reaction zone that is characterized by maximal pressure value.

References

1. **Sorochkin M.A., Shurov A.f., Uriev N.B.** *The carbon dioxide influence as the method of intensification of cement hydration/ DAN the USSR.1970. №1 - p.149-151.*
2. **Ramachadran V., Feldman R., Boduen J.** *The science of concrete.- Stroyizdat, 1986.- p. 261-262.*
3. **C.A. 1320202 the USSR, MKI C 04 B 40/2.** *The method of manufacturing concrete products/ Michailenko G.V., Solomatov V.I., Gara A.A.- Pub. In B.I., 1987, №24 - 6p.*
4. **Michailenko G.V., Gara A.A.** *The physical and mechanical properties of keramsit that had been hardened under carbonization.// The new effective materials in building.- Ashhabad, 1986.-p.93-94.*
5. **Lubomirsky N.V., Srebnik V.M., Bahtin A.S.** *The building composites on the lime basis of the carbonated hardening type/ Motrol. Motoryzacja i energetyka rolnictwa. – Simferopol-Lublin. - 2009. - Vol. 11A. - p. 229 – 238.*

STRUCTURAL MATERIAL SCIENCE

*Valerij Vyrovoy, Dr. Sc. Eng., Prof., Oxana Korobko, PhD Eng., Mihail Zavoloka, PhD Eng.,
Olga Kotsiurubenko, ass.*

Odessa State Academy Civil Engineering and Architecture, Ukraine

INTRODUCTION

The content of every paradigm consists of the system of scientific views based on the general model representations defined the entire set of conceptual, methodological, theoretical and experimental regulations [1, 2]. According to I. Prigozhin [3] such a system of natural scientific views forms scientific ideology. He noticed “...*the science is an ideology, it is also rooted in the culture*” [p. 49, 3]. According to the scientific ideology, a supporter of which I. Prigozhin was, one can argue that with the growing of internal conflicts inside the dominant scientific views the movement trajectory of this paradigm ideas gets in the bifurcation zone. It leads to the shift of paradigm and thereby it causes the displacement of scientific ideologies. A change of ideologies including scientific ones is a lengthy process often painful and tragic. It must be taken into account that it is talked not about replacement bad by good, backward by progressive etc. Drifting or change of paradigm implies the formation of a new system of views based on fundamentally different basic models.

Transition through the point of bifurcation changes the paradigm structure defining its content meaningfulness, the level of its methodological provision, theoretical saturation. The other ideological positions are forming, new scientific fields and schools are created which promote and develop becoming established paradigm ideas. The example is the change in the general scientific basic concepts of material (including building) science.

1. STRUCTURE IS THE BASE FOR ARCHITECTURE AND DEMONSTRATION OF BUILDING MATERIALS AND CONSTRUCTIONS

Simple, clear, accepted on faith the base model of building materials as the solid medium allows inventing the methodology of their assessment on the level of the average. The explanation of building materials mechanism formation is based

on the ideology of reductionism (lat. reduction – return, bringing back) that comes from the assumption that the whole can be understood just if its parts are understood. Ideas of allowable loads and strains those must be lower than limit values defined by laboratory, have formed the base of designed methods in products and constructions design. On this fundamental regulations many generations of ideologists of unstructured medium, its analysis and calculation and design methods both separate structural elements and structures, buildings and constructions with various kinds and purposes have been taught.

Ideology of unstructured medium implies an ambiguity of perception and evaluation of reality. There is the certain dualism in description of surroundings. There are originality and uniqueness of the processes and objects based on their structural dissimilarity on the one hand. There is unstructured medium on the other hand that is assessed average parameters of temperature, humidity and pressure. They differ in density and strength values, ratios of thermal conductivity, thermal expansion etc. Reality dissolves in the medium quality indicators accepted in the ideology of unstructured medium.

Emerged dualism can be considered as the beginning of the inner conflict within current paradigm. The system approach and synergy in its successful development arise from particular structure existing in objects of different nature and use. The holism ideology is forming (gr. *holos* – the whole, entire), the main point of it was declared by Aristotle (384 – 322 BC). He stated that the whole by its essence includes much more than there are summarized parts the whole consist of. The emergence and expression of something new is connected with the structural organization of objects-systems. The key parameter for creating the unexpected one is a structure. Accepting a structure as existing phenomena one can conclude that the ideological scientific positions start to change. Nicolay Gumelyov’s words are appropriate in this case “*the whole world is discovered again for me*”. The belief system ideologically oriented to the structure accountability for expressing and maintaining the properties of any object is forming.

In the evolution of different approaches and views a problem of terminology arises. Generally at the beginning existing terminology is used and some additional sense is given. Such a type of term that is widely used in different fields of knowledge is a term *structure*.

Widespread use of any term spreads its meaning to the blurriness. It is logically to say “*language structure*”, “*society structure*”, “*and metal structure*”, “*concrete structure*” and another ones. The term is used appropriately in biology, medicine, sociology, geology, mechanics, physics, chemistry, materials science and other sciences. The combined principal for objects not similar to their nature is certain hierarchy of their inner structure, inner architecture existed in the synthetic term structure.

Generally the structure (lat. *structura* – arrangement, order) is understood as a set of stable relations of object satisfied its integrity and identity to itself. In another word it is preserving the basic properties at various external and internal changes [4]. Such definition provides the structure to reflect some fixed state of the object that allows evaluate and describe qualitatively and quantitatively its structure taking into account the interaction and the relative position of the totality of the structural elements and groups of them.

According to [5] structure can be considered as “*stopped motion*” as moment fixed condition of the system in the process of its development, as certain configuration of its components. It is worth to say that term “*structure*” is used successfully in the description of dissipative systems [6], cooperative phenomena [7], processes of self-organization and adaptation various systems [8] without accurate definition of the essential content. This was the basis to bring into the essential content certain dynamics and self-support in autopoietic system [9], systems which development goes with an exacerbation [10]. Quite a lot of individual definitions of the term “*structure*” in separate crystals, metals, polymers and other materials descriptions are suggested.

Multiplicity of concept definition assumes its informative insaturation, certain dynamics of becoming unpreparedness of entering the generalized all-satisfied senses. Therefore, it seems logical to limit directly the semantic meaning of the term by providing structure in the form of a specific *model* (lat. *modulus* – measure, sample) of the object [11]. This method allows focusing on the structural features of the object which are responsible for the manifestation of certain properties according to a specific subject. Choice of

model structure depends on the subjective position of a particular investigator – his ideological positions, research objectives, methodology, instrumental and material resources, etc. The subjective nature of the “*appointment*” of the structure dominant elements is contained in the method of expert evaluations that basically allow us to estimate prevailing ideology of community of professionals in a time interval. Therefore making a particular model the purpose of the structural description of a particular object (the mechanism, the process) must be defined. One of the purposes of the structural approach is identifying the structural controllable factors which allow the structure to reproduce a required set of structural elements. To do this fixing a large-scale description of the boundaries and establishing a number of prioritize structure elements are needed to ensure the purpose of the object of analysis.

Many studies are devoted to allocation the scale levels on the size principle in the description of the structure of different nature materials (e.g. [12, 13]). There are supposed to allocate the levels of structural inhomogeneities on the basis of similarity of structural organization mechanisms in the publications [11, 14, 15] that allows to describe a product or constructional integral structure presented in the form of a system of a certain kind [16]. In the process of analyzing the structure organizational mechanism the borders of scales were found taking into account the principal difference in the processes implemented under the influence of force of gravity from the processes that almost do not react to the forces of gravity. V.I. Vernadskiy [17] noticed that macroscopic niche exists where a worldwide attraction reigns. He emphasized that a spatial multiscalement associates with timing multiscalement. This position is similar to H. Bergson’s statement [18] that multiple of levels of time and a multiplicity of life worlds exist at different levels. It is pertinently from our point of view to mention E. Petiot’s [19] conclusions about emergency (eng. *emergence* – appearance of a new one) existence and display two (at least) different levels of organization are required – one is underlying “*micro*” and another phenomenal “*macro*” observed at various spatial and temporal scales. The compulsory presence of a time series is noteworthy when the complex behavior of complex systems is considered [20, 21, 22]. A priori we will proceed from the time invariance (lat. *invariants* – unchanging) at different spatial scale levels without analyzing the nature of time. Within certain time slot (time quantum) the number of taking place and implemented events are

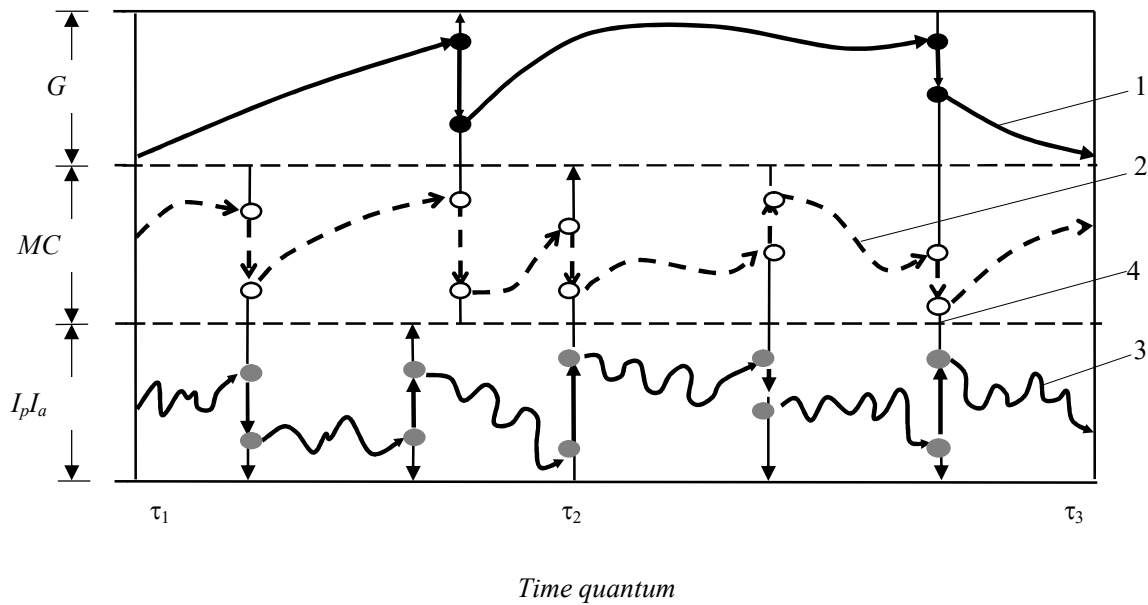


Figure 1. Diagram of multiscaled interactions. G – scale level where gravity proceeds; MC – scale level where gravity and interparticle interactions can proceed; $I_p I_a$ – scale level where interparticle interactions proceed; 1, 2, 3 – events at multi-scale levels of structure; 4 – interactions between the structural components at multi-scale levels.

fundamentally different, up to impalpability and therefore insensitivity [20].

The principal scheme of different scale structure coexistence is shown on the fig. 1.

The certain scale level, involved in the level of metastable state (MS) where individual particles and their families can reside in a metastable state, is allocated in a separate level. In the case of disintegration of the unit or particles cleavage from it (caused by physic and chemical, physical and physical and mechanical processes) the last transfer at the level where gravity is not dominant. When particles are combined into structural aggregates which weight is higher than force interactions of particles aggregate they fall under the effect of gravity automatically. It can be supposed that MS-level is a link (horizon of events) between two spatial levels. These levels differ from each other as the causes of certain events as their number occurring during a certain time quantum.

The difference between the mechanisms of structure formation at various spatial levels and the implementation of these acts of structure organization basically not matching in time suggest a certain level of independent existence. Processes occurring at every level subject to the laws manifested at this level, and cannot be carried out at another scale level in most cases. Impact of an event from one level on occurrence of events at another one relates to the rank of external events and occurs usually in mismatched time slots. It means certain autonomy of developments at every

level and a certain coexistence of diverse events in the whole system. It can be argued that this coexistence, realized through interaction of diverse events, provides the appearance of new (the other) qualitative characteristics of each scale level and the system as a whole.

Here the events are understood as a set of processes and phenomena of different nature implemented at different spatial scales for different time quantum. The problem arises to associate flows of events related but fundamentally different in essence occurring at different spatial scales and during different time lengths. It needs to identify elements that can be present at all scale levels simultaneously or belong to a specific spatial level and which are capable to provoke the birth of a certain event by their presence, fig. 1.

In order to determine these elements the task is to trace the formation history of the structure of a particular object. In publications [11, 14, 15] it is underlined that geometric characteristics of a particular product have a significant impact on the structure which components are local and integral field of residual (primary, technological, hereditary) deformations. It allows conclude that directed organization structure with a set of structural elements arises from the impact of the individual characteristics of a particular product. Geometric image of a specific object creates a unique qualitative and quantitative ratios of the structural components at different spatial levels with temporal difference of initiation of events displaying. The

geometrical parameters of objects should be regarded as significant management factors of the initial structure organization becoming the object-product. Thus the developed model of the structure should be related to a particular object (products, constructions, etc.).

2. THE ELEMENTS OF STRUCTURE OF OBJECT-SYSTEM

Structure models of a particular object should contain elements aimed at ensuring sustainable relationships to ensure the integrity and identity of the object under the action of all operational loads. An earlier analysis [14] allowed us to offer a classification of structural elements based on the difference in the speed of response of various elements when object is subjected to external and internal factors. In general case conservative metastable and active elements are marked.

Conservative (lat. *conservation* – saving) structural elements include elements changed their parameters slow enough during period when object functions. Usually conservative elements belong to the large-scale level where dominant force is gravity and phenomenological approaches of properties evaluation are implemented.

Elements of the structure which are relatively stable under these conditions and able to spontaneously going in the stable or unstable state by the action of external or internal factors are referred to the metastable (gr. *meta* – between, after, through) elements of the structure.

The hallmark of active (lat. *activus* – activities) structural elements is their ability to respond adequately to the proven impact in proportion time interval (one tempo rhythm).

Under the structure elements (lat. *elementum* – element, the original substance) various scale components of the system with specific features ensuring certain functions that contribute to the objectives of each structure level and the system as a whole are suggested for understanding. Structure elements may be specific material formation (e.g., components of the system, the pores and capillaries, cracks, etc.) of the system defining its internal state (e.g., local and integral technological and operational strain, osmotic phenomena, etc.).

System gets the entire set of structural elements in the form of building products and constructions [14] in the process of concrete receiving and its processing into products. At this stage, all the original members are actively involved in multiscale structural design with the formation of

new structural elements of the becoming system. The situations are not excluded where creating intermediate structural formations initiate the formation of the intermediate structural birth and development of fundamentally new elements included in the structure of the final product. Equifinality effects are characteristic (lat. *aequus* – equal proportionate; *finalis* – final). In our case it means the implementation of the structural organization of the various mechanisms that lead to the emergence of qualitatively identical structure elements. As examples, the origin of technological cracks is considered: - in the formation of discrete structures at the product level and at the level of tumors interaction of initial grain mineral binders; - in the development of gradients of own strains at the interfacial hardening matrix material and fillers; - under the influence of emerging gradient deformation at the level of product structures [11, 14].

A kind of "*albums portraits*" multiscale structures coexisting on different time scales are created as a result of mutual influence and interaction of all elements at all levels of irregularities. "*Albums of portraits*" means the permanent dynamics of structural components the totality of which defines a "family portrait" of the structure within a fixed time interval. In this context, a comparison with a "family portrait" suggests that at the same time it has all the elements of the family system. Thus the construction-system comes into the active phase of operation with a set of conservative, metastable and active elements of the structure. Further safe operation of the construction-system depends on the ability of the structural elements by self-consistent interactions and by transforming their own parameters to ensure the preservation of the system properties within continuous operational loads exposure.

Ensuring the stability of the properties for the required time of operation raises the problem of exception and analysis of models and structures in which adaptation processes (lat. *adaptation* – adjustment) can be implemented by percolation phenomena of self-organization at all various scales and multi time levels of construction-system. Adaptation of concretes [23, 24] should be attributed to the underlying determinants of the viability of products-systems. Therefore a prioritize number of elements that can alter the periods of adverse events should be defined in the model of the structure. This will identify the main governing factors aimed at creating a "*family portrait*" of the construction-system structure operated under adverse external influences.

3. CONCLUSIONS

A structured approach at this stage of its development should be considered as "an introduction to the explanation" of the mechanisms and processes of creation and functioning of various types and purposes systems. It is based on the becoming scientific ideology based on the ideas and methods of a systematic approach and synergy for which the term "structure" is the dominant concept. There are a paradigms shift based on the basic model of continuous medium in the direction of paradigms based on models of a structured self-developing medium. The fulfilled analysis has led to the conclusion that geometrical characteristics are one of the factors influencing the mechanisms of formation of building products and constructions. Therefore studying the structure of the material without his registration in some constructive forms is futile. In addition due to blurring and information uncertainty generalized definition of the term "structure" it is proposed to develop and analyze models of the structure of concrete products and constructions. The effect of the spatial levels of different scales in the mechanisms of the individual structures of each level of interaction and mutual influence taking into account the number of mismatches ongoing events over a fixed time slot to form an integrated structure construction-system should be taken into account. This allows us to consider the structure in a certain dynamics of development both in the establishment of the system and the action of its duty operation. It is proposed to classify the elements of the structure by the time of their response to external and internal influences on the conservative metastable and active elements of individual subsystems and the system itself.

References

1. **Kuhn T. S.** *The Structure of Scientific Revolutions.* Moscow, 317 p., 2009.
2. **Latour B.** *Science in Action: How to follow scientists and engineers through society.* St. Petersburg, 414 p., 2013.
3. **Prigogine I.** *The philosophy of instability. Problems of Philosophy, No.6, pages 45...57, 1991.*
4. **Soviet Encyclopedic Dictionary.** Moscow, 1980.
5. **Soroko E.** 2006. *Golden ratios, processes of self-organization and evolution of systems: Introduction to the general theory of harmony systems.* Moscow, 264 p., 2006.
6. **Nicolis G., Prigogine I.** *Exploring Complexity: An Introduction.* Moscow, 352 p., 2008.
7. **Haken H.** *Information and Self-Organization. A Macroscopic Approach to Complex Systems.* Moscow, 240 p., 1991.
8. **Synergetics: Research and technologies.** Moscow, 224 p., 2009.
9. **Maturana H. R., Varela F. J.** *The Tree of Knowledge: The Biological Roots of Human Understanding.* Moscow, 224 p., 2001.
10. **Knyazeva E., Kurdyumov S.** *Grounds of Synergetics: Synergetic Vision of the World.* Moscow, 240 p., 2005.
11. **Solomatov B., Vyrovoy V., Dorofeev V., Sirenko A.** *Composite building materials and constructions of the reduced material capacity.* Kiev, 144 p., 1991.
12. **Rybev I.** *Building materials on the basis of binders.* Moscow, 309 p., 1978.
13. **Sheikin A.** *The structure, strength and crack resistance of a cement stone.* Moscow, 192 p., 1974.
14. **Vyrovoy V., Dorofeev V., Sukhanov V.** *Composite building materials and constructions. Structure, self-organization, properties.* Odessa, 163 p., 2010.
15. **Fic S. B., Vyrovoy V., Dorofeev V.** *The processes of self-organization structure of composite building materials.* Lublin, 143 p., 2013.
16. **Vyrovoy V., Dorofeev V., Sukhanov, V.** *System approach to the analysis of the structure of build constructions. The Economical resource materials, structures, buildings, constructions, Rivne, pages 133...139, 2008.*
17. **Vernadsky V.** *Philosophical thoughts of the naturalist.* Moscow, 520 p., 1998.
18. **Bergson H.** *Creative evolution. Matter and memory.* Minsk, 1408 p., 1999.
19. **Petito E. A.** *Semiofizika and metaphysical realism. Synergetics. Anthology, Moscow, St. Petersburg, pages 329...342, 2013.*
20. **Alyushin A., Knyazeva E.** *Tempo-worlds: Speed of perception and time scales.* Moscow, 240 p., 2008.
21. **Prigogine I., Stengers I.** *Time, chaos, quantum.* Moscow, 272 p., 1994.
22. **Hawkins S. W.** *Three books about space and time.* St. Petersburg, 503 p., 2014.
23. **Sheynich L., Pushkareva K.** *The processes of self-organization of structure of build composites.* Kiev, 153 p., 2009.
24. **Cherniavsky V.** *Adaptation abiotic systems: concrete and reinforced concrete.* Dnipropetrovsk, 412 p., 2008.

Recommended for publication: 25.03.2017.

MODERN VIEW ON THE PROBLEM OF INTERACTION OF ART EDUCATION AND ETHNIC CULTURE

*Alla M. Radomska, ass.prof. of art-graphics
HNPU G. C. Skovoroda named*

1. INTRODUCTION

In the light of the global challenges exerting impact as on the states, the organizations, institutes in general, and on life of each person, such as: rapid social and technological transformations and in this regard of uncertainty in tomorrow life, economic and cultural globalization (standardization and a tendency to uniformity strengthening), growth of an individual and social variety, essential inequality of opportunities, poverty and the conflicts, economic crises and ecological destabilization, education in a broad sense is considered as investment into development of society. From the governments and the general public concern about adequacy of quality of education and the training invested by economic and social profitability into education of means grows. The question, what content of education will correspond to tomorrow, became a hot topic in political conversations and educational reforms around the world [10, c.1].

In the conditions of instability of social development and global cataclysms of the XXI century, for the younger generation planning steps and the directions of the development for ways of self-realization, the question of the choice arises often and everywhere. Need of independent orientation for life, for art, for public and cultural work at which young people should become "*author*" in the own life demands knowledge and certain skills.

2. STATEMENT OF THE PROBLEM

Problems of formation of ability of the personality to self-affirmation in the course of creative and art and cultural activity, successful integration and fruitful functioning in society are especially urgent for education today. In this context the thesis formulated by the world famous artist I. E. Repin who was born in Ukraine: "*To create on the national soil*" – it becomes more and more urgent theme [8]. In this regard tasks not only about teaching, but also all-round development of the personality are set for teachers in the sphere of

art education. "*Such development consists, first of all, in high-quality changes ..., in transitions from the lowest steps to the highest, in emergence of new lines of memory, perception, representation, thinking, will, character, etc., in formation of new qualities of the personality*" [1; c. 51].

3. ANALYSIS OF THE ACTUAL RESEARCHES AND PUBLICATIONS

In creative heritage of academicians of Sh. A. Amonashvili, I. A. Zyazyuna of D. S. Likhachev, L. V. Shaposhnikova, the culture is considered from essentially new positions – as the sphere in which space the human civilization successfully develops. Problems of successful socialization of the personality, her self-realization and self-affirmation even more often become an object of research of foreign authors (A. Maslou, the Item Torrance, V. Hoskins, E. Saarinen, P. Aasen, A. Telkhaug, O. Medias). The term "*position*" when studying questions of interaction of the personality and society in the sphere of culture is used by researchers (K. Albukhanova – Slavskaya, B. Ananyev, L. Bozovic, B. Bratus, V. Evdokimov I. Krivonos, Yu. Kunitskaya, L. Lisokhina, V. Lozovaya, I. Lutsenko, O. Rudenko, etc.)

Considering the ethnic culture as a subjective process of the interaction of many creative individuals, it is reasonable to imagine a scheme in the form of ethno-cultural sphere of art, in which the interaction occurs. This sphere can be considered also educational as in it all set of knowledge, abilities, skills and experience of the interacting persons belonging to ethnos is presented. Ethnocultural values are presented in such sphere of art is a huge intellectual richness and an inexhaustible reserve of reproduction of universal values and cultural and moral principles of the people without which process of national creation is impossible. The structure of the sphere of art can be presented like the form of several components. This art which is a product and a component of national world culture, bearing in itself universal values of

world culture; art works, basic of which will become a part of world cultural history. One more component are the values and works which are primordially belonging to separate national culture and the modern works close and clear to representatives of a certain ethnic culture but created in the context of current trends of attitude. It is the mixed art culture born in national educations on the basis of interaction of representatives of various social groups and layers in youth groups. One more making sphere of art there will be authentic, "primary" national culture of the nation living in a certain territory or nationality, so-called "folk art".

In the ethnographic plan the cultural world community represents the non-uniform education consisting of separate sociocultural educations with the ways of life, mentality and consciousness, with various socially - the economic and cultural levels of its development.

Thus, we can accent heterogeneity of the world community concerning as a set of art creations and art and universal values declared in them. Proceeding from importance of transfer when training in the younger generation of content of culture for the purpose of its preservation, creative display, and the subsequent development, experts seek to create a system which will help to each next generations to form creative identity as the personality capable to keep and increase properties of national culture.

Considering the processes happening in the sphere of art it is necessary to state inevitable washing out, dissolution in its borders a certain art currents and the directions, mixture of author's receptions and the technician. To these results leads the interethnic communication, in most cases aimed at studying, learning cultural and artistic experiences as their own national culture, and a stranger. Consideration of ethnic culture in the context of the communication process (Shavaeva M. Yu, 2017) allows you to allocate functions to implement in the course of this interaction. The most important features determining indispensable for the individual ethnic and cultural experiences in all the processes of artistic life and creativity are: tool (creation and environmental transformation), the function of inculturation (creation and transformation of the person), regulatory (creation of the system resources of the organization of collective life) and sign (cognitive, educational) function.

4. ARTISTIC EDUCATION IN COMMON SYSTEM OF CULTURE

The first three-dimensional model of the system development of the national culture as the crossing of the "vertical" component (deep values of national culture) with a horizontal component (priobschënnymi values of other cultures) has been considered in the context of the study of national and global aspects of the development of Ukrainian art-design culture and design Danilenko VY [3; from. 3].

Well-known historically developed creative position of the intelligence that the best of its representatives saw themselves in close connection with the customs and traditions of the national culture. Preserving and promoting, building on the achievements of contemporary culture, these people have made a huge contribution to the national culture and became known to the world precisely as the best representatives of the national culture. An example would be the position of the artist Ilya Repin, who, like many of his contemporaries realize their higher civilian mission - to be the expression of the national spirit and national perception of the world.

It was expressed in the "desire to live the higher spiritual aspects of life and to serve them". The cruel wars and revolutions throughout seyavshih aggression, blood and death, paintings Repin passed life in all its manifold manifestations. According to Ilya Repin: "a lot of pictures appeared in the hectic time, they worried about the society and directs it to the path of humanity" [8, c. 125].

The complex world calls for a reflective and holistic approach to life. Basic skills are important, but not sufficient in the light of the complexity of today's requirements and challenges as they manifest themselves in the workplace, in the political sphere, in the family, in all areas of human activity. Many scientists, experts agree that effective and responsible participation in the modern world requires the development of a higher intellectual level of complexity, the so-called author's level (Kegan, 2001), which implies the presence of critical thinking and reflective, holistic approach to life on the part of the person [8].

In order to form a holistic approach to life, it is necessary "... to enlighten the human mind, to lay before the eyes of a clear path of goodness" - wrote K. Ushinsky [4, c.99]

Consequently, higher education institutions, as part of the entire education system should function as centers of culture, knowledge and research, on which depends the scientific, technical and cultural

development of society. In the field of education university science younger and future generations of students have to learn to appreciate your own life, and to create harmony in it; and, forming a harmonious personality, to be ready to participate in productive changes in the social and cultural environment. [2, c.7-11]

5. THE LOOK AT THE ART EDUCATION FROM THE POINT OF VIEW ETHNIC CULTURE

The most important component of all humanitarian education - art education, is fundamental to the conservation status of each of the countries as the countries of the highest creativity in the field of culture and education. Art culture, as a nation, and of humanity as a whole - because of its universality and infinity impact on development and the formation of the whole person - is able to provide a developing society by people of high morals, preserving national interests and to create a single socio-cultural world space [12].

The process of education in the arts should be considered in the positions of the national ethnic culture in relation to the worldwide global educational process. In this connection it is necessary to emphasize the need to create an appropriate ethno-cultural position of students. In this context, ethnocultural position with one hand will contribute to ethnocultural identification of the student, on the other hand make it easier to integrate into the global society in accordance with the ideals and values of their own national culture.

Built so ethno-cultural position of students of is art-graphic faculties of how the younger generation of artists - teachers will allow a clear vision of involvement of individual perspectives into all processes in the arts and culture, will promote the development of national culture in the humanistic direction, enriching both world culture positive potential humanity inherent in the national culture and education.

Dualism and different trends characterize today's time most accurately. Huge challenges for young people is a large amount of knowledge available to many, in conjunction with some randomness in the possibilities of its acquisition - modern media technology, including the Internet, provide almost unlimited access to information and knowledge, however, does not guarantee their authenticity. Another negative factor, which can only be overcome through education - the existence for the individual weight of ways for self-

expression and, at the same time the absolute indifference of the "global" society to the originality of the individual. Only with the help of national and ethnic and cultural identification, through the implementation of laid down in the ethnic culture of ideological values, the person is able to adapt to such factors of global change within the world community. Increasing competition in the social and professional activity requires updating educational programs, continuous innovation in teaching methods. The orientation of the educational system, not only towards the individual, but also emphasizing the "successful" later in life and the functioning of the individual, becomes the most important task of science teaching. The student must master the skills of self-select the quantity and quality of necessary knowledge. Speaking about the students is art-graphic faculties of higher educational institutions of Ukraine, I would like to highlight as the main direction of the successful creative development of students' personalities, understanding the inseparable connection of this process with the artistic culture, both global and national. The most effective in consideration of the success of the individual as a subject of art education process, will in our opinion, the approach to this issue, with the position of pedagogy, sociology, art and ethnic culture. This will make an emphasis not only on the formation of personality, creativity, and on the problems of productive interaction between the individual and society in the sphere of culture.

Concepts such as the culture of view, the culture of thinking, the system will create the image are necessary components in the qualifying list a large number of actual trades for the twenty-first century. All of them are acquired as a result of the educational process. And the higher the quality of the education, the higher quality will be acquired skills. Consequently, the greater the probability of success of the person, get an education. Higher education in the sphere of culture and art education including in Ukraine becomes relevant and popular, in spite of the complexity and uncertainty of social, cultural and economic life of society. Attention young people and the demand for education in the arts is explained in the study not only of the internal situation in the field of national education and social services, where the product of this education is implemented, but it depends on the understanding of global processes that led to the rapid changes in the approach to education in general and higher arts education in particular. Dictionaries explain the concept of "art" as a skill, artistic skill, thorough

possession of skills, and as a branch of artistic activity.

In all the above definitions can be identified component that makes attractive the result of education in the arts, creativity, maysterstvo. Learn maysterstvu artistic profession and able to teach Bat maysterstvu / art of other people - a humane and promising model for the construction of their own life and the possibility of understanding Svoge uspishnogo functioning in society.

IA Zyazyun described the cultural function of personality as the ability to convert and create culture. This process is indicated by the investigator as a socio-psychological phenomenon in which realized the emotional and aesthetic activity with a complex personality, outside and inside the targeted cognitive and communicative functions [4, c. 35-46]. Given that art and graphic education provides the ability to acquire the skills of artistic and imaginative development of the world, which combines the object and the subject, and the attitude of the subject, we can say that in the process of artistic activity accumulated value information about the world. At the same time develops the ability to create artistic reality: visual, visual-simulation images; the ability to use the language of art, ie the ability to vividly simulate the objective environment and their attitude to it, the ability to embody the artistic images in real form.

CONCLUSIONS

All of the above explains the socio-psychological, cultural, emotional and artistic and aesthetic components of the demand for graphic arts education. Considering the artistic activity and creativity in terms of pedagogy of view, should be to identify them as a kind of human activity, during which a person, cultivates, develops, successfully implements, creates a spiritual and material values, having as an objective - social and subjective - personal value. Art and graphic creative activity, which expands the possibilities and send art and graphic education, is in this context that the most valuable as the highest form of self-realization and self-identity, which is actively involved in almost all the physical and spiritual powers of man [6, c. 7-15].

The reality of today's social situation of young people as the objects, such the main figures of the process of art education, requires the attention of experts to update the tasks in coordination of economic and social goals of the individual, the state and education through the renewal and

modernization of the educational standards of artistic pedagogy. According to European researchers, educational standard as a social norm is viable only if it in focus on learning outcomes - the characteristics of personality " own increments" in terms of providing effective vital activity of the individual in society and enhance its self-building within the framework of general and professional culture, morality, spirituality and social responsibility [11].

Thus, ethno-cultural position, formed in the process of artistic activity, will allow artists to raise - teachers with their own views on life and art. Finding your own ideal of excellence in the work of both, young people will have more confidence in themselves and their own abilities, feeling himself a follower of the famous members of their own national culture.

Bibliography

1. **Boldyirev N. I.** *Pedagogika / N. I. Boldyirev, N. K. Goncharov, B. P. Esipov, F. F. Korolyov. — M.: «Nauka», — 1968. — S. 51.*
2. **Bolyubash Ya. Ya.** *Modernizatsiya vischoj osviti Ukrayini i Bolonskiy protses / Ya. Ya. Bolyubash, K. M. Levkivskiy, M. F. Stepko, Yu. V. Suharnikov. //Osvita Ukrayini. — 2004. - #60-61. — S.7-11.*
3. **Danilenko V. Ya.** *Dizayn Ukrayini u svitovomu konteksti hudozhno-proektnoj kul'tury XX stolittya (natsionalniy ta globalizatsiyniy aspekti) 05.01.03 - tehnicna estetika. Avtoreferat disertazii na zdobuttya naukovogo stupenya doktora mistetstvoznavstva /V. Ya. Danilenko — Lviv, 2006. — S. 3.*
4. **Zyazyun I. A.** *Osvitniy prostir kulturi v pedagogichnij teorii /Ivan Andriyovich Zyazyun / Profesiyna osvita: pedagogika i psihologiya. Ukrayinsko-polskiy schorichnik. Za red. I. Zyazyuna, T. Levovitskogo, N. Nichkalo, I. Vilsh. — Chenstohova — Kiyiv: Vidavnistvo Akademii im. Yana Dlugosha v Chenstohovi, 2005. — Vip. 7. — S. 35-46.*
5. **Masol L. M.** *Hudozhno-pedagogichni tehnologii v osnovniy shkoli: Ednist navchannya i viovannya :metod. poslb. / L. M. Masol. — Harkiv: «Drukarnya Madrid», 2015. — 178 s.: il.*
6. **Masol L.M.** *Integratsiya v sistemi shkilnoj mistetskoj osviti i polihudozhnya pidgotovka vchiteliv // Psihologo-pedagogichna problema silskoj shkoli. — Vip. 4. — K: Nauk. svit, 2003. — S. 7-15.*
7. **Ushinskiy K.D.** *Tvori v 6-ti t./ K.D. Ushinskiy — T. 1. — K.: «Prosvit», 1954. — S. 99.*

8. Repin. I. E. *Pisma k hudozhnikam i hudozhestvennym deyatel'nyam / I. E. Repin — M.: «Iskusstvo», 1952, — S.125.*

9 Bolonskiy protses: *Normat.-pravoy dok. / Uklad.: Z. I. Timoshenko, I. G. Onischenko, A. M. Grehov, Yu. I. Paleha. — K.: Evrop. un-t, 2004. — 102 s.*

10. Sesiliya Braslavski *direktor MBP UNESCO O proekte mezhdunarodnoj mezhdistsiplinarnoj programmy “Opređenje i izbor kompetentzij teoreticheskie i kontseptual'nye osnovy”./ Definition and selection of competencies: theoretical and conceptual foundations – DeSeCo project, 2017, P.1-12.*

11 Rychen D.C. *Key Competencies for Successful Life and Well-Functioning Society / D.C. Rychen - OECD: Hogrefe and Huber, 2003. - 224 p.*

12. <http://www.worldallianceforartseducation.org/>
«Dorozhnaya karta», Programma UNESCO po hudozhestvennomu obrazovaniyu: Tzeli hudozhestvennogo obrazovaniya.

PRINCIPLES OF MOBILE WALKING ROBOT CONTROL IN SCOPE OF TECHNICAL MONITORING TASKS

Oleksandr M. Radomskiy

National Aerospace University KhAI, Kharkiv

INTRODUCTION

Modern mobile robots research shows that exist range of tasks in a limited environmental space when usage of flying robot it is energetically inefficient or impossible at all. Also there are environments where wheeled robots cannot operate efficiently because of inappropriate underlying surface. Limited environmental space is a closed industrial space of production facility, having number of obstacles, such as machines, communications and walls, so that robot cannot pass.

When solving tasks of industrial facilities technical monitoring [2] by means of the compact flying drones, it is necessary to overcome navigation difficulties and real-time obstacle avoidance in dynamical environment. Control of compact aircraft [1] in a three-dimensional space with dynamic and fast-moving obstacles is non-trivial task that depends on concrete kind of environment at production facility.

For every single limited space at facility it is necessary to provide a specify control conditions and limitations, or install more complex control algorithm and faster control unit. Complexity of navigation task, that aircraft need to solve, determines time period while aircraft still in flight but does not performing useful operations, consuming limited amount of fuel.

1. OVERVIEW OF EXISTING TECHNOLOGIES

For wheeled robots [3] one of the most significant limitations is the frequent change of surface level, where robot moves. To overcome such kind of limitations, additional ramps are needed to be installed to allow robot move over stairs, doorsteps and other obstacles of this type and having different height. Proposed proof of concept for mobile walking robot, that is less demanding on power resources comparing to aircraft, and having possibility overcome obstacles with height greater

than wheel radius for the same power wheeled robot.

Building of walking robots and research in scope of walking machines started in second half of previous century, because of extreme computing power grow. Nowadays exists a wide range of industrial and military walking machines, also robotic production companies are ready to achieve mass market housekeeping robots in near future, as shown in [4], [5].

As the designer of world class robotic systems can be mentioned USA based company DARPA Boston Dynamics, started early 70s at Massachusetts Institute of Technology (MIT) robotics research laboratory, presented their military robot carrier Big Dog in 2005 [6], that handle up to 110 kilograms of load and able to follow arm forces. Also DARPA presented range of four-legged robots such as Cheetah, modeling different stages of cheetah run and achieving speed of nineteen miles per hour that is world record for legged robots. Another one DARPA's robot is a Small Dog, equipped with bunch of sensors and designed especially research in motion algorithms over raw surface using artificial intelligence.

In 2010 Department of Robotics in Moscow State Technical University n. a. N.E. Bauman (MSTU) creates two-legged robot [7] for humanoid walking dynamic research [8].

2. ROBOT DESCRIPTION

2.1. Concept for mobile walking robot carrying

Proposed proof of concept for mobile walking robot carrying load up to sixty percents of own robot's mass. Control system includes computing unit, seven servos, three-axis accelerometer and moving camera operating in a visible range. Mechanical design can be described as follows: horizontal plate, where load is placed, mounded onto main baulk in the way so mass of load distributed symmetrically along roll axis of robot. Under main baulk accumulator batteries bracings

are placed. Symmetrical front and rear moving baulks are connected to the front and rear sides of the main baulk via bearing joint, so they can freely rotate around corresponding vertical axes. Both front and rear moving baulks are equipped identically and symmetrically with three servos each one. On the moving baulk one servo is installed vertically for rotating relatively to the main baulk around vertical axis, two other servos are installed in orthogonal plane, equipped with pillars and allow robot positioning in vertical plane. So pair of vertical servos provides rotating of moving baulks in horizontal plane while four other servos are used for moving pillars up and down.

Camera is coupled with compact crank mechanism and servo, so stereo image processing for navigation purposes can be achieved with one single camera. Advantage of such approach is saving computing power by retrieving one image at time instead of two images at time. Disadvantage of such moving camera unit is that camera cannot be calibrated so precise as fixed stereo-camera, but exists methods such as [9] and [10], where calibration of camera is not mandatory.

2.2. Motivation

Redundant numbers of servo-drives requires more power for keeping all kinematics links in desired position. After performing global analysis of energy required for specific robot motion and energy actually spent for that motion, can be roughly assumed that walking robot uses just a few links for motion while other links are moving lightly or still not involved in the operation at all.

Joints of living creatures has non-trivial complex structure, comparing to robotic analogues, with number of kinematics links for achieving maximum utilization of energy for specific motion and high maneuverability of creature. Numbers of degrees of freedom for artificial walking machines usually an order of magnitude lower that for living creatures. Forces and moments in joints of robot and in joins of creature are created using fundamentally different means, so problem of energy optimization is independent topic for discussion.

Adding additional degrees of freedom with additional kinematics link and corresponding muscles for limb of creature leads to better energy utilization when performing specific motion, but this cannot be applied to artificial limb. When creature's limb moves, number of tissues are involved - muscles, tendons, fat, skin, bones and their joins, performing damping, distribution of

loads and involved in forming of control forces and moments. For artificial limbs all of these functions, mainly, are performed by servo-drives attached to corresponding joint. So numbers of tasks, that are performed in a creature's limb with no energy consumption because of tissues elasticity, in artificial limb are performed with usage of electricity for positioning servo-drives.

2.3. Distinction from analogues

Basing on assumptions shown above proposed robot was designed in such way so it minimizes power consumption by excluding most of joints but still keeps walking for translation of its mass. Future minimization of power consumption requires change of moving principle that is not in scope of this article.

Main distinction of proposed robot kinematical scheme from nearest analogues having four legs is that proposed scheme uses single rotational degree of freedom for lifting and putting down legs, while analogues are designed with at least two rotational degrees of freedom for every leg, that significantly increases power consumption for every movement that robot can perform.

2.4. Robot tasks and control

Robot's scope of use can be limited to few groups such as tasks where required continuous monitoring without human and monitoring of damaged or dangerous facilities.

Control principle for such kind of object can be downscaled to control of servo-drives. Current version equipped with TowerPro MG996 servo drives, controlled by power width modulation. Working range of these servos is 0 to 180 degrees and depends on control pulse width on 50 Hz frequency.

Control system consists of main unit, responsible for servo-drives control following operator commands, or commands acquired from higher level control loop and regulator unit, responsible for adaptation of control commands respectively to sensors data. While waiting for new command, system continuously repeats last command. So when operator or higher control loop preparing control command that determines type of movement, main unit computes relations for pulses width changes in time. Next, regulator unit uses real-time data from sensors and updates computed pulses width so robot can keep on moving with no loss of efficiency.

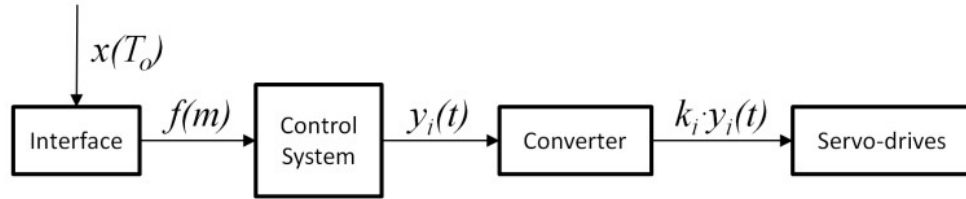


Figure 1. System structure: $x(T_0)$ input signal in binary form, $f(m)$ control command, $y_i(t)$ servo-drive actual control signals, k_i gain for i -th servo-drive actual control signal, $i \in \{1, 2, \dots, 7\}$.

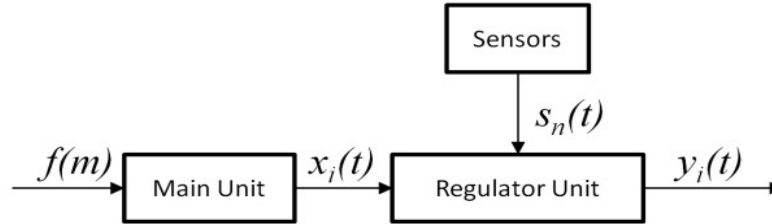


Figure 2. General schematic of control system: where: $x_i(t)$ is a servo-drive general control signals, generated from default set of robot movements, $s_n(t)$ data from n -th sensor, $n \in \{1, 2, 3\}$.

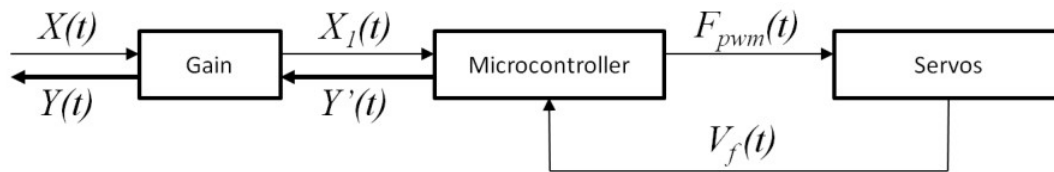


Figure 3. General structure of control unit: $X(t)$ general control signals, $X_1(t)$ control signals for microcontroller, $Y'(t)$ controller output signals, $F_{pwm}(t)$ control pulses for servo-drives, $V_f(t)$ feedback voltage.

Robot control algorithms computed using principle, described above - first, control command $x(T_0)$, that passed to the system input Interface. Next, after receiving command, values for servo-drives control, delays and control command $f(m)$ are computed. Control system computes relations for servos $x_i(t)$ using default preset of robot motions, and then retrieves data from sensors. Using sensors data Regulator Unit updates values for servos control.

When robot lose its dynamical stability while moving, say flip around roll axis because of some sort of disturbance, When robot loses its dynamical stability while moving, say flip around roll axis because of some sort of disturbance, design of robot body parts allows to arrange recovering operational condition, that means normal position of robot relative to the ground, by forming a set of special movements. First, when robot loses dynamical stability, control system performs actions to restore statically stable state of robot body. Then, robot performs set of motions to change relative position of its center of mass point in such way so body rotates around roll axis by 180 degrees. Also, while

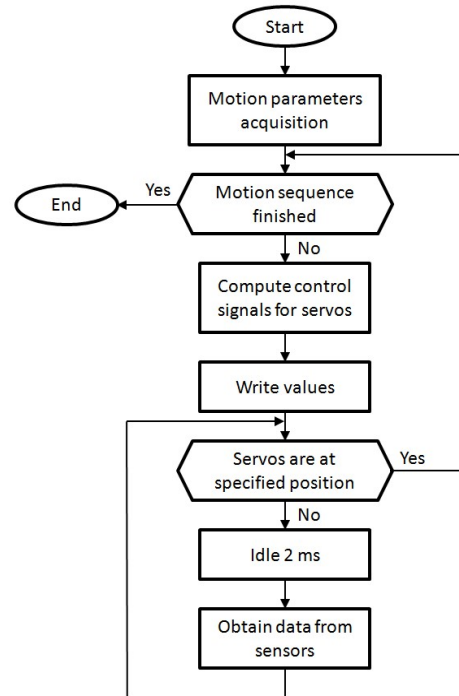


Figure 4. Generalized control algorithm.

restoring operational condition, robot body rotates by about 30 degrees around yaw axis, so additional movements are required to turn back to the robots route.

4. CONCLUSION

Shown above control principles and general schematic of control system for mobile robot can be used for the researches in a different operational conditions for the walking robots having design similar to mentioned above.

Proposed system uses only units involved in regular movement for restoring normal orientation when robot loses stability and falls down. Pairs of stereo images for the reconstruction of the observed space this system receives from a camera connected to the compact design of the crank mechanism. This way, it managed to reduce twice minimize the cost of the budget hardware required for the acquisition of stereoscopic images.

References

1. **Matveev S. I.** *Vysokotochnye sistemy RV i A: perspektivy i osnovnye napravleniya rabot po sozdaniyu razvedyvatelno-udarnyh i razvedyvatelno-ogneyih kompleksov / S. I. Matveev [tekst] Voennaya myisl. – 2003. – № 2. – S. 23-27*
2. **Myasnikov E. V.** *Vysokotochnoe oruzhie i strategicheskij balans (Izdanie Tzentra po izucheniyu problem razoruzheniya, energetiki i ekologii pri MFTI). [Tekst]/ E. V. Myasnikov – Dolgo-prudnyiy, 2000. – 43 s.*
3. **Dergachov K. Yu.** *Metodika viznachennya optimalnih marshrutiv ruhu ruhomih ob'Ektiv u kompleksni zadach komandnogo punktu dispatcheriskoj sistemi [Tekst]/ K. Yu. Dergachov, S. M. Flerko, D. V. Kravtsov Sistemi obrobki Informatsiyi Harklv: NANU, PANM, HVU. – 2005. - Vyp. 1. – S. 213-217*
4. **Maitin-Shepard J., Cusumano-Towner M., Lei J., Abbeel P.** *Cloth grasp point detection based on multiple-view geometric cues with application to robotic towel folding. In Proc. IEEE Int. Conf. on Robotics and Automation, 2010*
5. **Saxena A., Driemeyer J., Ng A. Y.** *Robotic grasping of novel objects using vision," Int. J. Rob. Res., vol. 27, no. 2, pp. 157–173, 2008*
6. **Buehler M., Playter R., Raibert M.** *Robots step outside. Int. Symp. Adaptive Motion of Animals and Machines (AMAM), Ilmenau, Germany, pages 1–4, Sep 2005*
7. **Kovalchuk A. K.** *Sintez funktsij upravleniya hodboj dvunogogo shagayushhego robota pri pomoshi uprosshennoj matematicheskoy modeli // A. K. Kovalchuk, D. B. Kulakov, S. E. Semenov, V. O. Lomakin, Nauka i obrazovanie: Elektronnoe nauchno-tehnicheskoe izdanie. M., 2010. № 1*
8. **Loffler K., Gienger M., Pfeiffer F.** *Sensor and Control Design of a Dynamically Stable Bi-ped Robot // Robotics and Automation. 2003: Proceeding. ICRA apos; 03. IEEE International Conference. W.t. 2003. Vol. 1. Issue 14 -19. P. 484 - 490*
9. **Bab-Hadiashar A., Suter D.** *Robust optical flow computation. International Journal of Computer Vision, 29:59–77, 1998*
10. **Bruhn A., Weickert J., Schnorr C.** *Lucas/Kanade meets Horn/Schunck: Combining local and global optic flow methods. International Journal of Computer Vision, 61(3):211–231, 2005.*

Recommended for publication: 16.02.2017.

STUDY OF CARTOGRAPHIC PROJECTS FOR PAN-EUROPEAN REPRESENTATIONS

*Ana Vlasenco, univ. lecturer, PhD student
Technical University of Moldova*

INTRODUCTION

With the development of the European integration programs for the spatial information infrastructure INSPIRE (Infrastructure for Spatial Information in Europe) used in various fields, it has become necessary to use a unique and homogeneous reference system for the whole Europe. The International Association of Geodesy (IAG) constituted the EUREF Subcommittee which since 1987 has carried out a series of activities to develop the European Terrestrial Reference System 1989 (ETRS89) based on the International Terrestrial Reference System (ITRS) [13] and the European Vertical Reference System 2000 (EVRS2000). These systems have been recommended for their adoption by the European Commission for spatial planning of the integration and evaluation policy of the candidate and integrated countries of the European Union [1, 9].

In perspective of the integration of the Republic of Moldova into the European Union, besides the adoption of reference systems must be taken into consideration cartographic projections compatible with those used for pan-European applications. For this purpose, the directions of the Directive 2007/2 / EC of the European Parliament and of the Council on the interoperability of spatial data sets and services for implementation will be followed [2, 6].

In this article a study will be made on the main features of cartographic projections used in European countries as well some possibilities of representing the territory of the Republic of Moldova in the recommended projections.

1. PROJECTIONS RECOMMENDED BY THE EUROPEAN COMMISSION

In order to unify a European Geographic Information System (GIS) so that domestic products to be compatible with this system, some studies and possibilities have been carried out by the European

Commission that recommending the following systems [1]:

- for statistical analysis and display on the display - *Pan-European Reference and Coordinate System with ETRS89 Datum in Lambert Azimuthal Equal Area coordinate reference system of 2001* (ETRS89-LAEA);
- For the preparation of pan-European compliant maps at scales smaller than or equal to 1: 500 000 - *Pan-European Reference and Coordinating System with ETRS89 Datum in Lambert Conic Conformal coordinate reference system of 2001* (ETRS89-LCC);
- For the preparation of the maps at scales larger than 1: 500 000 - *Pan-European Reference and Coordinate System with ETRS89 Datum in the Transversal Mercator coordinate reference systems* (ETRS89-TMzn).

These projections are available in the field of INSPIRE transformation services in accordance with EN ISO 19111 [3].

2. EUROPEAN LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION

Azimuthal equal-area projections are usually used to represent regions with round surfaces where the condition of representation is to maintain undeformed areas. Following the position of the projection pole, the straight azimuthal equal-area projections are used for the representation of the polar zones, transversal ones for the equatorial zones, and the oblique ones for the regions at medium latitudes [8].

For the preparation of pan-European maps for statistical analysis and visualization it was proposed to use the Lambert oblique azimuthal equal-area (LAEA).

The LAEA projection parameters established for Europe are [4]:

- the ellipsoid: GRS80;

- the latitude of natural origin: $\varphi_0 = 52^{\circ}00'00''N$;
- the longitude of natural origin: $\lambda_0 = 10^{\circ}00'00''E$;
- False Northing of natural origin: $X_0 = 4\,321\,000$ m;
- False Easting of natural origin: $Y_0 = 3\,210\,000$ m.

The geographical limits for Europe are: on the longitude 25W-45E, and on the latitude 32N-72N. The LAEA projection pole is chosen at latitude 52° N and longitude 10° E (Figure 1).



Figure 1. Europe in the Lambert azimuthal equal-area projection.

In the LAEA projection we have distortions of distances and angles that can be determined based on relations [5]:

$$k = \left\{ 2 / [1 + \sin \varphi_0 \sin \varphi + \cos \varphi_0 \cos \varphi \cos(\lambda - \lambda_0)] \right\}^{1/2};$$

$$h = 1 / k;$$

$$\omega = 2 \arcsin \left[(k^2 - 1) / (1 + k^2) \right]$$
(1)

where k - the scale factor in the direction of the parallels, h - the scale factor in the meridian direction, ω - the angular deformation.

After calculations we will obtain the following values of the relative linear deformations (in the direction of the meridians and the parallels) and the angular deformations for the Republic of Moldova area, which are presented in Table 1.

The graphical distribution of linear deformations relative to the longitude of the natural origin of the projection $28^{\circ}30'$ is shown in the following figures.

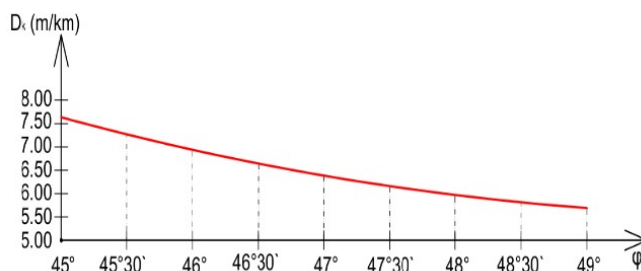


Figure 2. Relative linear deformations D_k (m/km) in the direction of the parallels ($\lambda = 28^{\circ}30'$) in the LAEA projection with the pole in the center of the Europe.

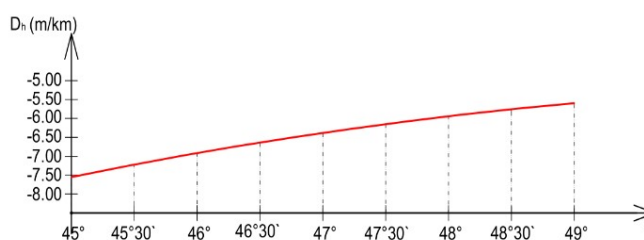


Figure 3. Relative linear deformations D_h (cm/km) in the direction of the meridians ($\lambda = 28^{\circ}30'$) in the LAEA projection with the pole in centre of the Europe.

Table 1. Relative linear and angular deformations in the Lambert azimuthal equal-area projection for the Republic of Moldova zone ($\varphi_0 = 52^{\circ}$ $\lambda_0 = 10^{\circ}$).

φ/λ ° ' "	27°			28°		
	D_k (cm/km)	D_h (cm/km)	ω ° ' "	D_k (cm/km)	D_h (cm/km)	ω ° ' "
45	6.685	-6.641	0.4548	7.269	-7.216	0.4947
45.30	6.381	-6.341	0.4344	6.959	-6.911	0.4740
46	6.097	-6.060	0.4147	6.669	-6.624	0.4541
46.30	5.831	-5.797	0.3958	6.393	-6.357	0.4350
47	5.584	-5.553	0.3817	6.145	-6.107	0.4207
47.30	5.537	-5.328	0.3644	5.912	-5.877	0.4031
48	5.149	-5.122	0.3518	5.698	-5.666	0.3903
48.30	4.959	-4.935	0.3400	5.503	-5.473	0.3743
49	4.789	-4.766	0.3250	5.327	-5.299	0.3631
φ/λ ° ' "	29°			30°		
	D_k (cm/km)	D_h (cm/km)	ω ° ' "	D_k (cm/km)	D_h (cm/km)	ω ° ' "
45	7.885	-7.823	0.5400	8.535	-8.463	0.5825
45.30	7.570	-7.513	0.5150	8.213	-8.146	0.5614
46	7.273	-7.221	0.4949	7.910	-7.848	0.5410
46.30	6.996	-6.947	0.4755	7.627	-7.569	0.5214
47	6.738	-6.693	0.4610	7.362	-7.308	0.5026
47.30	6.499	-6.457	0.4432	7.117	-7.067	0.4845
48	6.279	-6.239	0.4302	6.891	-6.843	0.4712
48.30	6.078	-6.041	0.4139	6.683	-6.639	0.4547
49	5.896	-5.861	0.4025	6.495	-6.453	0.4430

The graphical distribution of maximum angular deformations at the longitude of the natural origin of the projection 28°30' is shown in the following figure.

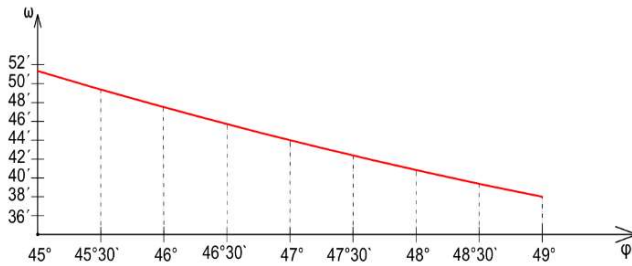


Figure 4. Maximum angular deformations ω (°) ($\lambda = 28^\circ 30'$) in the LAEA projection with the pole in the center of the Europe.

If we want to represent the territory of the Republic of Moldova in the Lambert azimuthal equal-area projection, we can use the following parameters:

- the ellipsoid: GRS80;
- the latitude of natural origin: $\phi_0 = 47^\circ 15' 00''N$;
- the longitude of natural origin: $\lambda_0 = 28^\circ 30' 00''E$;
- False Northing of natural origin: $X_0 = 500\,000$ m;
- False Easting of natural origin: $Y_0 = 500\,000$ m.

Table 2. The relative linear and angular deformations in the Lambert azimuthal equal-area projection for the Republic of Moldova ($\phi_0 = 47^\circ 15'$ $\lambda_0 = 28^\circ 30'$).

ϕ/λ°	27°			28°		
	D_k (m/km)	D_h (m/km)	ω °	D_k (m/km)	D_h (m/km)	ω °
45	0.233	-0.233	0.0136	0.197	-0.197	0.0122
45.30	0.157	-0.157	0.0105	0.121	-0.121	0.0049
46	0.100	-0.100	0.0041	0.064	-0.064	0.0026
46.30	0.061	-0.061	0.0028	0.026	-0.026	0.0011
47	0.042	-0.042	0.0017	0.007	-0.007	0.0003
47.30	0.042	-0.042	0.0017	0.007	-0.007	0.0003
48	0.060	-0.060	0.0025	0.026	-0.026	0.0011
48.30	0.098	-0.098	0.0041	0.064	-0.064	0.0026
49	0.155	-0.155	0.0104	0.121	-0.121	0.0049
ϕ/λ°	29°			30°		
	D_k (m/km)	D_h (m/km)	ω °	D_k (m/km)	D_h (m/km)	ω °
45	0.197	-0.197	0.0122	0.234	-0.234	0.0136
45.30	0.121	-0.121	0.0049	0.157	-0.157	0.0105
46	0.064	-0.064	0.0026	0.100	-0.100	0.0041
46.30	0.026	-0.026	0.0011	0.061	-0.061	0.0028
47	0.007	-0.007	0.0003	0.042	-0.042	0.0017
47.30	0.007	-0.007	0.0003	0.042	-0.042	0.0017
48	0.026	-0.026	0.0011	0.060	-0.060	0.0025
48.30	0.064	-0.064	0.0026	0.098	-0.098	0.0041
49	0.121	-0.121	0.0049	0.155	-0.155	0.0104

As a pole of projection, the geometric center of our country of latitude 47°15' and longitude 28°30' has been taken.

The graphical distribution of relative linear deformations and angular deformations at the longitude of the natural origin of the projection 28°30' are shown in the following figures.

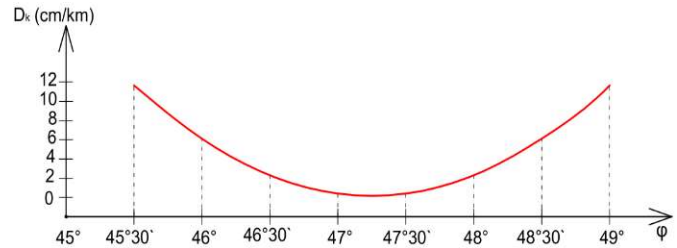


Figure 5. Relative linear deformations D_k (cm/km) in the direction of the parallel ($\lambda = 28^\circ 30'$) in the LAEA projection with the pole in the center of the Republic of Moldova.

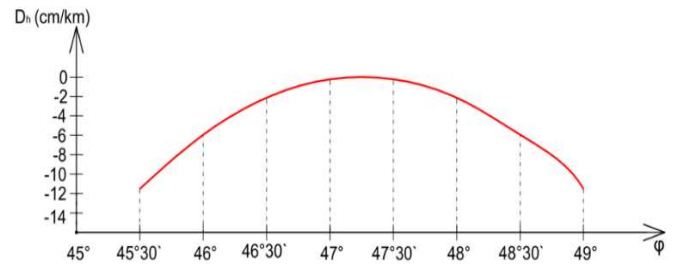


Figure 6. Relative linear deformations D_h (cm/km) in the meridian direction ($\lambda = 28^\circ 30'$) in the LAEA projection with the pole in the center of the Republic of Moldova.

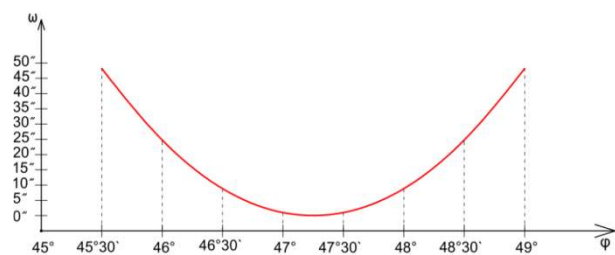


Figure 7. The maximum angular deformations ω (°) ($\lambda = 28^\circ 30'$) in the LAEA projection with the pole in the center of the Republic of Moldova.

Expressing the degree of deformation of the azimuthal equal-area projection through the ellipse of deformation (indicative of Tissot) on the territory of

the Republic of Moldova will have the following form presented in figure 8.

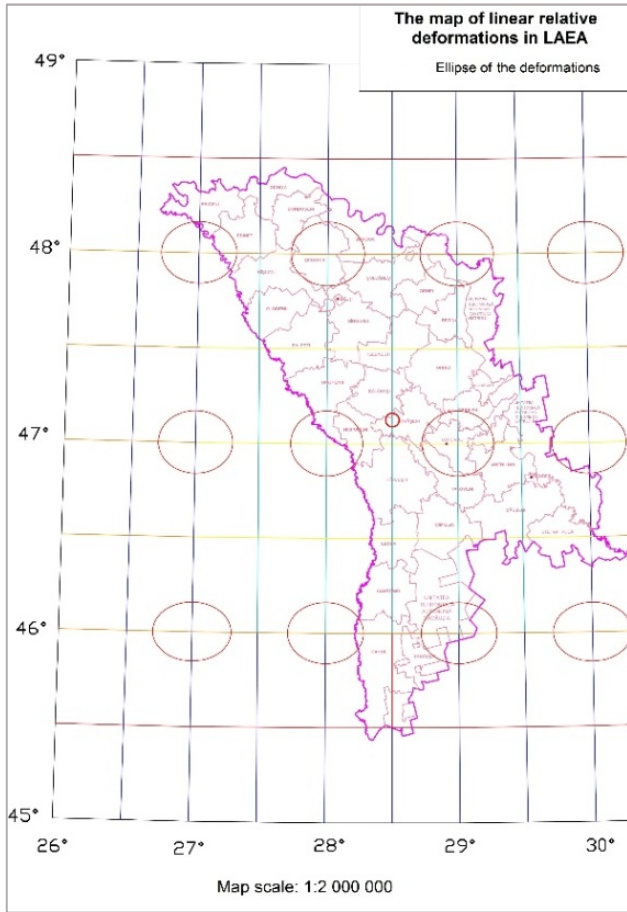


Figure 8. Ellipse of the deformations in the LAEA projection with the pole in the center of the Republic of Moldova.

This projection is advantageous in terms of deformations for the central area of the Republic of Moldova, since relative linear deformations are approximately ± 2 cm/km [15].

3. LAMBERT CONFORMAL CONIC PROJECTION

Straight conformal conic projections are typically used to represent territories at medium latitudes and where the largest axis is in the direction of the parallel. From the point of view of the deformations, in the plane of this projection we do not

have angular deformations, but the linear and areolar distortions depend only on the latitude [8].

The object of study refers to the representation of the ellipsoid on a secant cone after the secant parallel with known latitudes on the south φ_{kS} and the north φ_{kN} .

Lambert Conformal Conic Projection parameters for the Europe are [4]:

- the ellipsoid: GRS80;
- the latitude of natural origin: $\varphi_0 = 52^\circ 00' 00'' N$;
- the longitude of natural origin: $\lambda_0 = 10^\circ 00' 00'' E$;
- the latitude of the 1st standard parallel: $\varphi_{kS} = \varphi_1 = 35^\circ$;
- the latitude of the 2nd standard parallel: $\varphi_{kN} = \varphi_2 = 65^\circ$;
- False Northing of natural origin: $N_0 = 2\,800\,000$ m;
- False Easting of natural origin: $E_0 = 4\,000\,000$ m.



Figure 9. The Europe in Lambert Conformal Conic Projection

In the LCC projection, the angular deformations are null, as well as the deformations on the two secant parallels, and the linear and areolar ones are negative on the area located between the secant parallels and positive outside this zone [7].

A deformation study will be performed in this projection based on the linear deformation module (scale factor) [5,17]:

$$k = \frac{rn}{am} = m_1 t^n / (m t_1^n), \quad (2)$$

where:

$$m = \cos \varphi / (1 - e^2 \sin^2 \varphi)^{0.5}, \quad (3)$$

for m_1 is taken φ_1 and for m_2 respectively φ_2 , in which φ_1, φ_2 are the latitudes of the standard parallels, and a – semi-major axis of the ellipsoid.

$$t = \frac{\tan(\pi/4 - \varphi/2)}{[(1 - e \sin \varphi)/(1 + e \sin \varphi)]^{e/2}} \quad (4)$$

for t_1, t_2, t_0 și t it is used $\varphi_1, \varphi_2, \varphi_0$, and φ respectively.

$$r = aFt^n, \quad (5)$$

in which: $F = m_1 / (nt_1^n)$, (6)

$$n = (\ln m_1 - \ln m_2) / (\ln t_1 - \ln t_2), \quad (7)$$

To determine the relative linear deformations, being the same in the direction of the meridians as well as in the direction of the parallels (from the condition of conformity), as well as the relative areolar deformations, the relations [7, 16] will be used:

$$D = (k - 1) * 10^5 \text{ cm/km},$$

$$\text{or } D = (k - 1) * 10^3 \text{ m/km}, \quad (8)$$

$$P = (k^2 - 1) * 10^6 \text{ m}^2/\text{km}^2. \quad (9)$$

The values of these deformations for the geographic boundaries of Europe based on the use of the parameters set in the LCC projection will have the following variations shown in table 3.

Table 3. Relative linear deformations D and relative relational deformations P for Europe in the LCC projection ($\varphi_{KS} = 35^\circ$; $\varphi_{KN} = 65^\circ$).

φ	D (m/km)	P (m ² /km ²)
30°	24.816	50248.329
35°	0.000	0.000
40°	-18.076	-35825.421
45°	-29.549	-58224.790
50°	-34.275	-67374.771
55°	-31.751	-62493.897
60°	-20.954	-41469.163
65°	-0.000	-0.000
70°	34.620	70438.981
75°	90.021	188145.879

On the territory of the Republic of Moldova with the same parameters of Europe, the following values of the deformations presented in Table 4 will be produced.

Table 4. Relative linear deformations D and relative relational deformations P for the Republic of Moldova in LCC projection ($\varphi_{KS} = 35^\circ$; $\varphi_{KN} = 65^\circ$).

φ	D(m/km)	P(m ² /km ²)
45°	-29,549	-58224,789
45°30'	-30,330	-59740,640
46°	-31,044	-61124,470
46°30'	-31,690	-62375,891
47°	-32,268	-63494,422
47°30'	-32,777	-64479,473
48°	-33,217	-65330,362
48°30'	-33,587	-66046,295
49°	-33,887	-66626,370

The graphical distribution of relative linear deformations and relational relative deformations on the territory of the Republic of Moldova at the longitude of the natural origin of the LCC projection for Europe of $10^\circ 00'$ with the secant parallels at latitudes $\varphi_{KS} = 35^\circ$ and $\varphi_{KN} = 65^\circ$ are presented in the following figures below.

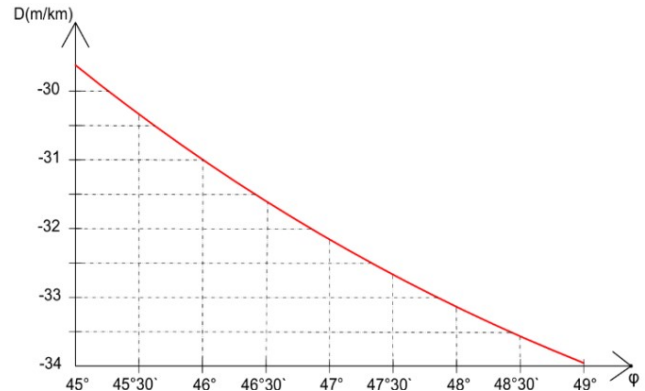


Figure 10. Relative linear deformations D (m/km) for the Republic of Moldova in the LCC projection ($\varphi_{KS} = 35^\circ$; $\varphi_{KN} = 65^\circ$)

The representation of the territory of the Republic of Moldova in the Lambert conformal conic projection can be performed by using the following parameters:

- the ellipsoid: GRS80;
- the latitude of natural origin: $\varphi_0 = 47^\circ 15' 00''\text{N}$;
- the longitude of natural origin: $\lambda_0 = 28^\circ 30' 00''\text{E}$;
- the latitude of the 1st standard parallel:
 $\varphi_{KS} = \varphi_1 = 46^\circ$;
- the latitude of the 2nd standard parallel:
 $\varphi_{KN} = \varphi_2 = 48^\circ$;

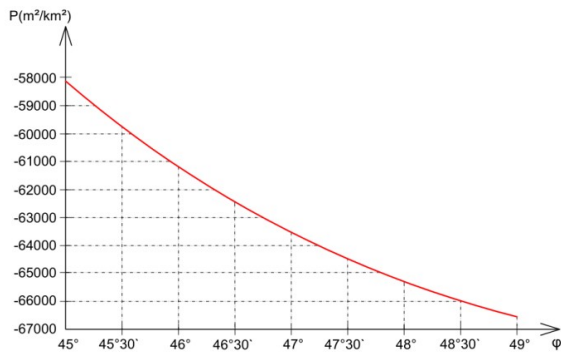


Figure 11. Relative areolar deformations P (m^2/km^2) for the Republic of Moldova in the LCC projection ($\varphi_{kS} = 35^\circ$; $\varphi_{kN} = 65^\circ$)

- False Northing of natural origin: $N_0 = 500\,000$ m;
- False Easting of natural origin: $E_0 = 500\,000$ m.

As a pole of projection, the geometric center of our country of latitude $47^\circ 15'$ and $28^\circ 30'$ longitude, and secant parallels with the latitudes $\varphi_{kS} = 46^\circ$ and respectively $\varphi_{kN} = 48^\circ$ has been taken.

If we determine the deformations according to these parameters established for the territory of our country we will obtain the situation presented in table 5.

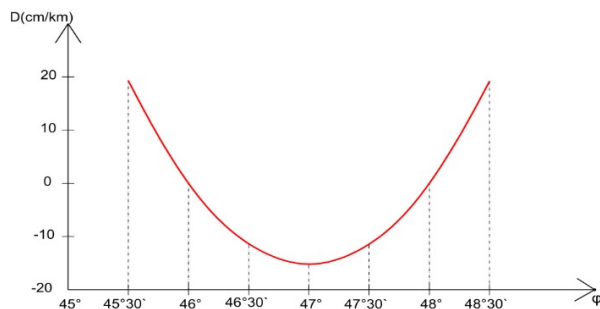


Figure 12. Relative linear deformations D (m/km) for the Republic of Moldova in the LCC projection ($\varphi_{kS} = 46^\circ$; $\varphi_{kN} = 48^\circ$).

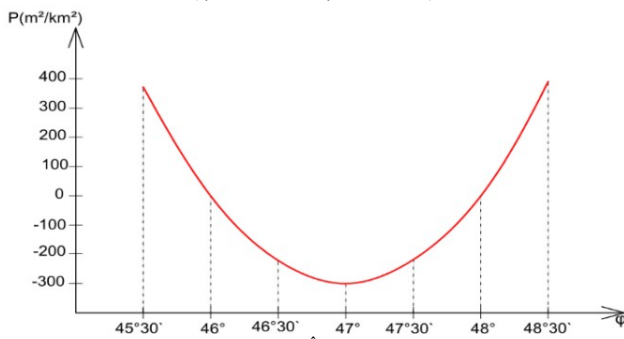


Figure 13. Relative relational deformations P (m^2/km^2) for the Republic of Moldova in the LCC projection ($\varphi_{kS} = 46^\circ$; $\varphi_{kN} = 48^\circ$).

Table 5. Relative linear deformations D and relative relational deformations P for the Republic of Moldova in LCC projection ($\varphi_{kS} = 46^\circ$; $\varphi_{kN} = 48^\circ$).

φ	D (cm/km)	P (m^2/km^2)
45°	45,012	900,452
$45^\circ 30'$	18,808	376,201
46°	0,000	0,000
$46^\circ 30'$	-11,352	-227,030
47°	-15,183	-303,644
$47^\circ 30'$	-11,424	-228,469
48°	0,000	0,000
$48^\circ 30'$	19,168	383,405
49°	46,166	923,530

Since the deformations are independent from the longitude and depend only on latitude, the isolines of the deformations coincide with the images of the parallels (Figure 14).

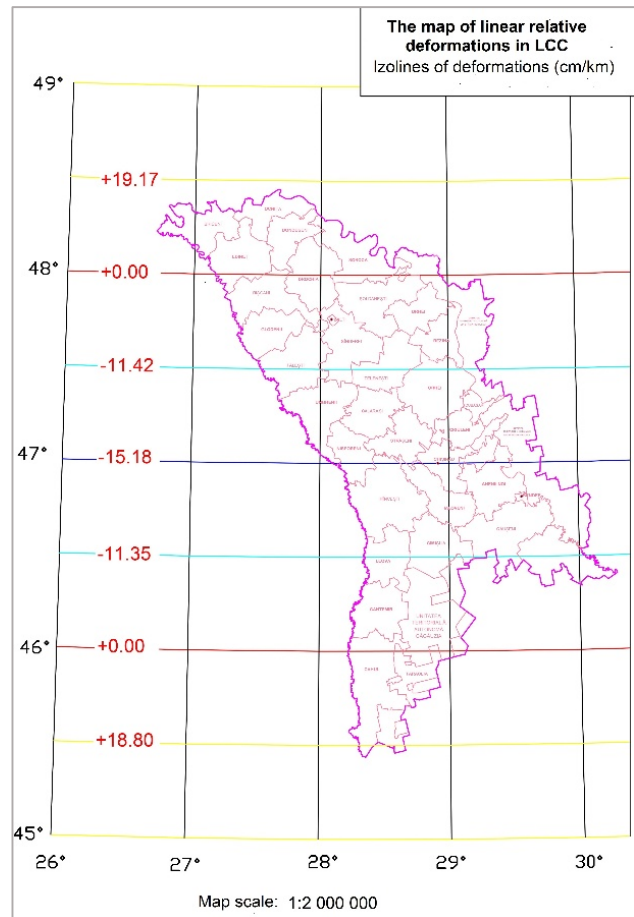


Figure 14. Isolines of the deformations on the territory of the Republic of Moldova in LCC projection ($\varphi_{kS} = 46^\circ$; $\varphi_{kN} = 48^\circ$).

4. THE EUROPEAN TRANSVERSAL MERCATOR PROJECTION

The European Transversal Mercator Projection (ETRS89-TMzn) is identical to the Universal Transversal Mercator (UTM) projection for the northern hemisphere, using the ETRS89 (GRS80 ellipsoid) geodetic data recommended by the European Commission for pan-European compliant maps at scales higher than 1:500 000, because for maps that have scales equal to or less than 1:500,000, the projection ETRS89-LCC [1, 4] is recommended.

The UTM projection is currently used in the Republic of Moldova for mapping on scales larger than 1:500,000, based on the WGS84 ellipsoid [10].

For the plane representation in the TMzn projection, the ellipsoid is divided into 60 zones of 6° longitude, numbered with Arabic numerals from 1 to 60, starting with the spindle 1, limited by 180° and -174° Western longitude, and in strips of 8° latitude from -80° S and up to + 84° N, written in letters of the Latin alphabet (Figure 15), except for the X band, that has a stretch of more than 4°, situated between the parallels of North 72° -84° [6, 11].

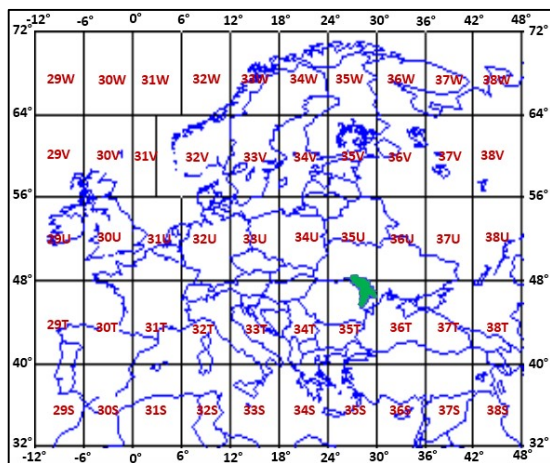


Figure 15. European zones in the ETRS89-TMzn (UTM) projection

Each zone has its own coordinate system: the ON axis is the image of the axial meridian with positive northward direction, and the OE axis is the equatorial image with positive eastward direction.

Most of the territory of the Republic of Moldova is located in the 35T and 35U zones with the axial longitudinal meridian 27°E (Figure 16).

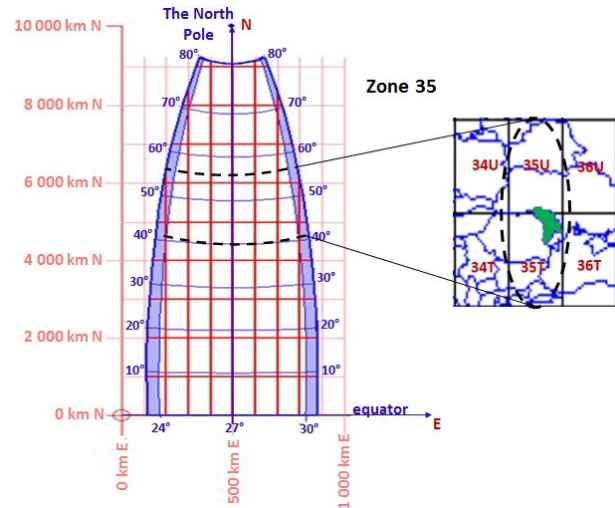


Figure 16. Zone 35 in the ETRS89-TMzn projection.

The plane rectangular coordinates N (x), E (y) of any point located in a particular spindle in the TMzn projection are determined based on the parameters of this projection, for example for the 35 zone the parameters are [12]:

- The ellipsoid: GRS80;
- The longitude of the axial meridian: $\lambda_0=27^\circ$;
- Scale factor: $k_0=0,9996$;
- false Easting: $E_0=500\ 000\ m$;
- false Northing: $N_0= 0\ m$.

From the point of view of the deformations, the TMzn (UTM) projection is a conformal one, so the angles are represented without deformations. In the projection plane there are two lines of symmetrical null deformations relative to the axial meridian in each zone where negative linear deformations occur and on the outside they are positive.

Next there will be presented the variation of deformations in the spindle 35 for the territory of the Republic of Moldova in the TMzn projection (TUM).

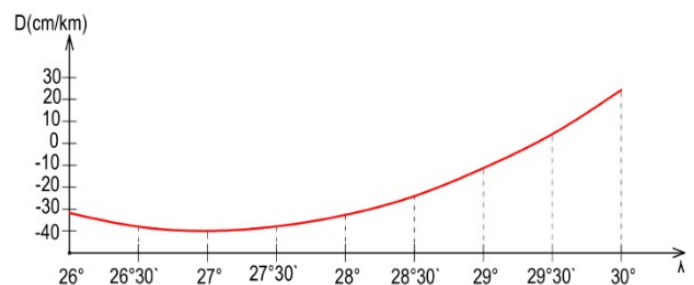


Figure 17. Relative linear deformations D (cm / km) at country average latitude = 47° in the ETRS89-TMzn projection (UTM)

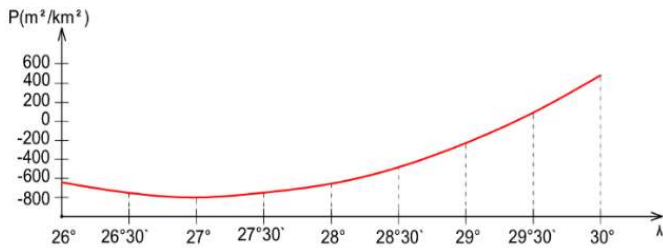


Figure 18. Relative areolar deformations P (m^2/km^2) at country average latitude = 47° in the ETRS89-TMzn projection (UTM)

With the presented information available, a map of the deformation isolines is presented for the whole territory of the Republic of Moldova in which are represented by means of color scales, the values of the relative linear deformations in the UTM projection.

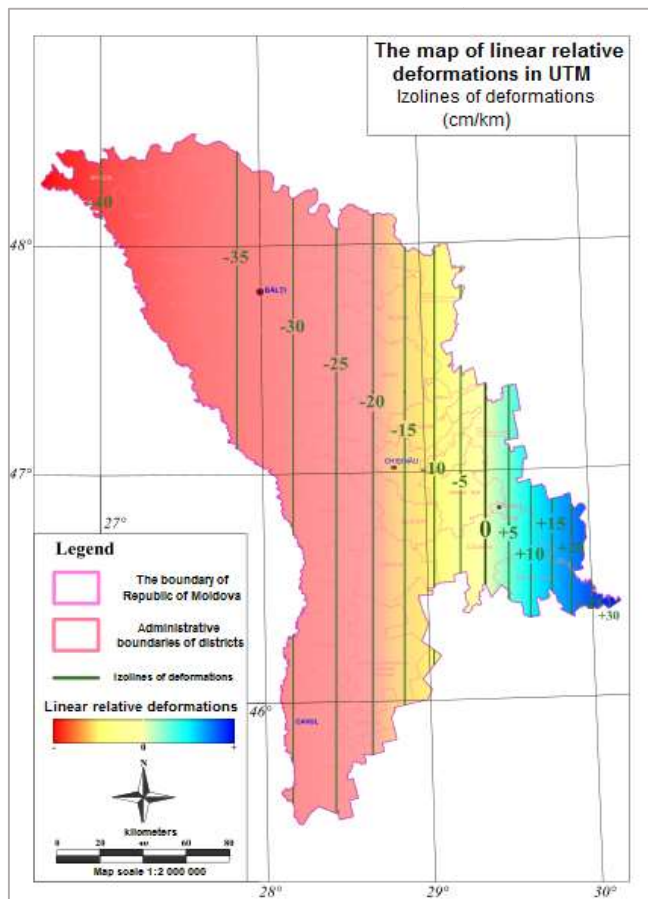


Figure 19. Isolines of deformations on the territory of the Republic of Moldova in the UTM projection.

5. CONCLUSIONS

Using the International Association of Geodesy (IAG) recommendations on the use of European projections in view of the accession of the Republic of Moldova to the European Community in this article was studied the real possibilities of their application in our country.

Following the study of the European Lambert Azimuthal Equal Area projection (ETRS89-LAEA) for statistical analysis and visualization, it was found that:

- When the projection pole is taken in the center of Europe, deformations increase with the distance from the pole, and for our country the relative linear deformations to the direction of the parallels range from $+4.78 \text{ m / km}$ to $+8.53 \text{ m / km}$, and in the direction of the meridians from -8.46 m / km to -4.76 m / km . Maximum angular deformations vary between $[0^\circ 32' \div 0^\circ 44']$;

- When the projection pole is taken in the center of the Republic of Moldova, the deformations increase with the deviation from the pole where the deformations are null and the relative linear deformations vary up to $\pm 12 \text{ cm / km}$ (lower compared to the Transversal Mercator projection for Moldova [14]). Maximum angular deformations are in the range $[0^\circ 00' 00'' \div 0^\circ 00' 50'']$.

Following the study of Lambert Conformal Conic projection (ETRS89-LCC) designed to draw pan-European maps at scales smaller or equal than 1: 500,000, it was found that:

- When the projection pole is taken in the center of Europe, and the standard parallels $\varphi_{KS} = 35^\circ$; $\varphi_{KN} = 65^\circ$, on the territory of our country there are negative linear distortions from -33.59 m/km in the north, to -30.20 m/km in the southern part of the territory. Relative areolar deformations vary from $-66046 \text{ m}^2/\text{km}^2$ to $-59488 \text{ m}^2/\text{km}^2$.

- When the projection pole is taken in the center of the Republic of Moldova, and the secant parallels on the territory of our country $\varphi_{KS} = 46^\circ$; $\varphi_{KN} = 48^\circ$, the deformations decrease greatly (approximately 20 times), so the linear deformations range from -15.18 cm/km to 19.17 cm/km and the areolar from $-303.64 \text{ m}^2/\text{km}^2$ to $+383.40 \text{ m}^2/\text{km}^2$.

Following the study of the European Transversal Mercator Projection (ETRS89-TMzn) which is identical to the Universal Transversal Mercator (UTM) projection recommended by the European

Commission for pan-European compliant maps at scales higher than 1: 500,000, it was found that:

– The zero strain lines cross the country's territory approximately at 180 km symmetrically to the axial meridian;

– The relative linear deformations have negative and positive values ranging between -40 cm/km on the axial meridian and +32 cm/km in the eastern part of the country;

– The relative areolar deformations have negative and positive values ranging from -800 m²/km² on the axial meridian and +650 m²/km² in the eastern part of the country.

Bibliography

1. *** Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).
2. *** Legea cu nr. 254 cu privire la infrastructura național de date spațiale. Adoptată de către Parlamentul Republicii Moldova pe data de 17 Noiembrie 2016.
3. *** International standard ISO 19111 Geographic information - Spatial referencing by coordinates. Second edition 2007-07-01.
4. **Annoni A., Luzet C., Gubler E., Ihde J.** Map projections for Europe. European Communities. Italy, 2003, 132 p.
5. **Snyder J. P.** Map Projections An Working Manual. US Government Printing Office Chicago, 1987, 412 p.
6. **Vasilca D., Ilieș A.** Posibile consecințe în domeniul cartografiei în cazul itegrării României în Uniunea Europeană. În: Revista de geodezie, cartografie și cadastru. Volumul 14, Nr. 1-2. București, 2005, pp. 382-395.
7. **Vlasenco A., Chiriac V.** Cartografie matematică. Curs universitar. Editura: U.T.M, 2012, 256 p. ISBN 978-9975-45-206-9.
8. **Munteanu C.** Cartografie matematică. Matrix Rom, 2003, 214 p. ISBN 973-685-599.
9. *** Directiva nr. 2007/2/CE a Parlamentului European și a Consiliului din 14 martie 2007 de instituire a unei infrastructuri pentru informații spațiale în Comunitatea Europeană (INSPIRE), publicată în Jurnalul Oficial al Uniunii Europene L108 din 25 aprilie 2007.
10. *** Regulamentul cu privire la trecere la sistemele de coordonate global și de referință și proiecțiile cartografice respective. Aprobate de Agenția de Stat, Relații Funciare și Cadastru (ASRFC), și pus în aplicare prin ordinul nr. 185 din 10 iulie 2001.
11. *** Atlas Florae European. New grid system. UTM (Universal Transverse Mercator) and Military Grid Reference System (MGRS). Available: <https://www.luomus.fi/en/utm-mgrs-atlas-florae-europaeae>.
12. **Moca V., Chirilă C.** Cartografia matematică întocmire și redactare hărți, Editura: U. T. GH. ASACHI, Iași, 2002, 130 p.
13. **Nistor I., Sălceanu Gh.** Considerations concerning the implementation of european geodetic datum ETRS 89 in Romania. In: Buletinul Institutului Politehnic Iași, Tom LII (LVI), fasc. 1-4, secțiunea Hidrotehnică, 2006, pp. 81-92.
14. **Chiriac V., Vlasenco A.** The comparative analysis of map projections for the Republic of Moldova territory. Modern achievements of geodesic science and industry Issue II (32), Lvov 2016, pp.129-132., UDC 528.92.
15. **Vlasenco A.** Necesitatea implementării unor proiecții cartografice în Republica Moldova. Conferință tehnico-științifică internațională „Probleme actuale ale urbanismului și amenajării teritoriului”. Chișinău, 17-19 noiembrie 2016, pp. 136-141. ISBN 978-9975-71-848-6.
16. *** Geomatics Guidance Note number 7, part 2, September 2016, 147 p.

Recommended for publication: 21.03.2017.

SOME ASPECTS OF INCREASING WIND TURBINE CONVERSION EFFICIENCY

¹Valeriu Dulgheru, Dr.Sc.prof., ²Catalin Dumitrescu, dr.ing, ²Radu Radoi, dr. ing.

¹Technical University of Moldova

²Hydraulics and Pneumatics Research Institute INOE 2000-IHP Bucharest, Romania

”First, there is the power wind, constantly exerted over the globe... Here is an almost incalculable power at our disposal, yet how trifling the use we make of it”

(Henry David Thoreau)

1. INTRODUCTION

Wind energy has been used by mankind over thousands of years. For over 3000 years the windmills have been used for pumping water or grinding (milling). Nowadays, in the century of information technologies, nuclear energy and electricity, thousands of windmills are used for pumping water and oil, for irrigation and production of mechanical energy to drive low-power mechanisms on different continents.

With the launch of the European Technology Platform on wind energy issues the EU Commissioner A. Piebalgs said [1]: *“Wind energy technology is certainly one of the fastest growing and plays an important role, contributing to create a sustainable and competitive energy policy in Europe”*. Nowadays, the phrase *“use of wind*

energy” means, primarily, non-pollutant electrical energy produced at a significant scale by modern *“windmills”* called *“wind turbines”*, a term that attempts to outline their similarity to steam or gas turbines, which are used for producing electricity, and also to make a distinction between their old and new destination. If in 1973 the main incentive for the development of WECS was the oil price, today another incentive is added - the tendency of mankind to produce *“clean”* or *“green”* electricity with little or no carbon monoxide emissions. The year 1993 was marked as the beginning of a wind boom characterized by an annual increase of over 20% of installed power capacity. Thus, in 1999 the global capacity increased by 4033 MW, which was a record for the wind energy sector [2]. In the period 1996-2016 the global wind power cumulative capacity has increased about 80 times

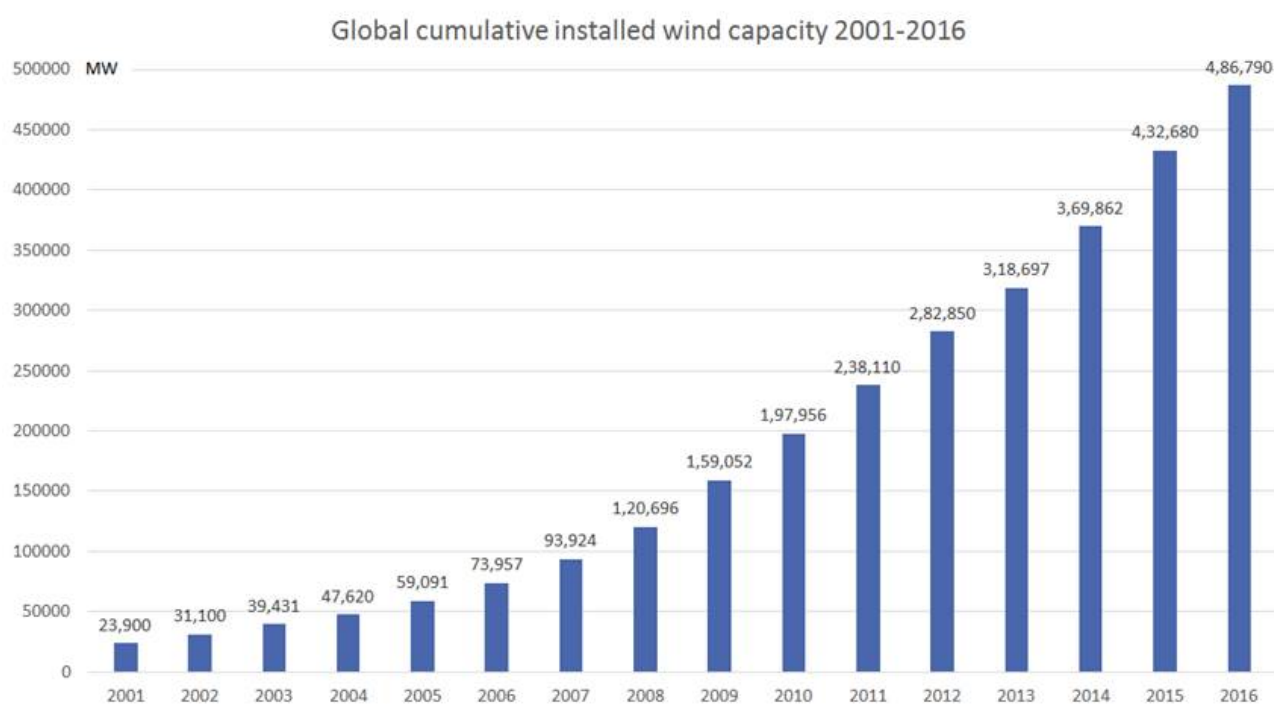


Figure 1. Global Wind Power Cumulative Capacity (Data: GWEC) [1].

and has reached 486,8 GW in 2016, up 12% from 2015 (Figure 1) [3].

The undisputed global leader is the European Community EU-27 with a 65% share, followed by the China and USA. 2015 was a record year for wind energy generation in the U.K, according to National Grid. National Grid's statistics show that 11 percent of the U.K.'s electricity was generated by onshore and offshore wind; last year – up to 9.5 percent in 2014. The newly installed turbines brought the country's total wind capacity to 13,602.5 MW and the U.K. has an installed onshore wind energy capacity of 8.5 GW and offshore wind energy capacity of 5.1 GW, onshore wind capacity built in the past year was down from 1.1 GW [4]. Germany and India continued to be the most important actors. Also, Brazil has achieved the highest growth rates in all major markets. Africa, Asia and Latin America will become the market leaders of the next decade [4].

Very important result in the field was obtained by some small countries. In July, 2017 Wind power production in Lithuania soared by 40 percent in the first half of 2017 year-on-year to 633 gigawatt-hours (GWh), accounting for half of the country's total electricity output during the six months [5].

Such a spectacular development knows no other global industry sector worldwide. In the years 2007-2010 an annual growth over 21% was expected. In fact, annual growth was of 35% on average. For 2010 the global installed capacity should have reached 160,000 MW. In fact, the total value of 197,000 MW has been reached, with more than 25% over the initial estimates. Germany connected 626 MW of newly built offshore wind capacity to power grids in the first six months of this year and expects to see total installation of 900 MW in the full year [6].

Global wind power installations will nearly double in the next five years as prices continue to fall and countries develop renewable energy to comply with emissions reduction targets, according to research published in Global Wind Energy Council (GWEC) flagship publication.

GWEC secretary-general Steve Sawyer said: *“Wind power led all technologies in new power generation in 2015. Led by wind, renewables have come of age and are transforming the power sector”*.

The global wind revolution was led by the Chinese industry, which installed 30.8 GW of new capacity and increased its cumulative capacity to 145 GW. Europe had a strong year thanks to Germany's record-setting 6 GW of installations, while the US ended the year with a *“surprisingly high”* 8.6 GW market.

The wind power industry is moving away from an era of costly subsidies and is trying to become more commercially viable and to bring down costs for consumers. The industry groups said that latest bids by companies to build and run turbines at zero subsidy costs in the next decade offered encouragement and reason to expand. *“This paradigm shift offers the next government chances to lift expansion targets to at least 20 gigawatts (20,000 MW) up to 2030 and at least 30 GW to 2035, utilizing the economic and industrial political potential of offshore wind,”* said the president of *HelWin-Cluster* located in Germany [6].

2. INCREASING POWER AND CONVERSION EFFICIENCY OF THE MEGA-WIND TURBINE

These major results have been achieved largely due to the optimization in terms of conversion efficiency in mega-wind turbines, the increase in power of a mega-wind turbine, and the reliability of the basic element of a mega-wind turbine – the blade. New research on the dynamic response of the blade in the turbulence phases opens up great prospects for the development of very powerful wind turbines. Currently wind turbines with a power in the range 1.1-2.5 MW are used to form wind farms. But the current solid trend is to increase the power of a wind turbine. Thus, the American company VESTAS switched to the production of wind turbines of 3.3 MW (from 2 MW) turbine installed power [7]. The German company Siemens has assimilated series production of optimized lightweight turbines of 3.3 MW for low wind speeds. Currently, turbines with a power of 5 - 6 MW are the most used. The British company "DONG Energy Gunfleet Sands" has announced that it installs two turbines of 6 MW each, produced by Siemens [8].

Lately, several daring projects have emerged aiming to overcome this power limit for a wind turbine. Thus the American company "Winter Wind Propels Texas" has reached a new record of 9.481 MW for a turbine [9]. Siemens will be supplying wind turbines for a 16-MW wind farm owned by the clean energy firm BayWare GmbH in Sweden [10].

An absolute world record seems to be attained by Danish researchers. Following five years of research at the joint European project UpWind, led by Risø National Laboratory for Sustainable Energy, the Technical University of Denmark (Risø DTU), scientists have now presented the first design

basis for developing mega wind turbines of 20 MW [10]. The researchers focused on the main components in wind turbines to find answers to two fundamental questions: Is it technically possible to build a 20 megawatt wind turbine? Is it economically feasible to build it? An intelligent wind turbine blade is one of the solutions. Risø DTU and DTU Mechanical Engineering have significantly contributed in the development of aeroelastic design methods for wind turbines of up to 20 MW. Aeroelastic methods are used to calculate the wind turbine's dynamic response to turbulence in the wind. In the UpWind project, Risø DTU and DTU Mechanical Engineering studied aeroelastic methods, materials, management and regulation and many other technologies to be developed for designing a 20 MW wind turbine [10]. "We have worked on developing several different types of sensor systems such as pitot tubes which are also used to measure the wind speed of aircrafts. Should we introduce these innovations to existing wind turbines, they would probably be more expensive, but if they are implemented on very large turbines the savings from load reductions probably would be competitive. Our conclusion is that upscaling opens up for new technologies", says Peter Hjulær Jensen, researcher from Denmark Technical University [10].

It is noticed that the blade becomes an important object to be studied in the plan to increase the power of a turbine. In the same context, the authors come up with an original idea to increase the wind turbine power by installing the blade at a certain downstream angle in the rotor hub (Figure 2) [11].

The wind turbine with horizontal axis comprise a tower (4), on which are installed a rotor (2) with three aerodynamic blades (1), located on the hub of the rotor (2) at an angle θ relative to the vertical plane of the rotor (2), the value of which is determined by the formula:

$$\theta = 2\arcsin \frac{y_{max}}{D} = 2\arcsin \frac{F_{max} \left(\frac{D}{2}\right)^3}{D^3 E I_y} = \arcsin \frac{F_{max} D^2}{12 E I_y}, \quad (1)$$

where: y_{max} is the amplitude of displacement of the blade tip; D - rotor diameter; F_{max} - maximum deflecting force; E - modulus of elasticity of blade material; I_y - the moment of inertia relative to the axis of symmetry of the blade's aerodynamic profile. The distance from the vertical plane of rotation of the blades 1 to the outer surface of the tower 4 is minimal.

The horizontal axis wind turbine operates in the following manner: the action of the wind currents on the aerodynamic profile blades 1 generates the aerodynamic effect, which drives the blades 1 in rotation motion transmitted to the rotor 2. If the blades 1 are located perpendicular to the rotor shaft 2 at the distance A (Figure 2) from the vertical plane of rotation of the blades 1 to the outer surface of the tower 4, at low wind speeds, the blade 1 is practically unwarped, and the rotatable area of the rotor 2 is determined according to the formula:

$$A = \frac{\pi D_0^2}{4}, \quad (2)$$

And the generated power is determined according to the formula:

$$P_0 = \frac{1}{2} k \rho V^3 A_0, \quad (3)$$

Where: k is conversion efficiency; ρ - air density; V - air speed; D_0 - wind rotor diameter.

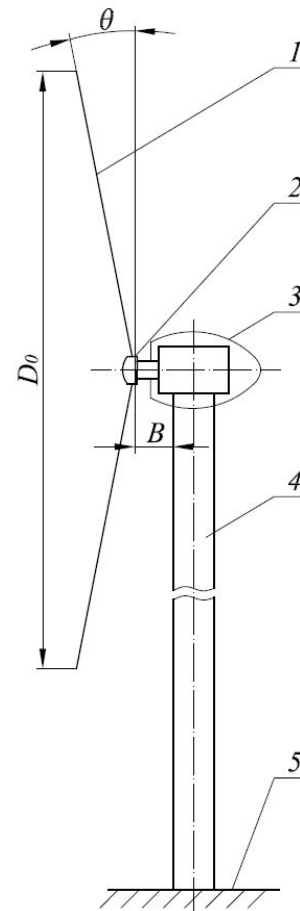


Figure 2. Wind rotor with vertical installed blades [11].

At high wind speeds, the blade 1 warps (Figure 3, b) at the distance a from the tip of the blade 1 to the

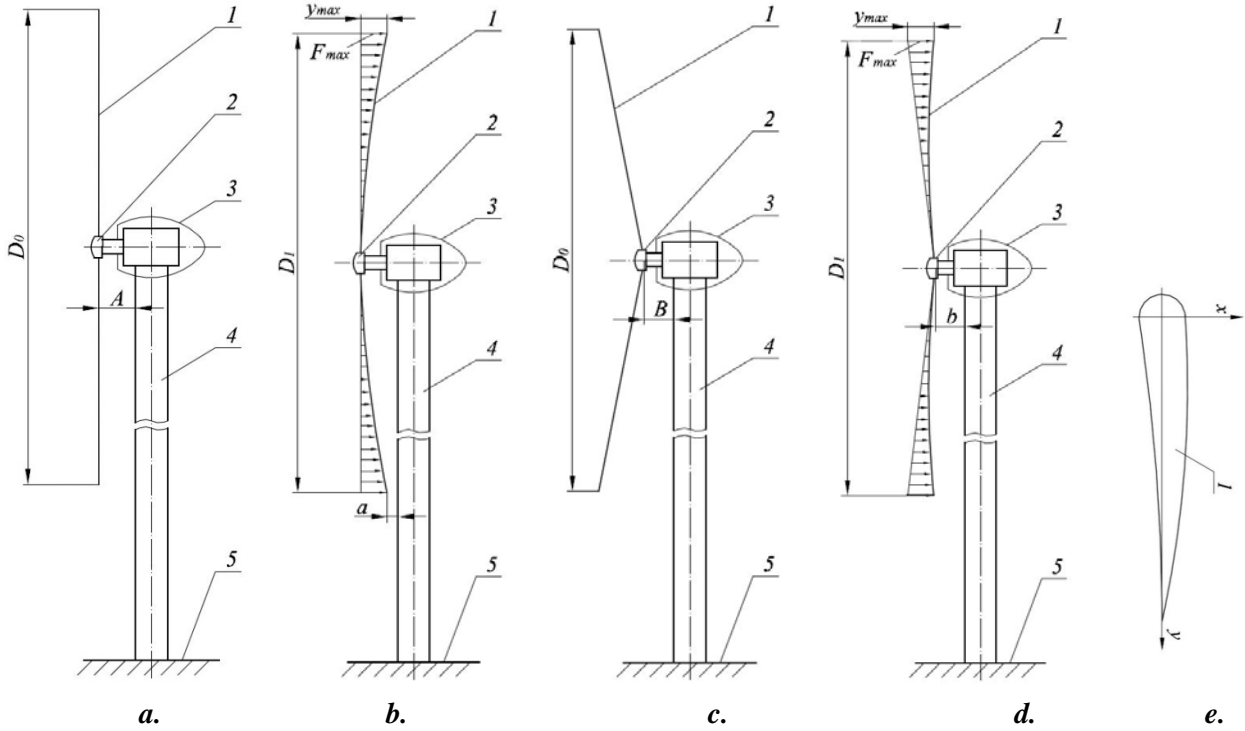


Figure 3. Calculus diagrams for a blade installed with no downstream bending angle (a, b) and with downstream bending at the angle θ (c, d); the coordinates of the blade in normal section (e).

outer surface of the tower 4, its tip moving as indicated by the arrow y_{max} , which is determined according to the formula:

$$y_{max} = \frac{F_{max} \left(\frac{D_0}{2} \right)^3}{3EI_y}, \quad (4)$$

where: F_{max} is maximum bending force generated by wind currents acting on the blade 1; D_0 - wind rotor diameter; E - elastic modulus, first degree, of the blade 1 material; I_y - moment of inertia of the blade 1 section against the axis "y" (Figure 3,e).

The rotatable area of the rotor 2 is determined according to the formula:

$$A_1 = \frac{\pi D_1^2}{4}, \quad (5)$$

Where $D_1 = D_0 \cos \theta$, and $\theta = 2 \arcsin \frac{y_{max}}{D_0}$.

The generated power is determined according to the formula:

$$P_1 = \frac{1}{2} k p V^3 A_1. \quad (6)$$

If the blades 1 are located at an angle θ downstream of the vertical plane of the rotor 2 at the distance B from the vertical rotation plane of the blades 1 to the outer surface of the tower 4, at low wind speeds, the blade 1 is practically unwarped

(Figure 3, c), and the rotatable area of the rotor 2 is determined according to the formula:

$$A_0 = \frac{\pi D_1^2}{4} = \frac{\pi (D_0 \cos \theta)^2}{4}, \quad (7)$$

In this case converted energy is determined according to the formula (3).

At high wind speeds, the blade 1 warps (Figure 3, d) at the distance b from the tip of the blade 1 to the outer surface of the tower 4, its tip moving as indicated by the arrow y_{max} , which is determined according to the formula:

$$y_{max} = \frac{F_{max} \left(\frac{D_1}{2} \right)^3}{3EI_y}, \quad (8)$$

The rotatable area of the rotor 2 is determined according to the formula:

$$A_1 = \frac{\pi D_0^2}{4}. \quad (9)$$

Converted energy is determined according to the formula (6).

Thus, when bending the blade tip at an angle below 7° the rotor diameter will decrease by approx. 2%, and consequently, the converted wind power will also decrease by 2% (in the calculus formula, the power is directly proportional to the rotatable area of the rotor), which for an installed turbine power of 5 kW represents approx. 100 kW.

CONCLUSIONS

The comparative analysis of the two examples demonstrates that, when installing the blades 1 at the angle θ downstream of the vertical plane of the rotor 2, at high wind speeds (when the energy potential is high) the blade 1, by warping, gets in a position close to the vertical one, thus enlarging the rotatable area, therefore also the amount of converted energy.

By placing the blades 1 on the hub of the rotor 2 at the angle θ , once warped under the action of wind currents at high wind speeds, the blades 1 will get in a position close to the vertical one. Therefore, in order to avoid collision between the blades 1 and the tower 4, the plane for installing the blades 1 in the hub is closer to the outer surface of the turbine tower 4 ($B < A$), which results in reduced bending moment generated by the forces acting on the blades 1 at high wind speeds. This in turn ensures lower stress on the mobile elements that connect the wind rotor 2 and the nacelle 3 to the tower 4. There also occurs a reduction in the forces acting on the bolts that fasten the tower 4 to the basement 5.

ACKNOWLEDGEMENTS

This paper has been developed in INOE 2000-IHP, as part of a project co-financed by the European Union through the European Regional Development Fund, under Competitiveness Operational Programme 2014-2020, Priority Axis 1: Research, technological development and innovation (RD&I) to support economic competitiveness and business development, Action 1.1.4 - Attracting high-level personnel from abroad in order to enhance the RD capacity, project title: Establishing a high level proficiency nucleus in the field of increasing renewable energy conversion efficiency and energy independence by using combined resources, project acronym: CONVENER, Financial agreement no. 37/02.09.2016.

Bibliography

1. **Piebalgs Andris.** *Wind Energy for Future.* "Mesagerul Energetic" journal, no. 66, April 2007, p. 14-16.
2. **Bostan I., Gheorghe A., Dulgheru V., Sobor I., Bostan V., Sochirean A.** *Resilient Energy Systems. Renewables: Wind, Solar, Hydro.* - Springer, VIII, 2013. - 507 p. - ISBN 978-94-007-4188-1

3. https://en.wikipedia.org/wiki/File:Global_Wind_Power_Cumulative_Capacity.svg. Accessed: 22.07.2017.
4. <https://www.linkedin.com/pulse/2016-outlook-wind-energy-industry-vural-cantug-akkas> Accessed: 22.07.2017.
5. <http://en.delfi.lt/lithuania/energy/wind-power-accounts-for-half-of-lithuanias-h1-electricity-output.d?id=75251809> Accessed: 22.07.2017.
6. <https://www.talkvietnam.com/2017/07/germany-expects-900-mw-of-new-offshore-wind-in-2017/> Accessed: 22.07.2017.
7. <https://cleantechnica.com/2015/11/24/vestas-receives-200-mw-order-new-3-3-mw-wind-turbine/>
8. <https://www.evwind.es/2015/03/03/siemens-to-provide-wind-turbines-for-16-mw-sweden-wind-power-plant/50757>
9. <http://www.governorswindenergycoalition.org/?p=481>. Accessed: 22.07.2017.
10. <https://www.sciencedaily.com/releases/2011/04/110415083320.htm> Accessed: 22.07.2017.
11. **Bostan V., Bostan I., Dulgheru V., Dumitrescu C., Ciobanu O., Ciobanu R., Guțu M.** *Brevet nr. 4487 (MD). Turbină eoliană cu ax orizontal.* 31.05.2017.

Recommended for publication: 18.05.2017.

RESPIRATION OF UNSHELLED WALNUTS (*JUGLANS REGIA L.*) AND WALNUT KERNEL

Eugenia Boaghi, PhD student
Technical University of Moldova

INTRODUCION

During postharvest handling and storage, fresh walnuts lose their quality via the respiration process. Walnut deterioration, such as lipid oxidation or impaired flavor, may result if the respiration rate is high. In order to minimize losses due to respiration, and thereby increase both market quality and shelf life, walnuts must be stored in a low temperature and low (70%) humidity environment. In this experiment the respiratory rates of nuts in English walnut (*Juglans regia L.*) were studied.

1. WALNUT QUALITY CHANGES DURING STORAGE

Worldwide walnuts are recommended as a constituent of balanced human nutrition. In Moldova, walnuts have been and continue to be a valuable agricultural product. Moldova is favorably positioned from a geographical point of view, on both climatic and pedological conditions for the cultivation of nuts [1], being among the top ten kernel and unshelled walnut producers in the world [2], The volume of production reaching about 30 thousand tons per year [3].

Storage of fresh harvested walnut for a certain period of time - is one of the most important processes [4]. The evolution of the chemical compounds of the walnut kernel is carried out in several ways, but the basic direction is breathing, which in fact presents a range of biochemical oxidation - reduction reactions.

It is obvious that the rate or intensity of respiration depends on the chemical composition of the walnut kernel, the degree of maturation and other external factors such as temperature, oxygen concentration in the air, etc [5-6]. Breathing is one of the oxido-reduction processes that can lead to the oxidative degradation of walnut lipids, respectively their qualitative degradation. It has been demonstrated [4] that under certain conditions the respiration intensity of walnuts is relatively slow.

For this reason, the purpose of this study was to investigate the intensity of walnuts respiration, as well as its dependence on the morphological state of stored fruits (nuts in shell or kernel) and on the temperature of the storage medium.

2. MATERIALS AND METHODS

During the research, walnuts of Calarasi variety from the harvest of 2014 were used.

To assess the intensity of respiration, as well as the influence of temperature on it, were used both nuts in shell and kernel.

To assess the influence of temperature on the respiration intensity of unshelled walnuts and kernel, they were kept under four temperature regimes: $6\pm 2^{\circ}\text{C}$, $18\pm 2^{\circ}\text{C}$, $30\pm 2^{\circ}\text{C}$ and $50\pm 2^{\circ}\text{C}$. The respiration intensity of breathing was determined by the confined atmosphere process as recommended by Boysen -Jensen [7]. The CO₂ capture method removed from the product with alkaline solution is the most perfect and most commonly used in scientific work.

3. RESULTS

Respiration is affected by a number of environmental factors such as light, temperature, chemical stress, pathogen attack, the action of radiation, the action of humidity, etc. The most important post-harvesting factors are temperature, atmospheric composition and physiological state.

The process of respiration of the fruit is relatively large topic discussed in the scientific literature and specialist, but the studies on *Juglans Regia* nuts are very limited [8-10], and on the nuts grown in Moldova are totally lacking. The evolution of breathing intensity of fresh nuts (directly after harvesting) kept at 20° C was monitored for 60 days from storage.

Initial respiration intensity of the walnuts is quite high, but falls sharply in the first 15 days of storage. In the following period, the respiration rate

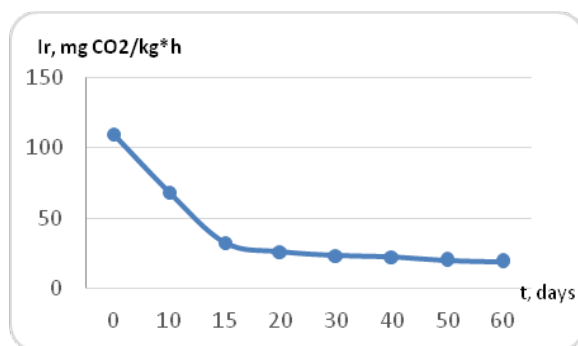


Figure 1. Evolution of respiration intensity of fresh harvested walnuts.

continues to decrease at a much lower rate. This decrease is likely (at least in part) related to the reduction in walnut moisture from 20% for fresh walnuts to 12% after 15 days and 8% - towards the end of storage.

In order to identify the impact of the ambient temperature and the walnuts morphological state on the respiration process, the respiration intensity of unshelled nuts (dried up to $W = 8\%$) and of the walnut kernel at different temperatures was studied. The results obtained are shown in Table 1 and Figures 2 and 3.

Table 1. Respiration intensity of unshelled nuts and kernel at different temperatures, mgCO₂/kg*h.

Product	Temperature, °C				
	4±2	16±2	30±2	50±2	60±2
Unshelled walnuts	4,55	6,37	17,6	15,25	13,2
Walnut kernel	5,41	7,3	22	19,8	15,32

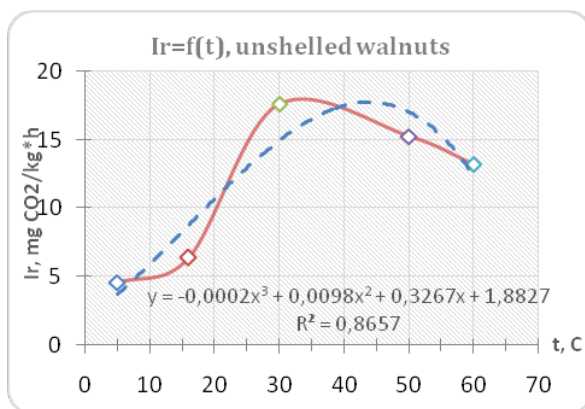


Figure 2. Dependence of the unshelled walnut respiration intensity of the ambient temperature.

The obtained data reflects the respiration intensity of walnuts in the shell. Maximum values of this indicator were obtained by storing walnuts at 30 ° C (17.6 mg CO₂ / kg * h), after $t > 40^{\circ}\text{C}$ the intensity of walnuts tends to decrease.

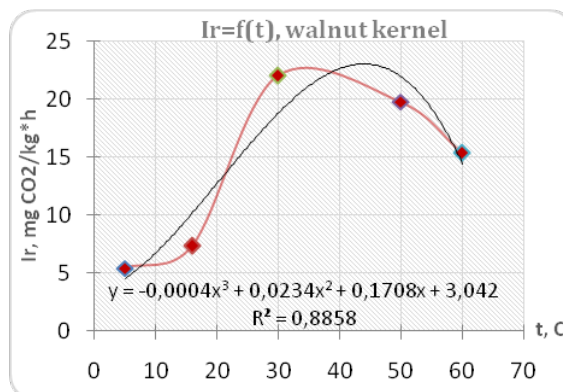


Figure 3. Dependence of the walnut kernel respiration intensity of the ambient temperature.

It has been found that the respiration intensity of the walnut kernel is greater than that of the nut in the shell. From the figures and equations presented we deduce that the respiration rate of walnuts and nuts depends largely on the temperature of their storage. Respiration intensity in both cases increases slowly with increasing temperature from 4 to 20°C, then suddenly rises to the maximum value at temperatures of about 30-40°C, followed by a decrease in respiration intensity at higher temperatures. It is worth mentioning that the respiration of the kernel is greater than the walnuts in shell, the shell serving as a barrier to the direct contact between the kernel and the oxygen.

Increased respiration intensity in the temperature range 20-37° C can be explained by increasing the activity of lipases that induce lipid hydrolysis processes and increase the amount of substrate (fatty acids) for respiratory processes. Endogenous lipids in the walnut kernel hydrolyze lipids to glycerin and free fatty acids, which are then oxidized to produce the energy required for germination and plant growth. At temperatures above 40°C enzymes are denatured and inactivated.

The dependence of the acidity index (expressing the free fatty acid content) of unshelled walnuts and kernel fats of nuts held at different temperatures is shown in Figure 4.

It is noted that the acidity index correlates with the storage temperature, but more pronounced in the case of the core and slower in the case of nuts in the shell.

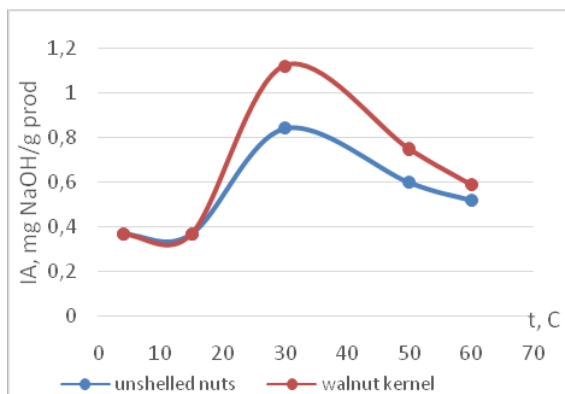


Figure 4. Dependence of acidity index of unshelled walnut and kernel lipids of storage temperature.

CONCLUSIONS

Initial respiratory intensity of walnuts is quite high, but drops sharply in the first 15 days of storage. The rate of breathing increases slowly with increasing temperature from 4 to 200°C, followed by a sudden increase to the maximum value at temperatures of about 30-400°C followed by a decrease in breathing intensity at higher temperatures. A relationship has been established between breathing intensity and storage temperature, as the temperature increases product respiration rate increases sharply (2, 3 times for each 10°C) and at 50 - 55°C reaches a maximum.

Bibliography

1. **Jenac A., Migalatiev O., Caragia V., Soboleva I.** Caracteristica CO₂ a extractului din fărimituri de miez de nucă. Akademos, nr. 4 (31), decembrie 2013, p.82
2. INC, NUTS AND DRIED FRUITS GLOBAL STATISTICAL REVIEW 2008-2013
3. <http://faostat3.fao.org/browse/Q/QC/E>
4. **Maté J. I., Saltveit M. E., Krochta J.M.** Peanut and Walnut Rancidity: Effects of Oxygen Concentration and Relative Humidity, Journal of Food Science - J FOOD SCI, vol. 61, no. 2, pp. 465-469, 1996.
5. **Yanping M., Xinghua L., Debao Yu. Limei W., Yifei Yu.** Changes of respiration intensity and quality of different varieties of fresh walnut during cold storage. Transactions of the Chinese Society of Agricultural Engineering, Volume 26, Number 1, 2010, pp. 370-374(5)
6. **Saltveit M.E.** Physical and physiological changes in minimally processed fruits and

vegetables. In: Phytochemistry of Fruit and Vegetables. F.A. Tomás-Barberán (ed) Oxford Univ. Press, pp. 205-220. 1996.

7. **Mihalescu L., Rosca O. M., Marian M., Vosgan Z., Maxim A., Cordea M.** Influence of Iron on Respiration in Corn (*Zea Mays*) Seedlings. Bulletin UASVM Agriculture, 68(1)/2011 Print ISSN 1843-5246; p.212-215.

8. **Blessing I. Offia-Olua.** Chemical, Functional and Pasting Properties of Wheat (*Triticum spp.*)-Walnut (*Juglans regia*) Flour, Food and Nutrition Sciences, 2014, 5, 1591-1604.

9. **Peng-Xia Li, Wei Wang, Li-Song Liang, Gui-Xi Wang.** Effects of Different Storage Temperature on Physiology and Quality of Walnut. Transactions of the Chinese Society of Agricultural Engineering, Storage & Process 2009-04.

10. **Zhang Zhihua, Gao Yi.** Studies on the Respiration of Nuts of Walnut. Transactions of the Chinese Society of Agricultural Engineering. 1994-03.

Recommended for publication: 20.03.2017.

PERCEPTION AND CREATIVITY ASSESSMENT IN GRAPHIC DESIGN

Cristina Ghencea, PhD student
Technical University of Moldova

INTRODUCTION

The study of creativity has a major interest in the current context of our society. It is important for companies to determine how creative their products can be, as innovation can generate 75% of their revenues [1]. As a result, companies and professionals responsible for expressing their creative potential need to use methods and measures to distinguish products that are considered the most creative from those that are less creative.

The general objective of this study is to contribute to the analysis of the different factors responsible for differences in the way creative works are evaluated. The research is focused on the field of graphic design, described by *La Maison de Artistes* as intended to "convey a visual message in all areas of life".

More specifically, our general objective can be subdivided into two parts:

- First, we want to identify the criteria used spontaneously by judges during the evaluation of the creativity of graphic design.

- Second, we want to determine the differences between assessments performed by judges with different profiles. The profiles taken into account are based on two factors: the "professional perspective" of judges – depending on their professional status and can influence their perception of graphic design – and their level of experience in the professional field – and their level of experience in the field of design (measured in number of years spent practicing an activity in this field).

1. CREATIVITY

1.1. Definition of creativity

Anyone working on creativity first has to define his or her understanding of this term [2]. However, such is the complexity and multidimensionality of the subject that a clear definition is difficult to achieve.

Plucker, Beghetto, and Dow selected 90 different articles from peer-reviewed journals on

creativity, business, education, and psychology, restricting their choice to those with the word "creativity" in their title. Only 38% of these articles explicitly defined creativity [2].

Some authors opine that creativity escapes definition [3] [4]. For example, Amabile asserts that the current state of science does not provide a sufficiently clear description of creativity for it to be given a definition. She claims that there is a plethora of data, but a dearth of definitive statements: we cannot yet establish the cognitive profile of a creative individual, that is, a person with all the traits and abilities needed to ensure the production of a truly creative outcome. Nor can we list the features that set a truly creative outcome apart from a noncreative one. However, quoting Kosslyn's observation that "it is not necessary to begin with a crisp definition of an entity in order to study it" [5], Amabile suggests that as long as the entity under consideration can be recognized with a reasonably good consensus, it makes sense to proceed with a scientific examination of that entity.

Many authors writing about creativity nonetheless attempt to provide some kind of definition of the term. Sarkar and Chakrabarti analyzed over 160 definitions of creativity and arrived at the following common definition: "Creativity occurs through a process by which an agent uses its ability to generate ideas, solutions or products that are novel and valuable" [6]. This is the definition we adopted for the purposes of the present research.

In a summary of scientific research into creativity, Michael Mumford suggested: "Over the course of the last decade, however, we seem to have reached a general agreement that creativity involves the production of novel, useful products" [7] or, in Robert Sternberg's words, the production of "something original and worthwhile" [8]. Authors have diverged dramatically in their precise definitions beyond these general commonalities: Peter Meusburger reckons that over a hundred different analyses can be found in the literature [9]. As an illustration, one definition given by Dr. E. Paul Torrance described it as "a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and

so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies: testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results” [10].

Creativity, with all its complexity and multidimensional aspects, is difficult to define in a clear and easily generalizable way. For this research, we will refer to the definition proposed by Sarkar and Chakrabarti [6], resulting from their analysis of about 160 definitions resulting from various research in the field of creativity. According to them, the common feature of all definitions of creativity is that it appears through a process implemented by the individual to generate ideas, solutions or products that are new and valid.

Moreover, in order to be recognized as creative, productions must be judged by what Csikszentmihalyi [11] in its systemic model calls “the field”, constituted by a group of people or institutions playing the role of *gatekeepers* (fig. 1).

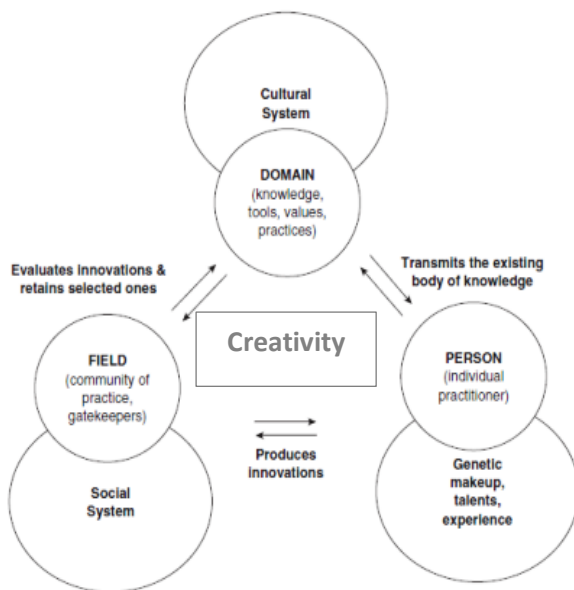


Figure 1. General Systems Model of Creativity [11]

It is the latter who will accept or reject production so that it may or may not be part of the domain (the domain), constituted by a set of cultural knowledge and symbols. It seems, therefore, that in order to obtain a positive judgment or approval for creative production, the author must become familiar with the requirements and values of the judges who will evaluate it in order to satisfy them.

1.2. Perceptions of creativity

Creativity is a subject that arouses a great deal of interest and curiosity. People are fascinated

by the way in which famous creative personalities such as Albert Einstein and Pablo Picasso came up with their discoveries or produced their masterpieces [12]. But creativity is not only about the great art, it also concerns the everyday life, since most of the artifacts present in our environment are the consequence of people’s creative invention [13] [14] [15].

Back in the 1950s, psychologists shifted their attention from the works of geniuses to those of ordinary people, and the late 1980s witnessed a growing interest in the social and cultural dynamics of creativity, including in everyday life [16] [17]. Increasing use is now being made of consensual forms of validation [3] [18], and creativity has started to be perceived of as something that takes place in the context of the community, within networks of social relations and social interactions, and using existing cultural artifacts.

The growing interest for the subject became a large public center of interest: self-help books, courses and workshops on how to develop one’s creativity are extremely popular in today’s society. There is an increasing demand for innovation in our society, in the form of new products, but these new products must be tailored to users’ actual needs and cognitive abilities.

From the theoretical point of view, the societal approach described above contrasts personal creativity, or creativity with a small c, with “*historical creativity*” or Creativity with a big C [19] [12]. Personal creativity refers to creations that of lesser importance for humanity as a whole, but which nevertheless have a great deal of value for their authors, as they are the result of an individual process. Historical creativity refers to the discoveries and masterpieces of famous creative personalities.

Beghetto and Kaufman extended this discontinuous view of the creativity concept by introducing the Four C model of creativity, adding to the existing creativities (with a small c and big C), creativity with a mini c, which refers to the “*novel and personally meaningful interpretation of experiences, actions, and events*” [20] and creativity with a pro c, referring to the creativity expressed through people’s creative professions, without any major impact on history.

In lines with these hypotheses, Johnson and Carruthers divided creativity into four categories: (1) Creation-common-place, of which the result is neither surprising nor uncommon, just a consequence of human activity; (2) Creation-creative-domain, where the creative domain can be art, the media, and so on, but where the creative discovery is made on an individual scale; (3)

Creative combination, which involves the improvement of an already existing artifact, by modifying a single feature such as method, context or use; and (4) Creative-new, which is innovative in the context of the history of humanity [21].

This desire to categorize creativity reflects the existence of different expectations associated with creativity, described by Sarkar and Chakrabarti [6]. The novel and valuable character of a product is perceived differently according to whether it has been created by a kindergarten pupil, a nonexpert adult or a creative professional.

In this research, in relation to the typology set out above, we focused on a brand of creativity that lies midway between the small-c and pro-c categories, insofar as the authors of the creative outcomes we analyzed were students enrolled on creative courses.

2. RESEARCH FRAMEWORK AND STUDIES

The aim of this study is to collect the criteria that people consider as important when assessing creativity in graphic design. In this study we aim to collect criteria reflecting the theoretical viewpoints, mental representations and declared priorities of our participants. In order to obtain that information, we asked the participants to express their criteria independently of any specific examples of design. Moreover, the participants involved in this study were not provided with lists of suggested criteria, but had to quote spontaneously what is important to them, while assessing the creativity of design.

The first objective of this research is to find out whether there is a set of general criteria adhered to by most people.

Second, is to analyze differences and common points between criteria proposed by participants with different professional viewpoints and with different levels of expertise in design.

2.1. Method

For this study we choose to use a survey for collecting the qualitative data, which were then analyzed with the use of an adapted version of the grounded theory method. The findings were then transformed into quantitative variables and statistically compared, in order to determine the differences observed between different groups of participants.

2.1.1 A survey with open questions

The most appropriate way to discover what is important for participants to assess creative design is simply to ask them about the criteria they think are the most suitable for this domain. Therefore, for the phase of data collecting we used an online survey with open questions.

2.1.2 Data analysis

To analyze the responses given during the survey, we adapted the grounded theory method. More specifically, in this study we proceed as follows:

- First we identify **codes**, by collecting terms used by participants of the survey to describe the criteria of creative design assessment. Thus we obtain a list of terms, which comprises different propositions of criteria expressed in various ways and by different numbers of occurrences.
- Second, we group the terms with similar content, in order to find the common concepts. Therefore, we assembled them in order to create the categories – entities spontaneously proposed by participants as important to evaluate creativity. For each category, we find the most representative label.

Using this methodology, we expected to find relatively detailed information about the representations and approaches to creative design assessment. More precisely, (1) our data show the vocabulary spontaneously used by people to describe criteria for assessing graphic design, (2) we compare the quantity and the nature of criteria mentioned by participants with different professional backgrounds and levels of expertise.

2.2. Participants

2.2.1. Recruitment

Our participants were recruited via Facebook and email invitation to fill in an online questionnaire. We sent invitations to participate in our study to approximately 150 design professionals and 100 other people. 61 design professionals and 14 other people responded positively to our demand and filled correctly the questionnaire. The participant's age is minimum 19 and maximum 67 years old.

This way of collecting responses seems the most appropriate, as it allows us to reach design professionals in the entire country. We could access a high number of people with the appropriate profiles, even if we knew that the percentage of

responses would be lower than if we contact them in person.

2.2.2. Establishing specialization profiles

We asked each participant what was precisely his or her professional activity and to indicate the number of years spent on this activity. They could choose one or more activities between:

- Graphic designer
- Graphic Design Student
- Art director
- Art teacher
- Other

We reserved the other category for participants whose activity was not connected with design, in order to obtain the control group of laypeople. We needed this group to compare the results obtained by the design professionals with those obtained by participants having no professional experience in design. Moreover, this group can be considered as the design audience and their opinion reveals the viewpoint of users' experience and their implicit theories about creativity.

Numerous participants indicated multiple professional activities, thus we decided to describe our sample in a more detailed way. Many professional designers are also art directors. Because of this, we decided that being an art director is a decisive criterion, since it changes the viewpoint on the domain: art directors are supervising the global directions of design and often they give directions to designers. We therefore separated our participants who were only designers from those who were art directors, even if their activities were multiple.

Being an Art teacher is an even more decisive criterion, as being able to explain the design to others, often from a theoretical perspective, also changes the viewpoint on the domain. If participants indicated that they were art teachers, we included them in the group of teachers, regardless of the other activities that they declared. Thus, even if a participant was not only a teacher, but also an art director or a designer, we qualified him or her as a teacher.

Because of this, for the participants professionally connected with design, we obtained the following groups:

- Designers
- Art directors
- Art teacher
- Graphic Design Student

2.2.3. Establishing experience profiles

Our aim was also to analyze differences related not only to the design specialization but also to the participants' level of professional experience in design. Within the same sample, we created additional groups.

Moreover, we aim to identify differences between participants, depending on their level of experience in the design field. We created the following groups:

- Participants with more than 10 years of professional experience in the design domain – 11 persons.
- Participants with 5 to 10 years of professional experience in the design domain – 11 persons.
- Participants with 3-5 years of professional experience in the design domain – 6 persons.
- Participants with 1-2 years of professional experience in the design domain – 19 persons.
- Participants with no professional experience in design at all, that we will laypeople – 28 persons.

2.2.4. Final sample

Finally we obtained a sample of 75 participants.

In order to obtain the groups with different professional backgrounds, we created the following groups:

- **18 designers** (9 males and 9 females, 7 with 1-2 years, 3 with 5-10 years, 4 with 3-5 years, 1 more than 10 years, 3 with no professional experience)
- **10 art directors** who are not teachers (9 males and 1 female, 5 with more than 10 years, 3 with 5-10 years, 1 with 3-5 years, 1 with 1-2 years)
- **8 art teachers** (4 males and 4 female, 4 art teachers with 5-10 years of professional experience, 1 art teachers with 3-5 years, 2 more than 10 years, 1 with no professional experience).
- **25 Graphic Design Student**
- **14 Others**

We chose 10 years of professional experience as limit differentiating experts from other participants, as suggested by a number of authors [22] [23] [12]. We compared data obtained from these participants with those obtained from less experienced design professionals and from laypeople.

2.3. Material

We created one questionnaire using Google documents. Furthermore, all participants were provided with instruction to write down, using their own words, the criteria that allow them to evaluate the creativity in the graphical design task.

2.4. Procedure for criteria finding

To analyze the data from all the participant's responses, we proceeded in three steps.

2.4.1. First step: identifying codes

We made a list of all the terms proposed by participants as criteria to assess graphic design. Therefore, these terms contains information about the subjective representations of what creativity in design is, and about the vocabulary used by participants to evoke the criteria to assess this creativity. The same term could be proposed by different participants. We collected the terms proposed to evaluate the creativity of graphical design.

2.4.2. Second step: categorization of finding criteria

Having a list of terms, we then proceeded to categorize their contents, in order to find those, which could be interpreted as synonyms and label these terms under the same concept.

For example, a label *Originality* was suggested to group the following terms from the graphic design list:

Innovation, presenting the message in an original way, original processing, new, innovative, surprising, cessation of what is usual, unusual, different, not ordinary, new idea.

We eliminated the items that appeared just once, without being linked to any category, or that were difficult to interpret.

To understand which criteria are the most commonly mentioned, we analyzed the number of occurrences of each of them in the participant's proposals. If participants used more than one item belonging to the same criteria, we considered that they used synonyms to describe the same criterion.

2.4.3. Third step: identification of criteria in creative assessment

We carried out the categorization of our criteria with the goal of obtaining criteria and their number of occurrences. We then analyzed the

number of occurrences of each criterion in the participant's proposals. If participants used more than one criteria belonging to the same criterion, we treated it as a single occurrence of that criterion.

2.5. Categorization results and criteria finding

During the categorization process, 21 categories were created to represent criteria for the assessment of graphic design creativity. We present all of them in the table 1, each with a short description and the numbers of times that was mentioned each criterion as being important when assessing creativity in graphic design.

We can observe that *Originality* obviously has the highest number of occurrences. This was the only criteria that had more than 50% of occurrences and of which we can assume that, according to the participants, it has a high importance for creativity. There was also *Design elements*, *Comprehension message*, *Aesthetic*, *Creative person qualities*, *Concept*, criteria mentioned by more than 10 % of the sample.

2.5.1. Criteria depending on the participant's professional backgrounds

The data are collected in a table whose lines are the participant's professional backgrounds, the columns of which are the criteria and whose general term x_{ij} is the number of times the criterion j is mentioned by the participants i (Table 1). This table can be seen as a contingency table considering that it has n criteria descriptions and these descriptions are ventilated by two categorical variables: the participant's professional backgrounds and the used criteria.

Correspondence analysis's based on the analysis of the contingency table through the row and column profiles [24]. Row profiles correspond to the relative frequencies of the different criteria mentioned by each group of participants with different professional backgrounds.

Dimensions are typically plotted to visualize the relationships among the variables. In CA, this graphical representation is called a "map".

Results of the CA were generated using the following code in RStudio [25]:

```
data <-
read.table("C:/Users/user/Desktop/poster.txt",
header=TRUE,sep="\t", na.strings="NA",
dec="," , strip.white=TRUE)
summary(data)
library(FactoMineR)
```

Table 1. The criteria related with creativity that were cited by all the participants in the area of Graphic Design

N	Criteria	Definition	Numbers of times that was mentioned the criteria
1	Originality	Reference to innovation, uncommonness	41
2	Design elements	Visual components of design	13
3	Comprehension message	Degree to which it is comprehensive for the user to understand the design functionalities	11
4	Aesthetic	The appearance of design	10
5	Creative person qualities	Describes the characteristics considered as important for person creativity	9
6	Concept	Quality and the elaboration of the idea on which the design is based	8
7	Simplicity	Use of simple means and minimum of elements	7
8	Quality of execution	Precision and finishing of the design work	7
9	Harmony	The way in which the design elements should be adjusted with each other to create an impression of unity	6
10	Style	Underlines the importance of some strong, recognizable traits	5
11	Layout	Organization of the design elements on the given surface	5
12	Functionality	the quality of being suited to serve a purpose well	5
13	Emotions conveyed	Evoking emotional reaction	5
14	Professionalism	the competence or skill expected of a professional	4
15	Relevance to the subject	Importance of the semantic connection between the content and the theme of the graphic design	3
16	User appropriateness	Connected with usability of the design	1
17	Tools	Technology used during the creation process	1
18	Impact	A marked effect or influence	1
19	Creative process characteristics	Divergent thinking and visibility of the creative process within the final production	1
20	Character adapted to the public	The design is adapted to the public needs	1
21	Appeal	Attracting the target attention	1

```
res = textual
(data,num.text=13,contingence.by=3)
res$nb.words
descfreq(res$cont.table,proba=0.2)
res = CA(res$cont.table)
```

The map is presented in Figure 2. The origin on the map corresponds to the centroid of each variable. The closer a row profile's vector location is to the origin, the closer it is to the average profile.

Dimension 1 is represented by the horizontal axis; Dimension 2, the vertical axis. Along Dimension 1, we see on the map that *Art Teacher* and *Graphic Design Student* are opposed and

furthest away from the origin and therefore have the most importance. Along Dimension 2, we see that *Art Director* and *Graphic Designer* have different vision about assessing criteria declared as important for the graphic design creativity assessment.

When analyzing data obtained within the groups with different backgrounds, we observed that for **Art directors** seem very important *Originality*, *Harmony* and *Aesthetic*.

Art teacher considerate more important criteria for assessing creativity in graphic design the *Originality*, *Aesthetic*, *Design elements*. This is the only group that shared moderately their conside-

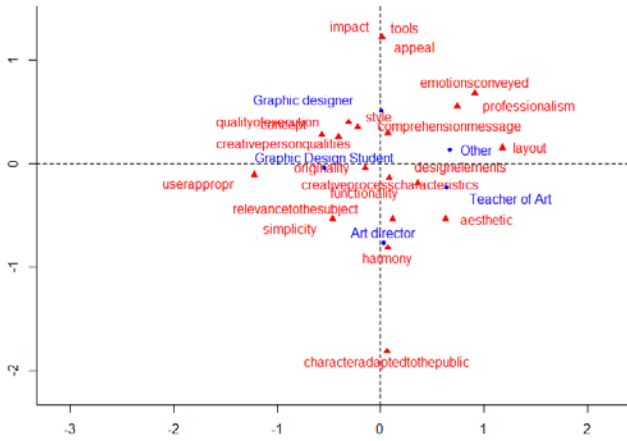


Figure 2. Correspondence analysis map of criteria used during the interview, within groups of persons with different backgrounds.

ration for *Comprehension message*.

Graphic Designers shared at least more interest to *Originality*, *Creative person qualities* and *Creative person qualities*.

For **Graphic Design Student** seem very important *Concept*, *Simplicity*, *Comprehension message* and *Originality*. Graphic Design Students shared their consideration to *Originality* as highly important for graphic design creativity, to a higher degree than other groups. We did not want to keep the criteria related to the creative-process or person, nevertheless in this case the number of participants with this specific profile that mentioned this criterion seemed high and we judged it interesting to note it as a specificity of student' group.

For **Other people** seems important *Originality*, *Comprehension of message*, *Concept* are most important criteria.

2.5.2. Criteria depending on the participant's level of experience in graphic design

When comparing the results of participants depending on their level of experience, we observe that the distribution of the most cited criteria is not equal.

Results of the CA were generated using the following code in RStudio.

```
data <-
read.table("C:/Users/user/Desktop/poster2.txt", header=TRUE, sep="\t", na.strings="NA",
dec=".", strip.white=TRUE)
summary(data)
library(FactoMineR)
res =
textual(data,num.text=13,contingence.by=4)
res$nb.words
descfreq(res$cont.table,proba=0.2)
```

res = CA(res\$cont.table)

The map is presented in Figure 3. The origin on the map corresponds to the centroid of each variable. The closer a row profile's vector location is to the origin, the closer it is to the average profile.

Along Dimension 1, we see on the map that the group of participants with *1-2 years of experience in graphic design* and *Impact* are furthest away from the origin and therefore have the most importance. Along Dimension 2, we see that participants with *3-5 years of experience in graphic design* and *Appeal* have the most importance. These results indicate that the most important difference or largest deviation from independence in the sample is between *1-2 years of experience in graphic design/Impact* and the other groups of persons and criteria. The second most important difference is between participants with *3-5 years of experience in graphic design / Appeal* and the other groups of persons and criteria. The other responses being closer to the origin imply that the deviations from the expected proportions are relatively small.

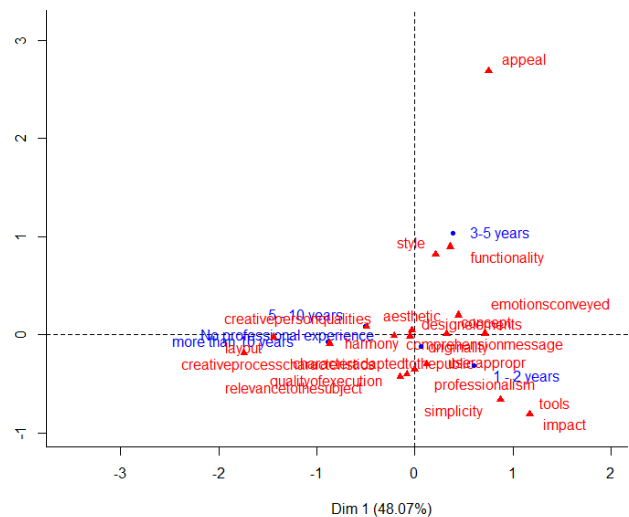


Figure 3. Correspondence analysis map of criteria used during the interview, within groups of persons with different level of experience in graphic design.

First axe separate the group which have few experience from the group of more than 5 years of experience. The second axe separates the group of 3-5 years of experience (style, functionality) of the group with 1-2 years of experience (simplicity).

For people with the **1 - 2 years of experience** in graphic design seems very important *Originality*, *Simplicity* and *Comprehension message*.

3-5 years of experience in graphic design shared at least more interest to *Originality*, *Style*, *Functionality* and *Appeal*.

The people with **5 – 10 years of experience** in graphic design consider more important criteria

for assessing creativity in graphic design the *Originality, Design Elements, Layout*.

The people with **more than 10 years** most important criteria are *Originality, Aesthetic and Layout*.

Asserted experts (5-10 years and more than 10 years of experience) show a common preference for a quite moderated quantity of criteria, but most of them reach the threshold of high importance. The distribution of their most shared criteria reflects the general preferences.

For **No professional experience** it is important *Originality, Design elements, Comprehension message and Concept*.

CONCLUSIONS

The results of this study have enabled to identify in greater detail the creativity criteria used in the area of graphic design. Furthermore, it allowed us to understand the influence of judges' characteristics, such as their professional background or level of experience in design, on the use of those criteria.

This study allowed us to understand better the nature of detailed criteria, representing the mental representations of design creativity. We will use criteria cited with the highest frequency by the participants of this study, in order to find out to which degree they influence the overall creativity assessment.

The first goal of this study was to find out whether there is a set of general criteria that people find important for the design creativity. After analyzing our findings, we can propose such a set of the most important criteria. Thus, for graphic design area, on which we focus in this study, it would be *Originality, Design elements, Comprehension message* and *Aesthetics Creative person qualities*. Additionally, we have *Concept* criterion was cited by participants few times, thus, we consider it as a moderately important criterion.

Some criteria issued from the state of art, were not included in our set of the most important criteria, since they were mentioned by a lower number of our participants: *Appeal, Character adapted to the public, Creative process characteristics, Impact, Tools, and User appropriateness*. It seems that in people's mental representations these criteria do not play the major role. Nonetheless, even if these criteria do not seem to be declared as important for creativity, it does not mean that they are not taken into account during the real situations of design assessment.

Our second goal was to verify if mental representations of creativity are different depending on the professional viewpoint and on the level of experience in graphic design.

First, we analyzed criteria declared by **participants with regard to their different professional viewpoints**. The most striking difference between the four profiles is that **designers** seem to have the most developed mental model of creativity, since comparing to other groups, they share the most important number of criteria that they consider important for creative design. While considering only the graphic design criteria, we can see that *Style, Creative person qualities* and *Quality of execution* are especially more considered by designers, than by other groups.

If we look at the quantity of criteria on which agree **art directors**, we see that it is moderate compared to designers. Art directors' considerations for graphic design criteria are very similar to those found in general results, which could be interpreted as a validation of this group as being the appropriate representatives of the domain voice. If it's their role to be opinion leader, to select the memes and transmit them to the relevant audience their choices and preferences should be somehow reflected by the choices and preferences of the domain in general. This is also in lines with Hooker, Nakamura and Csikszentmihalyi: domain gatekeepers should be able to identify the adequate degree of appropriateness and novelty, which means that to identify this adequateness, they should share, or at least have the knowledge about the mental representations of different actors of the field.

Teachers seem to have the strictest vision of creativity: they agreed on the lowest number of criteria. Their approach to creativity is similar to that of art directors, but comprises fewer criterions, which confirms that both groups are close to each other and can be put under the common label of domain gate keepers, but with a slightly different focus. In comparison to teachers, art directors' professional role consists more in meeting the audience's values. It seems that teachers developed a system of creativity values that is not only clear, but also restricted to only few shared criteria. The important number of non-shared criteria could be a result of differentiation of the approach to the design developed during the years of teaching experience, during which theory meets the variety of individual pedagogical cases. This could be interpreted in line with Caroff and Besançon [26], who underlined that some experts could diverge in their opinions about creativity, since their subjective understanding of it was developed differently during the acquisition of their own experience.

Nevertheless, we should also remember that the quantity of participants in this group was lower than in other group, which might influence the results.

When **comparing the results of participants with different levels of experience in design**, we can see that the main difference between **other people** and the more experienced participants is in their approach to the appropriateness criteria.

These findings are the most visible within more detailed criteria results concerning graphic design area: we can see that other people cited only *Originality* and *Emotions conveyed* as highly important for creativity. We can even observe that asserted experts agreed strongly on a smaller number of criteria, while intermediary experts agreed moderately on a higher number of criteria.

With increasing experience the professionals of design find more shared criteria and when they achieved the asserted expert's level, these criteria are reduced to a smaller number, but shared by more individuals. It could be due to the fact that more the experience of people increase in the graphic design area, more the criteria are shared. With time needed to acquire the experience, several criteria lose their importance and the agreement is kept only for those criteria that kept their universality towards different situations that can be encountered during the design professional's career.

Bibliography

1. **Milton F.** *Innovation survey*. 2003.
2. **Plucker J.A., Beghetto R.A., Dow G.T.** Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educational Psychologist*, 2004. 39: p. 83-96.
3. **Amabile T.M.** *Assessing the Work Environment for Creativity*. *Academy of Management Journal*, 1996. 39: p. 1154-1184.
4. **Piffer D.** *Can creativity be measured? An attempt to clarify the notion of creativity and general directions for future research*. *Thinking Skills and Creativity*, 2012. 7: p. 258-264.
5. **Kosslyn S.M.** *Image and mind*. 1980, Cambridge (Estados Unidos); London: Harvard University Press.
6. **Sarkar P.** *Studying engineering design creativity – developing a common definition and associated measures*. Springer Verlag, 2008.
7. **Mumford M.D.** *Where have we been, where are we going? Taking stock in creativity research*. *Creativity Research Journal*, 2003. 15: p. 107-120.
8. **Sternberg R.** *Creativity*. *Cognitive Psychology* 2011. 6 p. 479.
9. **Meusburger P.** *Milieus of Creativity: The Role of Places, Environments and Spatial Contexts*. Springer, 2009.
10. **Torrance P.** *Verbal Tests. Forms A and B-Figural Tests, Forms A and B. The Torrance Tests of Creative Thinking-Norms-Technical Manual Research Edition*. Princeton: p. 6.
11. **Csikszentmihalyi M.** *16 Implications of a Systems Perspective for the Study of Creativity*. *Handbook of creativity*, 1999. 313.
12. **Gardner** *Multiple intelligences : the theory in practice*. New York: Basic Books, 1993.
13. **Bonnardel N.** *Créativité et conception approches cognitives et ergonomiques*. Marseille : Solal, 2006.
14. **Lubart T.** *Creativity*. New York: Academic Press., 1994: p. 289-332.
15. **Mouchiroud C.** *An empirical study of the construct validity of social creativity Learning and Individual Differences*. 18, 2008: p. 372-380.
16. **Craft A.** *Creativity in schools: Tensions and dilemmas*. 2005: Psychology Press.
17. **Runco M.A., Pritzker S.R.** *Encyclopedia of creativity Vol. 1, Vol. 1*. 1999, San Diego, CA [etc.]: Academic Press.
18. **Hennessey B.A.** *The Social Psychology of Creativity*. *Scandinavian journal of educational research*, 2003. 47: p. 253-272.
19. **Boden M. A.** *The Creative Mind – Myths and Mechanisms*. (Pp. 304) Weidenfeld and Nicolson: London. 1990. *Psychol. Med. Psychological Medicine*, 1991. 21(03): p. 799.
20. **Beghetto R.A., Kaufman J.C.** *Toward a Broader Conception of Creativity: A Case for m`ini-c" Creativity*. *Psychology of aesthetics creativity and the arts*, 2007. 1(2): p. 73-79.
21. *Supporting creative and reflective processes*.
22. **Bloom B.S., Sosniak L.A.** *Developing talent in young people*. 1988, New York, N.Y.: Ballantine.
23. **Hayes-Roth B., Hayes-Roth F.** *A Cognitive Model of Planning**. *COGS Cognitive Science*, 1979. 3(4): p. 275-310.
24. **Clausen S.R.** *Applied Correspondence Analysis Vol. 121: an Introduction*. 1998, Los Angeles: SAGE Publications Inc.
25. **Husson F., Lê S., Pagès J.** *Analyse de données avec R*, 2016.
26. **Caroff X., Besançon M.** *Variability of creativity judgments*. *LEAIND Learning and Individual Differences*, 2008. 18(4): p. 367-371.

Recommended for publication:20.06.2017.

ARCHITECTURE OF THE ARMENIAN CHURCH OF HOLY APOSTLES PETER AND PAUL IN CHERNIVTSI

Iryna Korotun, prof. Dr.Sc.

Yuriy Fedkovych Chernivtsi National University

The contribution of Armenian culture to the development of world culture, town planning and architecture is the subject of scientific interest and the works of many theorists and practitioners of architecture and art criticism (history). The cultural heritage within the existing borders of the Republic of Armenia has been studied significantly and has received international recognition. Invaluable treasures of Armenian architecture include: complexes of the monasteries Ahpata and Sanain, cathedrals and churches of Echmiadzin, Zvartnots temple, Geghard monastery, which were included in the list of UNESCO World Heritage sites. As for the study of certain architectural objects that have emerged as the contribution of Armenians to the architecture of numerous European cities, in particular within the territory of modern Western Ukraine, these issues still await consistent scientific generalizations.

It is known that within the limits of the lands belonging to the territory of Western Ukraine during this period, large Armenian colonies were practically in all regions: in Podillya, in Galicia, in Bukovina (partly Chernivtsi region).

Armenian Church of Holy Apostles Peter and Paul was built between 1869 -75. At that time, Bukovina was part of Austrian Empire. The authoritative Austrian scholar and recognized expert on the history of Chernivtsi - Raimund Frederick Kayndl in his studies [1, p. 234] revealed the information about 4 Armenian-Catholic families, which were registered by the Polish border commissar Thomas von Voitsikevich for the period of province annexation, in 1774. And in 1820, the number of Armenians in Chernivtsi and its environs contained 30 families [2, p. 201], in 1865 there were more than a thousand families [2, p. 203]. Despite the fact that the number of Armenians was modest in comparison with other ethnic groups, they had sufficient influence. The area, where Armenians lived compactly, was adjacent to the central square of the city, Ringplatz.

In 1864, the construction of a grand architectural complex of the Metropolitan Residence of Bukovina and Dalmatia began, in Chernivtsi, under the directions of a young, but already well-known architect in Vienna, Josef



Figure 1. Street of Jakob von Petrovich.



Figure 2. General view of Armenian Church.

Glavka. He was entrusted with the development of Armenian church project.

Taking into account the small number and modest financial situation of the Armenian community, as well as the huge costs of construction work, the committee was created for implementation of the construction, headed by the chairman, who issued an appeal to public and private individuals, to Armenian communities from all around the world with a request to provide financial assistance to implement the project.



Figure 3. Church of the Holy Apostles Peter and Paul (photo 2015).

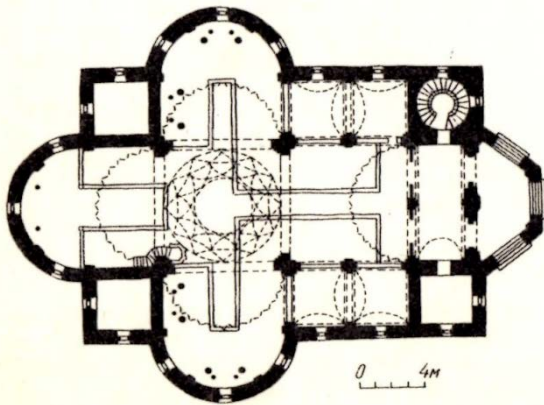


Figure 4. The plan is at the mark of 0.000 [5, p. 338].

The church is located in the historical center of the city, on a land plot of 0.5 hectares, pic. 3. The building is located on the axis of the street and closes its perspective, pic.1, and also organically merged with city's silhouette and panoramas of the historical center. The adjacent building creates a favorable background for the perception of a religious building. Dimensions of the structure are 32x24 meters (along the longitudinal and transverse axis of the cross).



Figure 5. The building of Armenian church on the map of Chernivtsi [4], 1898.



Figure 6. The modern general plan of the city.

The architecture of the Church of Holy Apostles Peter and Paul is a combination of the canonical traditions of Christian architecture and fashionable stylistic trends that dominated in Vienna in the second half of the nineteenth century. Traditional prototypes of Armenian cult architecture³ were correctly interpreted by Joseph Glavka. The basis of compositional solution is a plan in the form of a cross. At the intersection of the central nave and transept, the main vertical axis of the structure is formed, Pic. 2. Vertically, it ends with a tower on a cylindrical drum with a tent cover. The main longitudinal axis of the plan is directed toward the altar apse of the semicircular shape. The influence of the medieval temples of Armenia –

Geghart, Ahpat, Sanain, Hagartsin (included in the UNESCO World Heritage List) is clearly visible. The decoration of the facades of Armenian Church in Chernivtsi is made of red glossy bricks. The facades of the residence of Metropolitans of Bukovina and Dalmatia are decorated similarly, which makes them look-a-like. It is known that the architect, Joseph Glavka, was a passionate admirer of the indigenous folk architecture and a supporter of the preservation and usage of its traditions. Moreover, Joseph Glavka also used non-Gothic motifs in his works. For the Armenian Church, these are arcabouts, buttresses, pinnacles, a characteristic arrow-shaped form of white-stone frames of window openings of the upper tier, Fig. 4.

The interior of the church enriches the artistic fillings of stained-glass window openings which are made of colored glass in lead bindings: in the lower tier of the interior window openings are with polychrome stained-glass, windows in the form of ornament are located; The second tier of windows of the transept and the altar part are filled with stained glass windows on the themes of the New Testament. The sails of the dome are decorated with frescoes of the evangelists' images.

The dome drum is based on sail arches and is constructed with the usage of the constructive scheme of medieval Moldavian architectural traditions (autochthon architecture) in the form of crossed arches.

In 1875, on October 9, the first consecration of the Church of Holy Apostles Peter and Paul took place. After 1944, church was closed, for a long time its premises were empty. Subsequently, the building was used as a warehouse, while the church was blocked by concrete bays.

By the Resolution of the Council of Ministers of the USSR No. 442 dated September 6, 1997, the Armenian Church was declared a monument of architecture of national importance (security number in the state register - 1736). At the same time, the operation of the building was stopped due to unsatisfactory technical conditions.

Some of the stained glass windows were destroyed, the rest - dismantled and placed for



a.



b.



c.

Figure 7. Facades a), b). Photo by Denis Duliak. c). Interiors [6, p. 64, 65].

the maintenance on the funds of the Chernivtsi Regional Museum of Natural History.

In 1983, a group of young architects addressed an open letter to the Chernivtsi newspaper with the initiative to carry out restoration works and further adaptation of the empty and ruinous building of the Armenian Church, as an organ hall. The collective appeal was considered and after the appropriate examination of acoustics (design institute B.S. Mezentsev, Moscow) was supported by the authorities.

In 1986 the church building was transferred to the balance of the Chernivtsi Regional State Philharmonic. The project of restoration and adaptation under the organ hall was carried out by the Kiev design institute Ukrproektrestavratsiya, the chief architect of the project is Vasily Bezyakin. In addition to the restoration work, the premises were equipped with modern heating, lighting, providing the humidity regime necessary for the functioning of the organ.

The restoration was carried out by Kamenets-Podolsky restoration workshops corporation "Ukrrestavratsiya". Stained glass windows are recreated in the restoration workshops "UkrZahidProektRestauratsiya", Lviv. The active participation in the work was carried out by administrators, architects, restorers: M. Revenko, V. Lenchinsky, P. Kaspruk, V. Verig, A. Martynyuk, N. Orlenko, M. Kaverdinsky, T. Zubovich, I. Mohitich, V. Kostreb, M. Ryabukha, S. Zubarev, M. Dutchenko, and others. In 1988, the reconstruction and restoration were completed, an organ, which was made by Regent-Klosse in Prague, was assembled.

The total cost of works amounted to about half a million dollars. In 2010, sculptors P. Lemsky, M. Lysakivsky, D. Gorshkovsky restored and returned to their place sculptures of Holy Apostles Peter and Paul.

Currently, the structure is simultaneously used as the Organ Hall of the Chernivtsi Regional State Philharmonic and for its intended purpose. On weekends and weekdays, worship services of the church community of the Armenian Apostolic Church are held here.

August 11, 2012, the temple was visited by the head of the Armenian Apostolic Church

Catholics and the Supreme Patriarch of all Armenians, Garegin II. Thus, the process of gradual revival of the historical significance of the Armenian Church in Chernivtsi is being realized as an outstanding object of the cultural heritage and spiritual center of the Armenian community.

Bibliography

1. **Kajdl' R.** *Istoriya Chernivtziv vid najdavnivshix chasiv do s'egodennya. CHMGO "Komitet vibortziv"*. Chernivtzi, 2003, 253P.
2. **Nichirka M.** *Chernivtzi. Dokumental'ni narisi z istorii vylitz'*. Chernivtzi: Zoloti litavri, 2008, pp. 202-207.
3. *Armyane Ukrainy. Yakob fon Petrovich – pervyj Chernovitzkij burgomistr.* [URL Electronic resource] <http://sau.net.ua/content/armyane-ukrainy-yakob-fon-petrovich-pervyy-chernovickiy-burgomistr> (date of treatment 04.08.2017)
4. **CHODA.** *Plan von Czernowitz mit Angabe der neuen Straßenbenennung der Orientierung Nummern und Hohezahlen. Nach amtlichen Aufzeichnungen zusammengestellt von dem städt. Bauingenieur Ludwig West Verlad von Andreas Juszynski, H. Pardinische Universitätsbuchhadlung.*
5. *Pamyatniki gradostritel'stva I arhitektury Ukrainskoj SSR. Illyustrativnyj spravochnik-katalog, tom 4. K.: Budivel'nik. 1986, 338 P.*
6. *Chernivtzi. 239 kolyorovix fotografij. Zoloti litavri.* Chernivtzki: 2000, pp. 63-67.

Recommended for publication: 20.06.2017.

ROMANTICISM IN ARCHITECTURE OF CONSTRUCTIONS AND BUILDINGS OF NORTHERN BUKOVINA IN XIX – BEGINNING OF THE 20TH CENTURY

Tetiana Antoshchuk, postgraduate

Kyiv National University of Civil Engineering and Architecture

Relevance and problem statement. The study, preservation, restoration of original manifestations in artistic images in the architecture of buildings and structures of Northern Bukovina at the end of the XIX - early XX century are aimed at preserving and developing the historical architectural environment of the region.

Analysis of recent research and publications. S. V. Bilenkov [1, 2], O. A. Boyko, L. V. Vandyuk, V. V. Vechersky, T. I. Zubovich, A. Karpov (Moldova), B. V. Kolosok, O. I. Kordunyan, I. V. Korotun [7], Bo Larson (Sweden), I. R. Mohitich and R. I. Mohitich, O. M. Serdyuk and others domestic and foreign researchers who dedicated their studies to the architectural heritage of Bukovina and its capital, the city of Chernivtsi.

The national aspect in the architecture of buildings and structures of the late nineteenth and early twentieth centuries in different European countries was considered by scientists such as O.A. Borisov, T.P. Kadzhdan [3], V. V. Kirillov [5], E. I. Kirichenko [6], Ya. A. Krastinsh [8], V. G. Lisovsky [9], S. S. Levoshko, G. Yu. Sternin, V. V. Chepelyk [10], B. Miller Line [11] and others.

Formation of the purposes of the article. To study various trends of Romanticism in architecture of buildings and structures of Northern Bukovina at the end of XIX - beginning of XX centuries.

Presentation of the main research material. "*Romanticism*" is commonly referred to the ideological movement in literature and art that arose at the end of the 17th century in Germany, Great Britain and France, spread in the early nineteenth century in the Russian Empire, Poland and Austria, and since the middle of the nineteenth century has embraced other European countries as well as Northern and Southern America. Connected to the direction of the architectural styles of the late nineteenth and early twentieth centuries [9, p.6], in the course of historical development, acquired certain semantic features, transformed into a national romantic branch of the modern. With the access to the latest materials, technology, it acquired a new "*sound*", with the defining features,

which were rethought by architects and used to emphasize the nationality of the architecture of buildings and structures. Therefore, sometimes researchers use the notion of "*national romanticism*", call it one of the directions of the modern, characterized by the use of redefined forms and principles of folk architecture throughout Europe. The attention to national Romanticism, the inexhaustible riches of folk art, their significance in the general development of the culture of a particular nation is a natural trend in modernist architecture, which is determined to political and economic conditions and social demand of its time [7, p.156].

Northern Bukovina is a historic region, the territory which is now part of Ukraine as part of the Chernivtsi region and Southern Bukovina with its historical center in the city of Suceava, is currently part of the Chechen Republic of Suceava, Romania. From the second half of the XI century, the territory of Bukovina was part of the Terebovlian principality, from the middle of the XII century – to the Galician principality. At that time (the second half of the XII century) on the left bank of the Prut River on the site of modern Chernivtsi, the Galician prince Jaroslav Osmomysl founded a defensive settlement. At the end of the XIV century, this territory was submitted to Moldova. For the first time Chernivtsi is mentioned in the letter of the governor, Alexander Dobryj, in connection with the customs agreement, which he concluded with Lviv merchants (1408). In the period from the XV to the XVI century, Chernivtsi was a market center with fairs, which took place on the left bank of the Prut, and from the middle of the XVI century, Chernivtsi began to collapse because of the constant wars. From 1538 to the third quarter of the seventeenth century. In the territory of both Chernivtsi and Moldavia, the rule of the Ottoman Port was established. In 1774, nearly 250 years of Turkish rule ended. With the accession of Bukovina to the Habsburg monarchy, in order to intensify the development of the region, immigrants from different regions, primarily from neighboring Germany, were invited there, on the one hand, to accelerate economic development and, on the other,

to strengthen German influence [7, p.11]. Since 1774, the so-called "Austrian" period in the history of Chernivtsi had begun. Already in 1779 the city had 3200 inhabitants, and this number grew due to the influx of Germans (servants, teachers, traders), as well as Ukrainians and Polish from Galicia; Jews, Romanians and Ukrainians from Bukovina. The Austro-Hungarian Empire reigned until 1918. After that, from January 1918 to June 28, 1940, and from July 1941 to March 1944, the "Romanian period" continued in the construction of the province and the city of Chernivtsi. After that, in 1991, Chernivtsi region became a part of the Soviet Ukraine within the Soviet Union (the "Soviet" period). Beginning from 1991 to the present, Northern Bukovina is part of an independent Ukraine.

Thus, the political and economic conditions in the Austrian period contributed to an increase in the share of the German-speaking population (Germans, Jews) in the cities. While in the rural areas, Ukrainian, Moldavian and Romanian autochthonous populations prevailed. The complex history of the region leads to the richness of the national cultural heritage that has been created by different people for centuries.

The Romantic trend in architecture of Northern Bukovina of the late nineteenth and early twentieth centuries is represented by: Romanian, German, Polish, Armenian, Russian, Jewish and Ukrainian variants, which are reflected in public and residential buildings (Fig. 1). The typology of buildings, in the architectural form of which was the search for a national expression, includes residential, public, religious and industrial buildings.

Dwellings include: villas, mansions, china houses, own multi-storey houses, suburban elite residences. For example, in the city of Chernivtsi – residential houses were on 40, B. Khmelniysky str.; 31, 41 Aksenina str.; 27/27, Y. Fedkovich str.; the corner of Sidi Tal str., 16 L. Ukrainka str.; 5, P. Saksaganskogo str. There are also variants with modern touch: residential house on 32, Y. Gagarin str. In other settlements - the former lawyer's house I. Stryjsky (Kitsman city, 57 Nezalezhnosti street.); Palace of Manescu (Chortory village, Kitsman district); country palace de Zotte (Vyknno village, Zastovsky district) (Fig. 2); the palace of Baron Turkula (village Sudenets, Storozhinets district) (Fig. 3); Gross Palace (Baniliv-Podgorny village, Storozhinets district); the estate of Count Vasil'k (Beregomet-on-Seretya, Vyzhnytsya district) (Fig. 4); Kryshtofovichi Palace (Vashkivtsi village, Vyzhnytsky district).

Cults include: synagogues, churches, Roman Catholic churches, Lutheran churches, monasteries. For example, in the city of Chernivtsi, the Chernivtsi Synagogue (10, University Street), the synagogue "Beit Tifla Binyamin" (53, Kobylitsa St.), the synagogue Mordok and Taubi Korn (11, Sadovsky Street) [15], the Church of St. Anna (10, Pidkovy Street); in other settlements – Uspenskaya church in Bila Krynica village (Glybotsky district) etc.

The administrative buildings are represented with the industrial buildings of Sugar factory on 4, Khotynska str. A step towards the ethnic originality of Ukrainian architecture is represented by the building of the former lawyer's house, I. Stryjsky, (now – the building of the Kitsman City Council) in Kitsman, as well as the building on 14, Y. Fedkovich str. in Storozhynets [10].

The influence of Hutsul architecture is seen in usage of the Carpathian native motives. The planes of the walls of a dwelling house (31, Aksenyna Str., Chernivtsi) are decorated with Kosiv ceramics. Active silhouette of the roof has common features with the roof of the building of the former doctor Soletsky sanatorium in Lviv [10].

Romanian motives of Romanticism are presented in the style of Neo-Romanesque buildings in Chernivtsi: "The House of the Bishop" (7, Kotsiubynsky Str.); Border Guard House (7, Suvorova Str.); multistorey dwelling house (15, Universitetska Str., (Goethe's Corner)); the railway building (Y. Gagarina Str.); residential building (31, Y. Gagarina str.); villa (3, O. Griboyedova str.); Villa Filippovicha (5, Evdokimenko Str.); villa (11, O. Matrosova str.); Lawyer's villa (1, Peterhofskaya str.); architectural building (22, V. Trepka str.) and others.

Among the Bukovinian Polish, there was a group of large landowners, who had Armenian origin, but after the adoption of the Catholic faith they considered themselves Polish. Therefore, at that time, the name of Armenian-Polish was extended to this category of population [4]. Thus, the Armenian version of national Romanticism in architecture is the Armenian Church (28, Ukrainka Str., Chernivtsi) (architect J. Glavka, 1875). Polish national Romanticism in Chernivtsi is represented by the religious building – the Church of St. Anne (10, Pidkovy Str.); In a residential building – a mansion (41, Aksenina str.). The facade of Polish People House (40, O. Kobylianska Str., Chernivtsi) was made with Renaissance motives (architect F. Skovron) [2, p.66], and the finishing decorations of the premises were made by representatives of Zakopanska School [4].




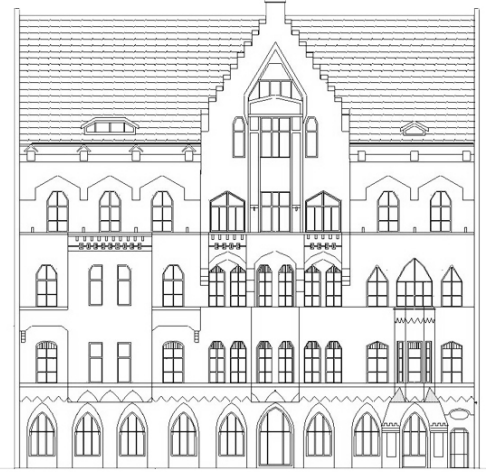
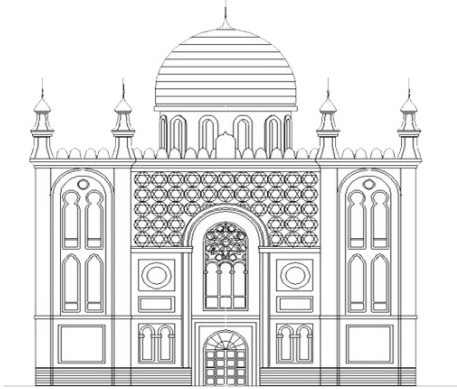
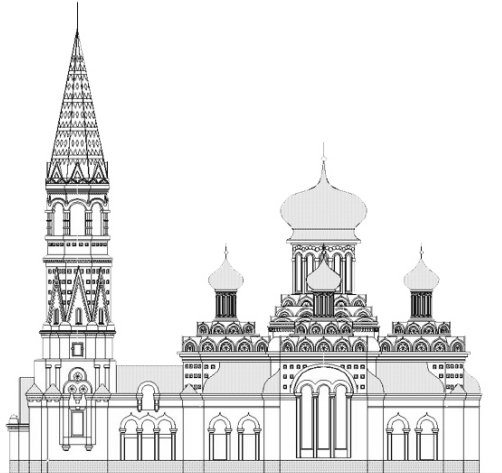
Ukrainian	 <p data-bbox="379 595 651 645">House of Lawyer I. Stryjsky 17, Independence str., Kitsman</p>	Romanian	 <p data-bbox="1015 595 1286 645">"Bishop's House" 7, Kotsjubinsky str., Chernivtsi</p>
Polish	 <p data-bbox="384 1218 635 1267">Residential building 41, Aksenina str., Chernivtsi</p>	German	 <p data-bbox="1015 1218 1318 1290">German House 47, O. Kobylanska str., Chernivtsi (architect Gustav Fritsch, 1908)</p>
Jewish (Neo-Mauritanian style)	 <p data-bbox="288 1816 719 1888">The original appearance of the former synagogue 10, Universitetska str., Chernivtsi (architect Julian Zakharevich, 1877)</p>	Russian	 <p data-bbox="975 1816 1326 1888">The Assumption Church Bila Krynica village, Glybotsky district (architect V.Klik, 1900-1908)</p>

Figure 1. Variants of national romanticism of Northern Bukovina.



Figure 2. Country Palace de Zotte, Vykno village, Zastavnovsky district (photo by A. Bondarenko) [12]



Figure 3. Palace of Baroons Mikuly-Volchinsky, Budenets village, Storozhinets district (photo by A. Bondarenko) [13]



Figure 4. Farmstead of Basil'ko, Beregomiet-on-Siret village, Vyzhnytsky district (end of XIX not preserved in its original form) [14].

The German variant of national Romanticism on the territory of Northern Bukovina was the most clearly manifested in the architecture of the building of German House (47, O. Kobilyanska Str., Chernivtsi) (architect G. Fritch, 1908).

Another variant of Romanticism on the territory of Northern Bukovina is the original appearance of the Chernivtsi Hasidic Assembly House (architect Y. Zakharevich, 1877), which was built in Neo-Mauritanian style, as well as the building of the former Jewish hospital (architect K. Moklovsky, 1901) on 8, Rappoport str., in Lviv and others.

Russian national Romanticism on the territory of Northern Bukovina is the Assumption Church of the Old Believers in Bila Krynytsa village, Glyboytsky District (architect V. Klitsch, 1908). The prototype of the object was the legacy of Moscow architecture of the last decades of the seventeenth century. However, the traditional use of the 'ship' composition was slightly changed: side walls are located on the sides of the cross, which corresponds to the traditions of the Byzantine Five-Glory [1, p.164].

Conclusions and perspectives for further exploration. As a result of the research, it is determined that in the architecture of Northern

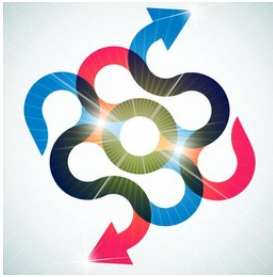
Bukovina XIX - early XX century, the motives of Romanticism were used. The typology of the buildings of Romanticism in Northern Bukovina includes residential, public, religious and industrial buildings. Prospects for further exploration should be aimed at studying the influence and inheritance of the original variations of the traditions of Romanticism on the architecture of Northern Bukovina.

Bibliography

1. **Belenkova S., Punin A.** Poiski "natsional'nyx variantov" stilya v arxitekture Bukoviny epoxy moderna (v kontexte resheniya problemy natsional'noj identichnosti v evropejskoj arxitekture kontza XIX⁸⁰ – nachala XX⁸⁰ vekov) / Teoriya ta istoriya arxitektury i mistpbuduvaniya. K., 2002. – Vip. 5, p.159-166.
2. **Bilenkova S.V.** Arxitektura Chernivtziv XIX-pershoj poloviny XX⁸⁰ stolit'. Chernivtzi: Bukrek, 2009, 440 p.
3. **Borisova E. A., Kazhdan T.P.** Russkaya arxitektura kontza XIX⁸⁰- nachala XX⁸⁰ vv. M.: Nauka, 1971. 239 p.

4. **Dobrozhans'kij O., Marsiyan N., Nikirka M.** *Natzii ta narodnosti Bukoviny u fondax Derzhavnogo arxivu Chernivetz'ko oblasti (1775-1940)*. Chernivtzi: Zoloti litavri, 2003. 172 p.
5. **Kirolov V.V.** *Arxitektura "severnogo moderna"*. M.: Editorial URSS, 2001. 112 p.
6. **Kirichenko E. I.** *Russkaya arxitektura 1830 – 1910^x godov*. M.: Isskustvo, 1978. 399 p.
7. **Korotun I.** *Emanu rozvitku Kopomyh I. Emanu rozvitku ta zabudovi mista Chernivtzi. Formuvannya istoriko-kul'turnoj zapovidnoj territorii // Arxitektura spadshhina Chernivtziv dobi: Materialy mizhnarodnoj naukovej konferentzii*. Chernivtzi: Zoloti litavri, 2003. P.9-17.
8. **Krastin'sh Ya. A.** *Stil' modern v arxitekture Rigi*. – M.: Strojizdat, 1988. 263 p.
9. **Lisovskij V. G.** *Arxitektura Rossii XVIII⁸⁰ – nachala XX⁸⁰ veka. Poiski natzional'nogo stilya*. M.: Belyj gorod, 2009. – 568 p.
10. **Chepelik V. V.** *Ukrainskij arxitekturnyj modern*. K.: KNUBA, 2000. - 378 p.
11. **Barbara Miller Lane.** *National Romanticism and Modern Architecture in Germany and the Scandinavian Countries* (New York: Cambridge University Press), 2000:10.
12. **Bondarenko A.** *Ukraina inkohnito* [Electronic resource URL]. Resource access mode: <http://ukrainaincognita.com/chernivetska-oblast/zastavnivskyi-raion/vikno/vikno>. (Date of treatment 05.09.2017). Name from the screen.
13. **Budentz' – Andy Travel UA** [Electronic resource URL] – Resource access mode: <http://andy-travelua.livejournal.com/98820.html>. (Date of treatment 09.09.2017). – Name from the screen.
14. **Beregomet (nad Seretom) – Andy Travel UA** [Electronic resource URL] – Resource access mode: <http://andy-travelua.livejournal.com/94896.html>. (Date of treatment 09.09.2017). – Name from the screen.
15. **Chernovitzkij muzej istorii i cul'tury evreev Bukoviny.** [Electronic resource URL] – Resource access mode: <http://muzejew.org.ua/Friz-Rus.html>. (Date of treatment 05.09.2017). – Name from the screen.

THE EDUCATION AND CREATIVITY



The creativity is very important at the global level. Creative accomplishments help to

build a more interactive world that fortifies human civilization. Humans would have no advancement in art, literature, science or invention if human creativity did not exist. Creativity is as natural and necessary for children as fresh air! But school actually limits children's creativity more than anything else because it is so egregious and is solely focused on how well you can cram and memorize things you will forget right after the fact, which is why we all hate it. *"Every child is an artist, the problem is staying an artist when you grow up"* say Pablo Picasso.

Creativity is found in the obvious subjects such as art and music, but can also be found in science and play. We automatically associate creative thinking with art, music, dance, and drama. However, we must recognize that creative thinking can be found in all aspects of a child's life and can be learned and used daily. Creativity is important at so many levels of our society, including both the individual and the social levels. Educators frequently teach students about creative and eminent people, but ignore teaching methods that foster students' creative thinking in the classroom. The importance of the school's role in the development of students' creativity has been highlighted in many studies regarding creativity. The Importance of Teachers in Fostering Students' Creativity Teacher attitudes, beliefs and classroom practices are deemed to be of crucial influence in the development of students' creativity. However the importance of promoting creativity in schools is a controversial topic. There's no doubt about it.

How could creativity instruction be integrated into scientific teaching [1]? Guidelines for designing specific course units that emphasize HOCS by using strategies of scientific teaching are now available from the current literature. Throughout the 3-wk unit, in accordance with the principles of problem-based instruction [2], course instructors encourage students to seek, interpret, and synthesize their own information to the extent possible. Students have access to a variety of instructional formats, and active-learning

"The task of the modern educator is not to cut down jungles, but to irrigate deserts."

(C. S. Lewis)

experiences are incorporated throughout the unit. These activities are interspersed among minilectures and give the students opportunities to apply new information to their existing base of knowledge.

What would such a class look like with the addition of explicit creativity-promoting approaches? Would the gains in problem-solving abilities have been greater if during the minilectures and other activities, students had been introduced explicitly to elements of creative thinking from the Sternberg and Williams [3] list described above? Would the students have reported greater gains if their instructors had encouraged idea generation with weekly brainstorming sessions; if they had reminded students to cross-fertilize ideas by integrating material across subject areas; built self-efficacy by helping students believe in their own capacity to be creative; helped students question their own assumptions; and encouraged students to imagine other viewpoints and possibilities? Of most relevance, could the authors have been more explicit in assessing the originality of the student plans? In an experiment that required college students to develop plans of a different, but comparable, type, Osborn and Mumford [4] created an originality rubric that could apply equally to assist instructors in judging student plans in any course. With such modifications, would student gains in problem-solving abilities or other HOCS have been greater? Would their plans have been measurably more imaginative?

Recall that in their meta-analysis, Scott et al. [5] found that explicitly informing students about the nature of creativity and offering strategies for creative thinking were the most effective components of instruction. From their careful examination of 70 experimental studies, they concluded that approaches such as social modeling, cooperative learning, and case-based (project-based) techniques that required the application of newly acquired knowledge were positively correlated with high effect sizes. The study was clear in confirming that explicit creativity instruction can be successful in enhancing divergent thinking and problem solving.

Finally, could a weekly brainstorming *"invention session"* included in a course like those described here serve as the site where students are

introduced to concepts and strategies of creative problem solving? As frequently applied in schools of engineering [6], brainstorming provides an opportunity for the instructor to pose a problem and to ask the students to suggest as many solutions as possible in a brief period, thus enhancing ideational fluency. Here, students can be encouraged explicitly to build on the ideas of others and to think flexibly. Would brainstorming enhance students' divergent thinking or creative abilities as measured by TTCT items or an originality rubric? Many studies have demonstrated that group interactions such as brainstorming, under the right conditions, can indeed enhance creativity [6], but there is little information from an undergraduate science classroom setting. Intellectual Ventures, a firm founded by Nathan Myhrvold, the creator of Microsoft's Research Division, has gathered groups of engineers and scientists around a table for day-long sessions to brainstorm about a prearranged topic. Here, the method seems to work. Since it was founded in 2000, Intellectual Ventures has filed hundreds of patent applications in more than 30 technology areas, applying the "*invention session*" strategy [7]. Currently, the company ranks among the top 50 worldwide in number of patent applications filed annually. Whether such a technique could be applied successfully in a college science course will only be revealed by future research.

5 Ways to bring more creativity into the classroom [8]

Introducing more creativity into your classroom and assignments doesn't have to make your job harder. It can actually make it a lot more interesting. Giving assignments that require more creativity will likely result in more engaging work for your students, and a more entertaining grading process for you.

1. Don't limit assignments to one format.

You can provide them the subject to cover, but give them some freedom in how they complete it. Some students will get more out of creating a video or drawing a comic strip than writing a paper. Even better, have them mix and match formats.

2. Set time aside for creativity. Take a cue from the 20% rule practiced by businesses. Work a "*genius hour*" into the school day. The amount of time is really up to you, but deciding to devote time to encouraging your students to explore new ideas and be creative can pay off. You can provide them with some tools to enable their creativity – crayons, clay, notebooks, iPads, or even just access to the library or internet (within reason). They can choose to create, or they can choose to do some digging

into a subject of interest to them. Encourage collaboration in these times, but don't force it. Allowing students the chance to follow their own interests and passions is the whole point and they should be given some leeway in what that looks like.

3. Use tech to broaden your idea of assignments. Tech literacy is almost as important to succeeding in the world today as creativity. And conveniently the two go hand in hand. Just using Google tools alone, we've already covered five creative assignments teachers can give. You can teach students about geography alongside history, literature, or any number of other subjects by having them map out a road trip in Google Maps. You can teach students how to make new contacts, conduct interviews, and turn what they learn from their interviews into a well-researched paper by making use of Google Hangouts or Skype. Students can take more ownership over their work by keeping a blog or making their own educational videos on their smartphones. And they can work more collaboratively with the help of social media. While all of these ideas teach students skills that will benefit them in finding jobs later in life, that's far from all they accomplish. They make them better learners, better thinkers, and give them more incentive to care about the work they do.

4. Introduce unconventional learning materials into class.

Have you ever seen a student excited when you assigned a chapter in a textbook? How about if you assigned TED Talks instead? Or educational (and entertaining) podcasts like Radiolab and StarTalk? Many of the people creating a lot of the entertaining pop culture out there have embraced the geekiness that pop culture used to shun. As a result, teachers have a ton of options for bringing more interesting and cool explorations of educational subjects into their classrooms.

5. Encourage discussion. Debates get kids involved and actively engaged with the topics they're discussing. The Socratic seminar method provides a lot of different benefits:

- It gets students thinking more critically about the material;
- It helps them learn to better communicate their ideas and opinions;
- It challenges them to listen to other students' opinions and think critically about their contributions and ideas;
- It gives them the opportunity to challenge each other intelligently and build off of each other's ideas;

The ability to communicate your ideas clearly and respectfully is something that will benefit

students in all areas of their life – and something a lot of people grow up never learning how to do well. Obviously, finding ways to get your students to be more creative requires some creativity on your part too. We've got a lot of resources that can provide you with some starter ideas, but we know educators and students can come up with many more. If you've had some success with activities in your classroom that inspire creativity, please share.

References

1. **Robert L. DeHaan.** *Teaching Creativity and Inventive Problem Solving in Science.* CBE Life Sci Educ. 2009 Fall; 8(3): 172–181. doi: 10.1187/cbe.08-12-0081
2. **Duch B. J., Groh S. E., Allen D. E.** *The Power of Problem-based Learning.* Sterling, VA: Stylus Publishers. 2001.
3. **Sternberg R., Williams W. M.** *Teaching for creativity: two dozen tips.* 1998. [accessed 27 July 2017] www.cdl.org/resource-ibrary/articles/teaching_creativity.php.
4. **Osburn H. K., Mumford M. D.** *Creativity and planning: training interventions to develop creative problem-solving skills.* Creativity Res. J. 2006;18:173–190.
5. **Scott G., Leritz L. E., Mumford M. D.** *The effectiveness of creativity training: a quantitative review.* Creativity Res. J. 2004; 16: 361–388.
6. **Paulus P. B., Nijstad B. A.** *Group Creativity: Innovation through Collaboration.* New York: Oxford University Press. 2003.
7. **Gladwell M.** *In the air; who says big ideas are rare?* *The New Yorker.* 2008. [accessed 27 July 2017]. www.newyorker.com/reporting/2008/05/12/080512fa_fact_gladwell.
8. **Kristen Hicks.** *Why creativity in the classroom matters more than ever.* March 17, 2015. [accessed 27 July 2017]. <http://www.edudemic.com/creativity-in-the-classroom/>

*Column written by professor Valeriu
Dulgheru, Ph.D. Dr. Sc. from Technical
University of Moldova*

PERSONALITIES OF THE SCIENTIFIC UNIVERSE: Augustin Sabinu Maior



Maiors': Olivia, Augustin, Iuliu, Gheorghe and Ana.

Augustin

Sabinu Maior was born on the 21st of August 1882 in Reghin. His father, Gheorghe Maior, was a primary school teacher at the Primary School of Reghin. His mother, Tereza, born Cornea, brought up and educated the five children of the

Learning, the basic condition for success

Due to his erudition, he managed to form to the children the desire to understand things beneath the first impression. German was the language he learnt the first poems in, at the German kindergarten of Reghin. German was the language he learnt to write in during the primary school of Reghin. In 1892 he was enlisted in the first grade of the Evangelic German High school of Reghin. He studied here until 1896. Then, he continued school until the sixth grade at the Apiarist High school of Târgu Mureş, then the one in Budapest. Here, he met Professor Schmidt Agoston, a gifted pedagogue, who opened his way towards sciences. During all these years, he proved a remarkable passion for research, for documentary research, for explaining the reality using science, not only his intuition. In 1900 he graduated high school and passed the baccalaureate exam. In autumn, he became a student at the Polytechnic Institute from Budapest, faculty of Mechanics. In 1905 he became an engineer, but before practising as an engineer, he spent several months at universities of Wien, München and Göttingen for research. He attended several post-academic courses and here he met a lot of scientific personalities of that time, among who we can mention Hermann. Minkowski, the one who added the dimension of time to the other three dimensions of space, resulting the tetra dimensional variety of space-time. This property was later used by August Maior in his studies.

The beginnings of the research in the domain of multiple phone system

He found a job as an engineer at the technical department of the Post Company of Budapest, he participated to the contest organized in November 1905 and he convinced the examination board that he had great theoretical knowledge, so he started his activity at the Experimental Station of the Post Company.

The name "*Experimental Station*" or "*research Station*" was used in Europe for a long period of time, included in Romania in order to name a research institute.

The problems studied were related to the phone industry, to the increase of the quality of phone conversations, to support an increasing number of conversations per time unit. This was happening only after thirty years after 1876, when Graham Bell transmitted the first words through a phone. This was happening only after thirteen years after 1892, when the first automatic phone switchboard started functioning in Indiana, the U.S.A. He conducted a lot of experiments and he substantiated theoretically solutions for a simultaneous transmission of several conversations on the same electric circuit.

Experimental and theoretical success

Only after one year after his hiring as an engineer, at the end of 1906, he managed to transmit five simultaneous conversations between two phone switchboards situated at 15 kilometres from each other and which were linked by only one phone line made up of two electric conductors. The theory was published in 1907 in "*Elektrotechnische Zeitschrift*" Journal. In 1908 he participated at the First International Conference of the Engineers from the Phone and Telephone Company, where he presented the paper "*The Harmonic Telephony*" in which he described his experimental and theoretical results. Unfortunately, he didn't grant a patent for his technical solution; so Augustin Maior's priority in this domain is assured only by the copyright. Even Nicolae Vasilescu- Karpen wrote a letter to the Academy of Sciences of Paris in 1909 where he described his proposals regarding the multiple telephony starting from the experience he had in wireless telephony. During 1910-1911 the American George Owen Squier conducted several

experiments regarding multiple telephony, but he also granted a patent for the technical solution.

Unknown priority

Augustin Maior noticed the danger of not having his priority recognized in this domain and, as a result, he wrote a letter to the *The Electrician Journal* a letter which was published in the 21st of April 2011 issue. Augustin Maior stated “*I demonstrated mathematically that multiple telephony could be realized with high-frequency alternative currents, so every current could transport a conversation. I also mentioned that I managed to transmit five messages simultaneously. I presented my experiments at the first European conference of posts and telegraph and I communicated at the conference that I managed to transmit message at 15 kilometre distance.*” In spite of all these facts, in 1921, E.H. Colpitts published a synthesis paper in *Transactions AIEE Journal* in which he stated that George Owen Squier, due to his experiments between 1910 and 1911, managed to make the multiple telephony. It is true that he quoted in bibliography his of the theoretical papers written by Augustin Maior, but he didn't mention his priority.

The Big Union

After the proclamation of the Union on the 1st of December 1918, Augustin Maior came back to Cluj, being appointed general Manager of Posts, telegraphy and Phones.

He got involved in the development of the academic system from Transilvania. This is why he was appointed professor at University of Cluj in July 1919. He taught here the courses entitled “*Electricity and magnetism*” and “*Acoustics and optics*”. During 1919 - 1946 he was dean of the Faculty of Science. In 1919 he contributed to the setting up of the first school of telegraphy and telephony at Sibiu.

Being a dedicated practitioner, he conducted as manager, the activity of the Institute of Theoretical and technological Physics of Faculty of Science. He approach several different research directions: electricity and magnetism, acoustics and optics, telecommunications, gravitation, thermodynamics of radiations, theory of quantum and statistics theory.

He died on the 3rd of October 1893 at Cluj-Napoca.

Acknowledgement

Augustin Maior's life was full of events, and the jobs he had demonstrates the appreciation of the others. In 1946 he was elected member of the Romanian Academy. The political changes from 1947 weren't favourable to him, even if he was praised abroad. Louis de Broglie, a winner of the Nobel Prize in 1929, made a synthesis of Augustin Maior's paper entitled “*The Gravitational fields and magnetism*” which he presented at the Franch Academy in 1950. But, history changed again, and after 1990, Augustin Maior's activity is praised again: starting from the 21st of March 1994, the school of Reghin, where he learnt to write and read is called “*The State Gymnasium Augustin Maior*”, from March 1995 one of the amphitheatres of the Faculty of Physics is named after him, the telecommunication High school from Cluj-Napoca bears his name. On the 7th of July 2000, the City Hall of Cluj-Napoca mounted a memorial plate on the house from 9 Octavian Goga where Augustin Maior lived.



Column written by professor eng .Gheorghe Manolea PhD, University of Craiova, Doctor Honoris Causa of Technical University of Moldova from Chisinau

↓(11 points)

**TITLE OF ARTICLE, MAXIMUM 3 ROWS, ON THE ENTIRE WIDTH OF THE PAGE,
(R_TIMES 14 POINTS, BOLD, CENTER, ALL CAPS)**

↓(11 points)

Aurel Bradu, dr.prof. (The name(s) of Authors(s), R_Times, 11 points, bold, Italic, center)
University... (Name of the institution where the Author works, R_Times, 11 points, italic, normal, center)

↓(11 points)

↓(11 points)

INTRODUCTION (R_TIMS 13 POINTS, BOLD, CENTER, ALL CAPS)

↓(11 points)

<Tab> The paper may contain an introduction of 20 lines maximum describing the general aspects the background of issues dealt with.

↓(11 points)

↓(11 points)

1. TITLE OF THE FIRST CHAPTER, NUMBERED IN ARABIC NUMERALS (R_TIMS 13 POINTS, BOLD, CENTER, TWO COLUMNS, ALL CAPS)

↓(11 points)

<Tab> In front of each chapter title leave an empty space of two lines. The text of the paper (R_Times, 11 points, normal) begins after chapter titles, after leaving a blank line (↓ 11 points).

↓(11 points)

1.1. Sample of subtitle with 2 indexes (R_Times 13 points, bold, justify)

↓(11 points)

<Tab> In front of the text of each title of sub-chapter with two indexes leave a one line empty space. In the text, each new paragraph is marked by the introduction of a „<Tab>”.

↓(11 points)

1.1.1. Sample of subtitle with 3 indexes (R_Times 12 points, bold, justify)

<Tab> If the work contains subtitles with three indexes, their text begins directly after subtitle without space. To emphasize the importance of certain words **within the text they can be entered only by marking them with bold text (without underlining).**

↓(11 points)

↓(11 points)

2. INSTRUCTIONS FOR PAPER TYPEWRITING

↓(11 points)

2.1. General aspects

↓(11 points)

<Tab> The works that do not comply with the instructions exactly will be rejected. Paper typewriting is binding in word processor Microsoft Word for Windows '95 / '97 / '98 / '2000, Version 6.0, Version 7.0, Windows NT. Only fonts R_Times (normal, bold, italic, ALL CAPS, or ALL CAPS) are used for typewriting. The paper is submitted in one copy, laser or ink get printed, and is accompanied by a floppy disk that will contain „doc files” of the paper and summary.

↓(11 points)

2.2. Page skeleton:

↓(11 points)

<Tab> Page skeleton is the following: Top: 2,0 cm; Bottom: 2,0 cm; Left: 2,0 cm; Right: 2,0 cm; Header: 1,75 cm; Footer: 0

↓(11 points)

2.3. Typewriting format of the paper text:

2.3.1. Writing in two-column format. The paper text, computing relations, figures and tables are inserted on two columns under this sample:

Number of Columns: 2; Width: 8.15 cm; Spacing: 0.7 cm.

<Tab> Where the text must contain embedded tables or figures that exceed the column width specified above, to maintain their clarity, you can enter on the page a work area in a single column (between two „session break”).

↓(11 points)

2.3.2. The format of writing paragraphs

<Tab> Text of the paper is drawn at a single line (single), all paragraphs are left / right aligned (justify).

2.3.3. Header

<Tab> The „Header” contains the full title of the paper (R_Times, 11 points, bold, italic, centered), **unless it exceeds one line, situation in which the title is written partially followed by....**

↓(11 points)

2.3.4. Fonts

<Tab> The text of the paper shall be written using only font R_Times,

11 points, normal, (eventual R_Times, 11 points, bold, if special highlights of text passages are necessary). Font R_TIMES, BOLD, ALL CAPS are used only for the title and the chapter titles of the paper.

↓(11 points)

2.3.5. Paper pagination

<Tab> **THE PAPER IS NOT PAGINATED, as it follows to be inserted in the journal.**

2.4. Figures, tables and mathematical formulas

2.4.1. Figures

<Tab> All figures are inserted in the file „paper.doc”. The maximum width of an inserted figure to the text (one column) cannot exceed the column width. All figures are numbered in Arabic numerals and presented according to the sample below. Before and after each figure inserted into the text leave one blank line. If images are inserted, they will be scanned with a minimum resolution of 300 dpi (600 dpi preferable), and will be edited such as to have good contrast. **It is not allowed sticking photos or drawings on separate sheets. If the figures have annotations in the form of numbers or letters they should have a height of letters equivalent to font R_Times, 11 points, normal, and under the title of figure the legend is inserted with necessary explanations.**

Figure 1. Systematic unitary concept of „R1 integrated in the environment...”. 1 – unity; 2 – ensemble...

↓(11 points)

2.4.2. Tables. Tables are numbered in Arabic numerals and presented according to the sample below.

Table 1. Sample of titrating a table.

↓(6 points)

Features /Measurements	Determ. Nr.1	Determ. Nr.2	Determ. Nr.3
------------------------	--------------	--------------	--------------

↓(11 points)

<Tab> Before and after each table included in the text leave one blank line... All grid lines forming the table have the same thickness (1 point). In the Table the text/figures are written using R_Times font, 11 points, and normal, **except the head of the table.**

↓(11 points)

2.4.3. Mathematical formulas. All mathematical formulas are written **COMPULSORY** with the equation editor of the word processor **Microsoft Word for Windows '95, '97, '98, 2000, (Version 6.0, / Version 7.0, 2000), bold, italic, centered according to the sample below.**

↓(6 points)

$$A^2+B^2=C^2$$

(1)

↓(6 points)

2.5. Reference. Before Reference leave two blank lines... (11 points). Between the title „Reference” and bibliographic references themselves leave one blank line. References are written according to the sample below:

Reference

(R_Times, 11 points, italic (in bold only the surname and name of author), justify. Sources in Cyrillic characters will be transliterated)

↓(11 points)

1. Nicolescu, A., Stanciu, M. Static capacity and elastic deformations of the guides // TCMM Conference, Chişinău, pages 141...148, 1996.

2. Nicolescu, A., Enciu, G. Design of industrial robots. Meridian Ingineresc No.1, Chişinău, pag.11...20, 1995.

3. Nicolescu A. Industrial robot // Patent no. 1344MD. BOP1 no. 10, 1999.

ABSTRACTS

<Tab> **For each paper submitted to be published in the journal, it is mandatory to draw up an abstract in ROMANIAN, ENGLISH, FRENCH and RUSSIAN. The abstract should contain a maximum of 10 lines and will be presented following the sample.**

Nicolescu A. Design of industrial robots. This paper....

<Tab> Abstracts are drawn **SEPARATELY from the paper and are submitted all in one file.**