MECHANICAL ENGINEERING TECHNOLOGY

DOI: 10.15587/2312-8372.2017.105634

DETERMINATION OF THE MAXIMUM COOLING CAPACITIES OF TWO-STAGE COOLERS WITH A VARIATION IN THE GEOMETRY OF BRANCHES IN STAGES

Page 4–10

Zaykov Vladimir, *PhD, Chief of Sector, Research Institute «STORM», Odesa, Ukraine, e-mail: gradan@i.ua, ORCID: http://orcid.org/0000-0002-4078-3519*

Mescheryakov Vladimir, *Doctor of Technical Sciences, Professor, Head of the Department of Informatics, Odessa State Environmental University, Ukraine, e-mail: gradan@ua.fm, ORCID: http://orcid.org/0000-0003-0499-827X*

Zhuravlov Yurii, *PhD, Senior Lecturer, Department of Technology of Materials and Ship Repair, National University «Odessa Maritime Academy», Ukraine, ORCID: http://orcid.org/0000-0001-7342-1031*

A model of the relationship between the reliability indices of two-stage TECs of various designs with the geometry of the branches of thermoelements in cascades in the ΔT_{max} mode with electrical series of cascades (stages) is proposed and analyzed. Relations are obtained for determining the optimal geometry of the branches of thermoelements in cascades corresponding to the maximum temperature difference. The expression allows to estimate both the maximum cooling capacities and the reliability indices of two-stage thermoelectric cooling devices of various designs. The possibility of increasing the maximum temperature drop to 4 % is shown by choosing the optimal geometry of the branches of thermoelements in cascades (stages). This is achieved under the condition that the ratio of the length to the cross-sectional area of the elements of the first stage is greater than the ratio of the length to the cross-sectional area of the second stage, which differs from the traditional equality of these ratios for a given working current. The proposed approach makes it possible to estimate the maximum temperature drop and to predict the reliability indices of two-stage thermoelectric coolers of various designs for various operating conditions and to conduct an optimized design of radio electronic equipment using cascade thermoelectric cooling devices.

Keywords: thermoelectric cooling device, geometry of the branch of thermoelements, maximum temperature drop, cooler designs.

References

1. Zebarjadi, M., Esfarjani, K., Dresselhaus, M. S., Ren, Z. F., Chen, G. (2012). Perspectives on thermoelectrics: from fundamentals to device applications. *Energy & Environmental Science, 5 (1),* 5147–5162. doi:10.1039/c1ee02497c
2. Jurgensmeyer, A. L. (2011). *High Efficiency Thermoelectric Devices Fabricated Using Quantum Well Confinement Techniques*. Colorado State University, 54.
3. Tsai, H.-L., Le, P. T. (2016). Self-sufficient energy recycling of light emitter diode/thermoelectric generator module for its active-cooling application. *Energy Conversion and Management, 118,* 170–178. doi:10.1016/j.enconman.2016.03.077
4. In: Rowe, D. (2012). Materials, Preparation, and Characterization in Thermoelectrics. *Thermoelectrics and Its Energy Harvesting, 2 Volume Set*. Boca Raton: CRC Press, 544. doi:10.1201/b11891
5. Zaykov, V., Kirshova, L., Moiseev, V. (2009). *Prediction of reliability on thermoelectric cooling devices. Book 1. Single-stage devices*. Odessa: Politehperiodika, 120.
6. Zaikov, V., Kinshova, L., Moiseev, V., Kazanzhi, L. (2009). Prediction of reliability indices of a two-stage thermoelectric cooling device in the ΔT_{max} mode. *Technology and design in electronic equipment, 4,* 45–47.
7. Zaykov, V., Mescheryakov, V., Zhuravlov, Yu. (2016). *Prediction of reliability on thermoelectric cooling devices. Book 2. Cascade devices*. Odessa: Politehperiodika, 124.
8. Brown, S. R., Kauzlarich, S. M., Gascoin, F., Snyder, G. J. (2006). Yb14MnSb11: New High Efficiency Thermoelectric Material for Power Generation. *Chemistry of Materials, 18 (7),* 1873–1877. doi:10.1021/cm060261t
9. Riffat, S. B., Ma, X. (2004). Improving the coefficient of performance of thermoelectric cooling systems: a review. *International Journal of Energy Research, 28 (9),* 753–768. doi:10.1002/er.991
10. Gromov, G. (2014). Obiemnye ili tonkoplenochnye termoelektricheskie moduli. *Komponenty i tehnologii, 9,* 38.
11. Mischenko, A. S. (2006). Giant Electrocaloric Effect in Thin-Film PbZr0.95Ti0.05O3. *Science, 311 (5765),* 1270–1271. doi:10.1126/science.1123811
12. Singh, R. (2008). *Experimental Characterization of Thin Film Thermoelectric Materials and Film Deposition VIA Molecular Beam Epitaxial*. University of California, 54.
13. Kruglyak, Yu. A. (2013). Landauer-Datta-Lundstrom Generalized Electron Transport Model. *Nanosystems, Nanomaterials, Nanotechnologies, 11 (3),* 519–549.
14. Sootsman, J. R., Chung, D. Y., Kanatzidis, M. G. (2009). New and Old Concepts in Thermoelectric Materials. *Angewandte Chemie International Edition, 48 (46),* 8616–8639. doi:10.1002/anie.200900598
15. Nesterov, S. B., Kholopkin, A. I. (2014). Evaluation of the possibility of increasing the thermoelectric quality of nanostructured semiconductor materials for refrigeration equipment. *Refrigerating Technique, 5,* 40–43.
16. Gorskyi, P. (2014). *Layered structure effects as realisation of anisotropy in magnetic, galvanomagnetic and thermoelectric phenomena, 14*. New York: Nova Publishers, 352.
17. Sano, S., Mizukami, H., Kaibe, H. (2003). Development of high-efficiency thermoelectric power generation system. *KOMATSU Technical Report, 49 (152),* 1–7.
18. DiSalvo, F. J. (1999). Thermoelectric Cooling and Power Generation. *Science, 285 (5428),* 703–706. doi:10.1126/science.285.5428.703
19. Wereszczak, A. A., Wang, H. (2011). Thermoelectric Mechanical Reliability. *Vehicle Technologies Annual Merit Reviewand Peer Evaluation Meeting*. Arlington, 18.
20. *Thermoelectric Cooler Reliability Report*. (2002). Melcor Corporation, 36.
21. Choi, H.-S., Seo, W.-S., Choi, D.-K. (2011). Prediction of reliability on thermoelectric module through accelerated life test and Physics-of-failure. *Electronic Materials Letters, 7 (3),* 271–275. doi:10.1007/s13391-011-0917-x

DOI: 10.15587/2312-8372.2017.105635

INVESTIGATION OF THE METHOD OF DECOMPOSITION OF A COMPLEX SCIENCE-INTENSIVE INSTRUMENT-MAKING DEVICE FOR THE FORMATION OF A RATIONAL STRATEGY FOR ITS MODERNIZATION

page 11–16

Shevchenko Tetiana, *Department of Theoretical Mechanics, Mechanical Engineering and Robotic Systems, Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Ukraine, ORCID: http://orcid.org/0000-0003-1296-4600*

Sobchak Andrey, *PhD, Associate Professor, Department of Management, Zhukovsky National Aerospace University «Kharkiv*

Aviation Institute», Ukraine, e-mail: sobchak@ukr.net, ORCID: http://orcid.org/0000-0002-0006-6240

Shostak Igor, *Doctor of Technical Sciences, Professor, Department of Computer Engineering, Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Ukraine, e-mail: iv.shostak@ukr.net, ORCID: http://orcid.org/0000-0002-6428-2831*

Popova Olga, *Commercial Director, Limited Liability Company Scientific-Production Enterprise «KIATON», Kharkiv, Ukraine, e-mail: Batbkivna@ukr.net, ORCID: http://orcid.org/0000-0002-0310-4388*

Morozova Olga, *PhD, Associate Professor, Department of Theoretical Mechanics, Mechanical Engineering and Robotic Systems, Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Ukraine, e-mail: oligmorozova@gmail.com, ORCID: http://orcid.org/0000-0002-0604-9927*

The object of research is the life cycle of products (a complex equipment object) of a manufacturing enterprise. Each product has its own life cycle, i. e., time interval, expiration date. In Ukraine, it is a period of 5 years. All the problems of enterprises lie in this fact. The current situation in the country does not allow enterprises to update their production capacity every 5 years, and therefore it is the most problematic place. To solve this problem, a method for decomposing an object of complex equipment (OCE), which allows to determine the necessary, morally outdated component in the OCE, and modernize it to a more modern – innovative. It also allows to extend such stage of the product life cycle as – operation, adding additional functions and (or) capabilities to the product. In this case, of course, there is a risk, which is to correctly identify the necessary element of modernization. For this purpose, a mathematical apparatus is applied in the work, which unlike others, allows to decompose the OCE with the greatest accuracy.

The author laid the foundation in the cardinal sense with respect to the ecological component, as well as the duration of the product life cycle, which theoretically can last for infinity and requires a deeper and more detailed study.

Keywords: complex science-intensive product, service life of the product, modernization path, object of complex equipment.

References

1. *Filosofiia sovremennogo nauchno-tehnicheskogo razvitiia.* Available: https://www.zubolom.ru/lectures/philosophy3/57.shtml
2. Surkova, L. E. (2011). Struktura sistemnogo analiza. *Sistemnyi analiz v servise.* Available: http://www.studfiles.ru/preview/3176323/
3. Sobchak, A. P., Popova, O. I. (2016). Informatsionnaia podderzhka etapa utilizatsii izdelii slozhnoi naukoemkoi tehniki. *Systemy upravlinnia, navihatsii ta zviazku, 4 (40),* 47–54.
4. Vnukova, N. V., Goroh, N. P., Suhorukov, I. E., Gorbik, Yu. Yu. *Problemy i perspektivy kompleksnoi utilizatsii munitsipal'nyh othodov g. Har'kova.* Available: https://cyberleninka.ru/article/n/problemy-i-perspektivy-kompleksnoy-utilizatsii-munitsipalnyh-othodov-g-harkova
5. Kuznetsova, L. P. (2009). Problema utilizatsii otrabotannyh motornyh masel. *Molodoi uchenyi, 10,* 60–63.
6. Li, D. (2016). Review of Recycling and Processing of Waste Electronic Equipment. *Proceedings of the 2016 International Conference on Education, Management and Computing Technology (ICEMCT-16).* Atlantis Pres. doi:10.2991/icemct-16.2016.219
7. Menad, N.-E. (2016). Physical Separation Processes in Waste Electrical and Electronic Equipment Recycling. *WEEE Recycling,* 53–74. doi:10.1016/b978-0-12-803363-0.00003-1
8. Usik, I. Y., Kharitonov, R. T. (1962). Modernization of mechanical and electrical equipment. *Metallurgist, 6 (7),* 331–333. doi:10.1007/bf00734951
9. Cheibub, J. A., Vreeland, J. R. (2016). *Modernization Theory. Oxford Handbooks Online.* Oxford University Press. doi:10.1093/oxfordhb/9780199845156.013.26
10. Dobrov, P. P. (2016). Monitoring of the performance efficiency of the equipment at the enterprises of aviation instrumentation. *MIR (Modernization Innovation Research), 7(2(26)),* 208–211. doi:10.18184/2079-4665.2016.7.2.208.211
11. Legarth, J. B., Erichsen, H., Gregersen, J. C. (1997). Re-design of electromechanical products for re-use and recycling. *Life Cycle Networks,* 215–224. doi:10.1007/978-1-4615-6381-5_18
12. Mann, R. D. (1995). The economics of equipment recycling. International *Conference on Clean Electronics Products and Technology (CONCEPT).* doi:10.1049/cp:19951175
13. Wang, S. (2002). Study on the recycling technology of mechatronic products. *Chinese Journal of Mechanical Engineering, 38 (supp),* 76. doi:10.3901/jme.2002.supp.076
14. Sobchak, A. P., Shostak, I. V., Pavlenko, V. N., Popova, O. I. (2016). Informatsionnaia tehnologiia avtomatizatsii tehnologicheskoi podgotovki virtual'nogo proizvodstva predpriiatiia. *Systemy upravlinnia, navihatsii ta zviazku, 3 (39),* 118–125.
15. Sobchak, A. P., Popova, O. I. (2016). Modelirovanie povedeniia litsa prinimaiushchego resheniia na virtual'nom predpriiatii. Primenenie modelei v informatsionnyh tehnologiiah. *Visnyk natsionalnoho tekhnichnoho universytetu «KhPI». Ser. Avtomatyzatsiia ta upravlinnia mekhaniko-tekhnolohichni systemy ta kompleksy, 7 (1179),* 72–77.

METALLURGICAL TECHNOLOGY

DOI: 10.15587/2312-8372.2017.104769

ANALYSIS OF TECHNOLOGICAL DAMAGEABILITY OF CASTINGS MANUFACTURED IN SAND MOLDS

page 17–23

Kuzin Oleg, *PhD, Associate Professor, Department of Applied Material Science and Materials Engineering, National University «Lviv Polytechnic», Ukraine, ORCID: http://orcid.org/0000-0003-3669-0237*

Kusyj Jaroslav, *PhD, Associate Professor, Department of Mechanical Engineering Technology, National University «Lviv Polytechnic», Ukraine, e-mail: jarkym@ukr.net, ORCID: http://orcid.org/0000-0001-5741-486X*

Kuzin Nikolai, *Doctor of Technical Sciences, Associate Professor, Lviv Branch of V. Lazaryan Dnipropetrovsk National University of Railway Transport, Lviv, Ukraine, ORCID: http://orcid.org/0000-0002-6032-4598*

In order to assess the process of accumulation of damages in billets obtained by casting in sand molds, studies of castings made from an aluminum alloy are conducted. Analysis of the physical heterogeneity of the material is carried out on the basis of the microstructural studies, as well as the LM hardness method. It is shown that it is expedient to evaluate the technological damageability of various zones of cast billets with complex spatial geometry that contain massive thermal assemblies and thin walls, according to the dispersion degree of the hardness characteristics. The technological damageability of billets obtained in sand molds varies widely and mainly depends on the conditions of crystallization of their individual volumes:

– distribution of temperature fields;

– direct heat reducing;

– features of the metal feeder with a liquid phase during crystallization.

The influence of the mold design on the formation of technological damage is analyzed. Increasing the distance from the feeder promotes growth, and accelerated crystallization and directed heat removing promote reduce in technological damage to the volume of the casting when cured. Damageability of the material of cast billets serves as a parameter that is quantitatively evaluates the reliability characteristics of products, and its definition allows to formulate new approaches to the selection of foundry alloys and improve casting technologies to increase their operational durability. On the basis of the conducted studies it is established that the technological damageability is 1.3–6.5 times higher than for the base material in the near-surface layer at a depth of 2 mm.

Keywords: technological damageability, Weibull homogeneity coefficient, accelerated crystallization, liquid phase, foundry defects.

References

1. Kusyj, J. (2002). *Tekhnolohichne zabezpechennia fizyko-mekhanichnykh parametriv poverkhnevykh shariv metalevykh dovhomirnykh tsylindrychnykh detalei vibratsiino-vidtsentrovym zmitsnenniam*. Lviv, 260.
2. Kusyj, J., Kuk, A. (2015). Method devised to improve technological reliability of machine parts. *Eastern-European Journal of Enterprise Technologies, 1(7(73))*, 41–51. doi:10.15587/1729-4061.2015.36336
3. Kusyj, J., Kuzin, O., Kuzin, N. (2016). The dependence of intergrain damageability of casting on the technological treatment route. Eastern-European *Journal of Enterprise Technologies, 1(5(79))*, 39–47. doi:10.15587/1729-4061.2016.59845
4. Kuzin, N. (2015). Ob odnoi matematicheskoi modeli izmeneniia ekspluatatsionnyh svoistv materiala. *Prikladnaia mehanika, 51 (4)*, 125–132.
5. Suslov, A. G. (2000). *Kachestvo poverhnostnogo sloia detalei mashin*. Moscow: Mashinostroenie, 320.
6. In: Suslov, A. G. (2008). *Inzheneriia poverhnosti detalei*. Moscow: Mashinostroenie, 320.
7. Pronikov, A. S. (1978). *Nadezhnost' mashin*. Moscow: Mashinostroenie, 592.
8. Hrulindik, D. S., Petrovskii, E. A. (2011). FMEA – instrument vliianiia na kachestvo protsessov obsluzhivaniia proizvodstva. *Sovremennye problemy nauki i obrazovaniia, 6*, 39.
9. Kuzin, O., Kusyj, J., Topilnytskyj, V. (2015). Influence of technological heredity on reliability parameters of products. *Technology Audit and Production Reserves, 1(1(21))*, 15–21. doi:10.15587/2312-8372.2015.37678
10. Yashcheritsyn, P. I., Ryzhov, E. V., Averchenko, V. I. (1977). *Tehnologicheskaia nasledstvennost' v mashinostroenii*. Minsk: Nauka i tehnika, 256.
11. Bozhydarnik, V. V., Hryhorieva, N. S., Shabaikovych, V. A. (2006). *Tekhnolohiia vyhotovlennia detalei vyrobiv*. Lutsk: Nadstyria, 612.
12. Ogorodnikova, O. M. (2012). Possibilities of Siemens PLM software for robotics research and production management. *Proceedings of Russian-Korea scientific workshop «Advanced computer and information technologies»*. Ekaterinburg: UrFU, 122–128.
13. Skoogh, A., Perera, T., Johansson, B. (2012). Input data management in simulation – Industrial practices and future trends. *Simulation Modelling Practice and Theory, 29*, 181–192. doi:10.1016/j.simpat.2012.07.009
14. Wang, L. (2013). Data Representation of Machine Models. *Dynamic Thermal Analysis of Machines in Running State*. London: Springer-Verlag, 11–29. doi:10.1007/978-1-4471-5273-6_2
15. McDowell, D. L. (2007). Simulation-assisted materials design for the concurrent design of materials and products. *Journal of the Minerals, Metals and Materials Society, 59 (9)*, 21–25. doi:10.1007/s11837-007-0111-7
16. Dalskii, A. M. (1975). *Tehnologicheskoe obespechenie nadezhnosti vysokotochnyh detalei mashin*. Moscow: Mashinostroenie, 319.
17. Durham, S. D., Padgett, W. J. (1997). Cumulative Damage Models for System Failure with Application to Carbon Fibers and Composites. *Technometrics, 39 (1)*, 34–44. doi:10.2307/1270770
18. McEvily, A. J. (2013). *Metal Failures: Mechanisms, Analysis, Prevention. Ed. 2*. John Wiley & Sons, 480. doi:10.1002/9781118671023
19. In: Zohdi, T. I., Wriggers, P. (2005). An Introduction to Computational Micromechanics. *Lecture Notes in Applied and Computational Mechanics*. Springer, 198. doi:10.1007/978-3-540-32360-0
20. Kundu, T. (2008). *Fundamentals of Fracture Mechanics*. Boca Raton, FL, USA: CRC Press, Taylor and Francis Group, 304.
21. Lebedev, A. A., Muzyka, N. R., Volchek, N. L. (2003). Metod diagnostiki sostoianiia materiala po parametram rasseianiia harakteristik tverdosti. *Zavodskaya Laboratoriya. Diagnostika Materialov, 12*, 49–51.
22. Lebedev, A. A., Muzyka, N. R., Volchek, N. L. (2003). A new method of assessment of material degradation during its operating time. *Zaliznychnyi Transport Ukrainy, 5*, 30–33.

DOI: 10.15587/2312-8372.2017.105636

DEVELOPMENT OF A SYSTEM FOR ORGANIZING A MODULAR DESIGN AND TECHNOLOGICAL PREPARATION FOR THE PRODUCTION OF CAST IRON PISTONS FOR INTERNAL COMBUSTION ENGINES

page 23–27

Puliaiev Anton, *Postgraduate Student, Department of Foundry Production, National Technical University «Kharkiv Polytechnic Institute», Ukraine, e-mail: antonpuliyaev@gmail.com, ORCID: http://orcid.org/0000-0002-8785-1582*

Orendarchuk Julia, *Postgraduate Student, Department of Foundry Production, National Technical University «Kharkiv Polytechnic Institute», Ukraine, e-mail: Juliaorendarchuk@gmail.com, ORCID: http://orcid.org/0000-0002-8184-906X*

Penziev Pavel, *Assistant, Department of Foundry Production, National Technical University «Kharkiv Polytechnic Institute», Ukraine, e-mail: djpenzev@gmail.com, ORCID: http://orcid.org/0000-0003-0402-9575*

Akimov Oleg, *Doctor of Technical Sciences, Professor, Head of the Department of Foundry Production, National Technical University «Kharkiv Polytechnic Institute», Ukraine, ORCID: http://orcid.org/0000-0001-7583-9976*

Marynenko Dmytro, *Department of Foundry Production, National Technical University «Kharkiv Polytechnic Institute», Ukraine, e-mail: prostooelementary@gmail.com, ORCID: http://orcid.org/0000-0001-7720-9222*

Marchenko Andriy, *Doctor of Technical Sciences, Professor, Vice-rector for Scientific-and-Research Work, National Technical University «Kharkiv Polytechnic Institute», Ukraine, ORCID: http://orcid.org/0000-0001-9746-4634*

Modern engine building requires a significant increase in power, fuel efficiency and ensuring high environmental performance of internal combustion engines (ICE). When forcing the operating modes of diesel engines, one of the most loaded engine parts becomes a piston, due to a significant increase in mechanical and thermal stresses. With increasing load on the piston, the difficulty of meeting the high demands for them increases. When creating modern ICE and improving the quality of existing ones, special attention is paid to the design and technological preparation of the production of pistons, which is the object of research. Pistons determine the reliability and life of the engine as a whole.

To solve this problem, all the main works related to the design and manufacture of cast-iron pistons are proposed to divide into separate modules, performed simultaneously in three areas:

organizational, design and technological. These modules are integral sectors of a single modular system for organizing design and technological preparation for production of cast iron pistons. Modeling of the stressed-strain state of monolithic cast-iron pistons is considered for an example of implementation of one of the modules. The results of calculations of the stress-strain state and the temperature distribution field in the body of the piston are presented. The results show that the maximum temperature is 315 °C and concentrated on the edge of the combustion chamber. The stress does not exceed 617 MPa.

Keywords: modular system, ICE piston, vermicular graphite, stress-strain state, aluminum CGI.

References

1. Engelke, W. D. (1987). *How to Integrate CAD/CAM Systems: Management and Technology (Mechanical Engineering)*. CRC Press, 400.
2. Bazrov, B. M. (2001). *Modul'naia tehnologiia v mashinostroenii*. Moscow: Mashinostroenie, 368.
3. Puliaev, A. A., Akimov, O. V., Taran, B. P. (2016). Aliuminievyi ChVG – material dlia porshnei forsirovannyh dizel'nyh DVS. *Liteinoe proizvodstvo, 1,* 14–16.
4. Taran, B. P., Akimov, O. V., Marchenko, A. P. (2010). Otsenka termicheskoi vynoslivosti materialov porshnei DVS. *Dvigateli vnutrennego sgoraniia, 1,* 70–72.
5. Belogub, A. V. (2011). *Nauchno-tehnicheskie osnovy integrirovannogo proektirovaniia i proizvodstva tonkostennyh porshnei DVS*. Kharkov, 469.
6. Zotov, A. A. (2010). *Sovershenstvovanie tehnologii proektirovaniia tonkostennyh porshnei DVS s prinuditel'nym zazhiganiem*. Kharkov, 150.
7. Lu, Y., Zhang, X., Xiang, P., Dong, D. (2017). Analysis of thermal temperature fields and thermal stress under steady temperature field of diesel engine piston. *Applied Thermal Engineering, 113,* 796–812. doi:10.1016/j.applthermaleng.2016.11.070
8. Liu, X. F., Wang, Y., Liu, W. H. (2017). Finite element analysis of thermo-mechanical conditions inside the piston of a diesel engine. *Applied Thermal Engineering, 119,* 312–318. doi:10.1016/j.applthermaleng.2017.03.063
9. Ong, J. H. (1990). Steady state thermal analysis of a diesel engine piston. *Computers in Industry, 15 (3),* 255–258. doi:10.1016/0166-3615(90)90024-j
10. Zhang, H., Lin, Z., Xing, J. (2013). Temperature field analysis to gasoline engine piston and structure optimization. *Journal of Theoretical and Applied Information Technology, 48 (2),* 904–909.
11. Spaniel, M., Macek, J., Divis, M., Tichanek, R. (2003). Diesel engine head steady state analysis. *International Journal of Middle European Construction and Design of Cars, 2 (3),* 34–41.
12. Tichanek, R., Spaniel, M., Divis, M. (2003). Steady state heat analysis of engine head. *International Journal of Széchenyi István University of Applied Sciences, 20 (3),* 74–75.

MATERIALS SCIENCE

DOI: 10.15587/2312-8372.2017.104807

RESEARCH OF ELECTRICAL PROPERTIES OF EPOXY COMPOSITE WITH CARBON FILLERS

page 28–34

Melnyk Liubov, *PhD, Senior Lecturer, Department of Chemical Technology of Composites, National Technical University of Ukraine «Ihor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: luba_xtkm@ukr.net, ORCID: http://orcid.org/0000-0001-5139-3105*

The object of research in this study is electroconductive epoxy compositions with carbon fillers. Based on the porous structure of the filler, the technology of manufacturing composite materials in the form of films using ultrasound is proposed. The effect of the type and content of the carbon filler on the electrical properties of the epoxy composite is investigated. It is found that the resistivity in the direction perpendicular to the axis of formation of samples with content of thermally expanded graphite (normal and after ultrasonic grinding at room temperature) can reach $7.5 \cdot 10^{-6}$ Ω·m, while for carbon nanotubes is $5.1 \cdot 10^{-8}$ Ω·m. It is found that the percolation threshold for systems of epoxy resin – thermally expanded graphite is ~5 wt. %, and for epoxy resin systems – carbon nanotubes is ~1 wt. %. Research results of the effect of carbon filler on the dielectric properties of epoxy composite are presented. It is experimentally established that as the filler concentration increases, the dielectric constant increases in the polymer matrix. A sharp increase in the dielectric constant of research systems is observed with a CNT concentration of 1 %. An increase in the dielectric losses of the orientational polarization is observed as the frequency of the alternating current increases to 10^5 Hz.

Keywords: carbon nanotubes, epoxy composite, thermally expanded graphite, resistivity, dielectric constant.

References

1. Trenisova, A. L. (2009). *Poluchenie kompozitsionnyh materialov na osnove epoksidnogo oligomera i nanonapolnitelei*. Moscow, 16.
2. Meleshko, A. I., Polovnikov, S. P. (2007). *Uglerod, uglerodnye volokna, uglerodnye kompozity.* Moscow: SAINS-PRESS, 192.
3. Melnyk, L. I. (2009). *Zakonomirnosti formuvannia i zastosuvannia termostiikykh strumoprovidnykh syloksanhrafitovykh materialiv.* Kyiv, 167.
4. Asai, K., Okamoto, M., Tashiro, K. (2008). Crystallization behavior of nano-composite based on poly(vinylidene fluoride) and organically modified layered titanate. *Polymer, 49 (19), 4298*–4306. doi:10.1016/j.polymer.2008.07.037
5. Hagedorn, H.-W., Lower, Y., Dickel, T., Stenger, K., Yong, L. X., Teo, K. W., Fritzsche, S., Schafer, M.; Assignee: Heraeus Deutschland GMBH&Co. Kg, Heraeus Materials Singapore Pte., Ltd. (2016, February 04). Epoxy resin-based electroconductive composition. *WIPO Patent Application WO/2016/018191.* Appl. № SG2015/000131. Filed June 19, 2015. Available: http://www.sumobrain.com/patents/wipo/Epoxy-resin-based-electroconductive-composition/WO2016018191A1.html
6. Chung, S.-L., Lin, J.-S. (2016). Thermal Conductivity of Epoxy Resin Composites Filled with Combustion Synthesized h-BN Particles. *Molecules, 21 (5),* 670. doi:10.3390/molecules21050670
7. Gu, J., Zhang, Q., Dang, J., Xie, C. (2011). Thermal conductivity epoxy resin composites filled with boron nitride. *Polymers for Advanced Technologies, 23 (6),* 1025–1028. doi:10.1002/pat.2063
8. Wattanakul, K., Manuspiya, H., Yanumet, N. (2010). Effective surface treatments for enhancing the thermal conductivity of BN-filled epoxy composite. *Journal of Applied Polymer Science, 119 (6),* 3234–3243. doi:10.1002/app.32889
9. Kim, K., Kim, J. (2014). Fabrication of thermally conductive composite with surface modified boron nitride by epoxy wetting method. *Ceramics International, 40 (4),* 5181–5189. doi:10.1016/j.ceramint.2013.10.076
10. Gladkikh, S. N., Kuznetsova, L. I., Naumova, L. I., Vyalov, A. I. (2009). Heat-conducting adhesives based on modified epoxy resins. *Polymer Science. Series D, 2 (4),* 238–242. doi:10.1134/s1995421209040108
11. Shirshova, N., Bismarck, A., Greenhalgh, E. S., Johansson, P., Kalinka, G., Marczewski, M. J., Shaffer, M. S. P., Wienrich, M. (2014). Composition as a Means To Control Morphology and Properties of Epoxy Based Dual-Phase Structural Electrolytes.

The Journal of Physical Chemistry C, 118 (49), 28377–28387. doi:10.1021/jp507952b
12. Kats, E. A. (2008). *Fullereny, uglerodnye nanotrubki i nanoklastery: Rodoslovnaia form i idei*. Moscow: LKI, 296.
13. Diachkov, P. N. (2006). *Uglerodnye nanotrubki: stroenie, svoistva, primeneniia*. Moscow: BINOM, Laboratoriia znanii, 293.
14. Harris, P. J. F. (1999). *Carbon Nanotubes and Related Structures: New Materials for the Twenty-first Century.* Cambridge University Press, 279. doi:10.1017/cbo9780511605819
15. Suhno, I. V., Buzko, V. Yu. (2008). *Uglerodnye nanotrubki. Part 1. Vysokotehnologichnye prilozheniia*. Krasnodar: KubGU, 55.
16. Chernysh, I. H. (1994). Pryrodnyi hrafit ta materialy na yoho osnovi. *Khimichna promyslovist Ukrainy, 4,* 4–8.
17. Melnyk, L. I., Volynets, R. P., Budya, D. O. (2010). Structure, physical and chemical properties of natural and reinforced graphites. *Research Bulletin of NTUU «KPI», 6,* 141–146.
18. Melnyk, L. I., Budya, D. O., Vasylieva, O. O. (2012). Strumoprovidni kompozytsii na osnovi vuhletsevykh napovniuvachiv i epoksydnoho zviazuiuchoho. *Tezy dopovidei VI Mizhnarodnoi naukovo-tekhnichnoi web-konferentsii «Kompozytsiini materialy»*. Kyiv, 165–167.
19. Tsurul, M. F., Kharkov, Ye. Y., Matsui, L. Yu., Vovchenko, L. L., Morozovska, N. O. (16.07.2001). Method for obtaining metallized thermally expanded graphite. *Patent of Ukraine № 40256, MPK C01B31/04*. Appl. № 2000116217. Filed. 02.11.2000. Bull. № 6. Available: http://uapatents.com/3-40256-sposib-oderzhannya-metalizovanogo-termorozshirenogo-grafitu.html
20. Kariakina, M. I. (1977). *Laboratornyi praktikum po ispytaniiu lakokrasochnyh materialov i pokrytii*. Moscow: Khimiia, 240.

DOI: 10.15587/2312-8372.2017.105637

INVESTIGATION OF SURFACED PRESS MOLDS MADE ITS WORKING RESOURCE

page 34–38

Blokhina Inna, *Postgraduate Student, Department of Equipment and Technologies of Welding Production, Donbass State Machine-Building Academy, Kramatorsk, Donetsk region, Ukraine, ORCID: http://orcid.org/0000-0003-4831-8870*

The object of research is the repair of press molds with the help of plasma-MIG surfacing. The weld metal on the repaired press molds wears out unevenly, has a different structure and hardness, which is characteristic of multi-layer surfacing of alloyed steels. The greatest way to manage the storage and quality of surfacing is a combined method – plasma-MIG surfacing. An analysis is made of all plasma-MIG surfacing options for surfacing in order to strengthen the surfaces in the repair and manufacture of products operating under thermal cyclic loads. It is established that when restoring press molds working under thermocyclic loads, to ensure uniform hardness over the cross-section of the welded metal layer, the surfacing should be carried out with a minimum step in the optimum operating regime: α_H=16–19 g/A·h. $\psi_{B.S}$=4–5 %; K_V=91 %. It has been experimentally proved that in order to reduce the width of the eutectic sections that is distinguished along the grain boundaries, and hence also the decrease in the probability of crack formation in the deposited layer, the plasma-MIG surfacing on the developed unit should be carried out at the lowest possible current I=75–90 A. This will significantly increase the crystallization rate of the deposited metal.

Keywords: plasma-MIG surfacing, flux-cored wire, structural heterogeneity of surfaced metal, working capacity of press molds.

References

1. Vlasov, A. F., Kuznetsov, V. D., Makarenko, N. O., Bohutskyi, O. A. (2010). *Naplavlennia*. Kramatorsk, 332.
2. Chyharov, V. V., Makarenko, N. O., Kondrashov, K. A. (2001). Doslidzhennia strukturnoi neodnoridnosti naplavlenoho metalu i yii vplyv na pratsezdatnist pres-form. *Pratsi 11 Mizhnarodnoi naukovoi konferentsii «Suchasni problemy elektrometalurhii stali»,* 102–103.
3. Makarenko, N. O. (1998). Udoskonalennia plazmotrona i ustanovky dlia plazmovoho naplavlennia. *Avtomaticheskaia svarka, 1,* 40–43.
4. Makarenko, N., Kondrashov, K. (2001). Vosstanovlenie i ukreplenie shtampov i press-form. *Sovershenstvovanie protsessov i oborudovaniia obrabotki davleniem v metallurii i mashinostroenii,* 101–103.
5. Makarenko, A., Chigariov, V., Kondrashov, K. (2001). Issledovanie strukturnoi neodnorodnosti naplavlennogo metalla i ego vliianie na rabotosposobnost' press-form. *Tezisy dokladov XI mezhdunarodnoi nauchnoi konferentsii. – Cheliabinsk,* 102–103.
6. Makarenko, A., Kornienko, A., Kondrashov, K. (2001). Preimushchestva ukrepleniia i vosstanovleniia press-form dlia stekla sposobom plazma-MIG naplavki. *Materialy mezhdunarodnoi nauchno-tehnicheskoi konferentsii «Inzheneriia poverhnosti i renovatsiia izdelii»*. Feodosiia, 126–128.
7. North, R. W. (1980). Molded curved drums and molds therefor. *The Journal of the Acoustical Society of America, 67 (6),* 2132–2132. doi:10.1121/1.384363
8. Zu-bao, Z. (1986). Micro-beam plasma arc powder surfacing. *Advances in Thermal Spraying.* Elsevier, 727–736. doi:10.1016/b978-0-08-031878-3.50080-0
9. Zhu, S., Guo, Y., Yang, P. (2005). Remanufacturing system based on totally automatic MIG surfacing via robot. *Journal of Central South University of Technology, 12 (2),* 129–132. doi:10.1007/s11771-005-0024-y
10. Zu-bao, Z. (1986). Micro-beam plasma arc powder surfacing. *Advances in Thermal Spraying,* 727–736. doi:10.1016/b978-0-08-031878-3.50080-0
11. Chyharov, V. V., Makarenko, N. O., Kondrashov, O. V., Hranovskyi, O. V., Hranovskyi, M. O. (15.07.2003). Ustanovka dlia plazmovoho naplavlennia. Patent *of Ukraine № 58462A: MKI V23K9/04*. Appl. № 20021210534. Filed 24.12.2002. Bull. № 7, 5.
12. Chyharov, V. V., Makarenko, N. O., Kondrashov, K. O., Hranovskyi, O. V. (17.09.2001). Zvariuvalna ustanovka. *Patent of Ukraine № 41618: MKI V23K9/00*. Appl. № 2000116282. Filed 07.11.2000. Bull. № 8, 4.
13. Chyharov, V. V., Makarenko, N. O., Kondrashov, K. O., Hranovskii, M. O. (15.07.2002). Ustanovka plazmovoho naplavlennia. Patent of Ukraine № 47627A MKI V23K10/10: MKI V23K10/10. Appl. № 2001053573. Filed 15.05.2001. Bull. № 7, 4.

DOI: 10.15587/2312-8372.2017.105678

INVESTIGATION OF THE INFLUENCE OF ORGANOMINERAL ADDITIVES ON THE COLLOID-CHEMICAL PROPERTIES OF GEOCEMENT DISPERSION

page 38–43

Guzii Sergii, *PhD, Senior Researcher, V. D. Glukhovsky Scientific Research Institute for Binders and Materials, Kyiv National University of Construction and Architecture, Ukraine, e-mail: sguziy@ukr.net, ORCID: http://orcid.org/0000-0003-0147-5035*

The object of research is the geocement dispersion of the heulandite-clinoptilolite composition of the structural formula $Na_2O{\cdot}Al_2O_3{\cdot}6SiO_2{\cdot}20H_2O$, modified with an organomineral additive

The results of the effect of an organomineral additive on the colloidal-chemical properties of geocement dispersion are presented. Mathematical models that characterize the effect of the concentrations of constituent organomineral additives on changes in its basic physical and colloidal chemical properties are obtained:

– conventional viscosity;
– density;
– wetting angle;

– surface tension;

– works of adhesion, cohesion and wetting of geocement dispersions, factors $X1...X3$ have an influence that are significant. Also, the joint effect of factors, respectively, $x1x2x3$, $x1x2$, $x1x2$ and $x1x3$ has a significant effect.

The coefficients of wetting and spreading of geocement dispersions are significantly influenced only by the joint action of the factors $x1x2x3$.

Relationship is established between the conditional viscosity and the wetting coefficient, between the wetting angle, adhesion, wetting and spreading work and between the density, surface tension and work of cohesion. The composition of the organomineral additive is optimized and the areas of permissible concentrations of its constituents are determined:

– along the $X1$ axis, 2–2.3 % of polymer RI-551Z;

– along the $X2$ axis, 2.1–2.5 % of microcalcite;

– along the $X3$ axis, 4.5–6.5 % of aluminate cement, which, when introduced into a geocement dispersion, allows $Na_2O{\cdot}Al_2O_3{\cdot}6SiO_2{\cdot}20H_2O$ to stabilize its colloidal-chemical properties.

It is determined that the changes in the values of the other output parameters are tied to the change:

– the conditional viscosity and their values are in the following limits:

$\rho = 1.571–1.766$ g/cm^3, $\cos\Theta = 0.50–0.67$;

– surface tension $\sigma = 114–128$ mN/m;

– works of adhesion, wetting and cohesion, respectively, 184–204 mN/m;

– coefficients of wetting and spreading –0.77–(–)0.84, –37–(–)55 mN/m.

Keywords: geocement dispersion, optimization of organomineral additive composition, colloid-chemical properties.

References

1. Boxley, C., Nair, B., Balaguru, P. (2008). Practical Applications of Geopolymers. *Developments in Porous, Biological and Geopolymer Ceramics,* 321–336. doi:10.1002/9780470339749.ch29
2. Korneev, V. I., Brykov, A. S. (2010). Perspektivy razvitiia obshchestroitel'nyh viazhushchih veshchestv. Geopolimery i ih otlichitel'nye osobennosti. *Tsement i ego primenenie,* 51–55.
3. Shi, C., He, F., Fernandez-Jimenez, A., Krivenko, P., Palomo, V. (2012). Classification and characteristics of alkali-activated cement. *Journal of The Chinese Ceramic Society, 1 (40),* 69–75.
4. Fernandez-Jimenez, A., Flores, E., Maltseva, O., Garcia-Lodeiro, I., Palomo, A. (2013). Hybrid alkaline cements. Part III. Durability and industrial applications. *Romanian Journal of Materials, 43 (2),* 195–200.
5. Palomo, A., Krivenko, P., Garcia-Lodeiro, I., Kavalerova, E., Maltseva, O., Fernandez-Jimenez, A. (2014). A review on alkaline activation: new analytical perspectives. *Materiales de Construccion, 64 (315),* e022. doi:10.3989/mc.2014.00314
6. Bernal, S. A., Provis, J. L. (2014). Durability of Alkali-Activated Materials: Progress and Perspectives. *Journal of the American Ceramic Society, 97 (4),* 997–1008. doi:10.1111/jace.12831
7. Pacheco-Torgal, F., Labrincha, J., Leonelli, C., Palomo, A., Chindaprasit, P. (2014). *Handbook of Alkali-Activated Cements, Mortars and Concretes.* N.Y.: Springer, 852. doi:10.1016/c2013-0-16511-7
8. Funke, H. L., Gelbrich, S., Kroll, L. (2016). An Alkali Activated Binder for High Chemical Resistant Self-Leveling Mortar. *Open Journal of Composite Materials, 06 (04),* 132–142. doi:10.4236/ojcm.2016.64013
9. Krivenko, P., Drochytka, R., Gelevera, A., Kavalerova, E. (2014). Mechanism of preventing the alkali-aggregate reaction in alkali activated cement concretes. *Cement and Concrete Composites, 45,* 157–165. doi:10.1016/j.cemconcomp.2013.10.003
10. Kryvenko, P., Cao, H. L., Weng, L. Q., Kavalerova, E. (2014). Mineralogical Aspects of Durable Geocement Matrix Formation – Role of Alkali. *Advanced Materials Research, 1004-1005,* 1523–1530. doi:10.4028/www.scientific.net/amr.1004-1005.1523
11. Kryvenko, P., Volodymyr, K., Guzii, S. (2016). Influence of the ratio of oxides and temperature on the structure formation of alkaline hydro-aluminosilicates. *Eastern-European Journal of Enterprise Technologies, 5(5(83)),* 40–48. doi:10.15587/1729-4061.2016.79605
12. Petránek, V., Krivenko, P., Petropavlovskiy, O., Guzii, S. (2014). Perlite Concrete Based on Alkali Activated Cements. *Advanced Materials Research, 897,* 280–283. doi:10.4028/www.scientific.net/amr.897.280
13. Funke, H. L., Gelbrich, S., Kroll, L. (2016). An Alkali Activated Binder for High Chemical Resistant Self-Leveling Mortar. *Open Journal of Composite Materials, 06 (04),* 132–142. doi:10.4236/ojcm.2016.64013
14. Hewayde, E., Nehdi, M., Allouche, E., Nakhla, G. (2006). Effect of geopolymer cement on microstructure, compressive strength and sulphuric acid resistance of concrete. *Magazine of Concrete Research, 58 (5),* 321–331. doi:10.1680/macr.2006.58.5.321
15. Kriven, W. M., Gordon, M., Ervin, B. L., Reis, H. (2008). Corrosion Protection Assessment of Concrete Reinforcing Bars with a Geopolymer Coating. *Developments in Porous, Biological and Geopolymer Ceramics,* 373–381. doi:10.1002/9780470339749.ch33
16. Gupta, A., Mandal, S., Ghosh, S. (2012). Durability of geopolymer coated recycled aggregate concrete exposed to Sulphuric acid. *International Journal of Applied Engineering Research, 7 (1),* 91–103.
17. Siti Salwa, M. S., Mustafa Al Bakri, A. M. (2013). Review on Current Geopolymer as a Coating Material. *Australian Journal of Basic and Applied Sciences, 7 (5),* 246–257.
18. Shaikh, F. U. A. (2014). Effects of alkali solutions on corrosion durability of geopolymer concrete. *Advances in Concrete Construction, 2 (2),* 109–123. doi:10.12989/acc.2014.2.2.109
19. Kryvenko, P., Guzii, S., Kovalchuk, O., Kyrychok, V. (2016). Sulfate Resistance of Alkali Activated Cements. *Materials Science Forum, 865,* 95–106. doi:10.4028/www.scientific.net/msf.865.95
20. Krivenko, P. V., Guziy, S. G., Kyrychok, V. I. (2014). Geocement-Based Coatings for Repair and Protection of Concrete Subjected to Exposure to Ammonium Sulfate. *Advanced Materials Research, 923,* 121–124. doi:10.4028/www.scientific.net/amr.923.121
21. Krivenko, P. V., Guziy, S. G. (2013). Aluminosilicate coatings with enhanced heat- and corrosion resistance. *Applied Clay Science, 73,* 65–70. doi:10.1016/j.clay.2012.10.010
22. Krivenko, P., Guziy, S., Al-Musaedi, H. A. J. (2015). Atmospheric Corrosion Protection of Metallic Structures Using Geocements-Based Coatings. *Solid State Phenomena, 227,* 239–242. doi:10.4028/www.scientific.net/ssp.227.239
23. Guzii, S., Al Moussa, J. H. A. (2016). Investigation of adhesive properties of barrier-type geocement-based coatings. *Technology Audit and Production Reserves, 4(4(30)),* 13–17. doi:10.15587/2312-8372.2016.76515
24. Glad, E. (2013). *Porosity control of alkali-activated aluminosilicates via functional alkoxysilane additives.* Urbana: College of the University of Illinois at Urbana-Champaign, 156.
25. Musil, S. (2014). *Novel, Inorganic Composites using Porous, Alkali-activated, Aluminosilicate Binders.* Illinois: University of Illinois at Urbana-Champaign, 188.
26. Yuan, Y., Lee, T. R. (2013). *Contact Angle and Wetting Properties.* Springer Series in Surface Sciences, 3–34. doi:10.1007/978-3-642-34243-1_1
27. Antonova, N. M. (2011). Otsenka adgezionnoi prochnosti zashchitnyh kompozitsionnyh pokrytii po rabote adgezii k tverdomu telu ishodnoi suspenzii. *Korroziia: materialy, zashchita, 9,* 36–42.
28. Bogdanov, V. N., Vorontsova, O. A., Vezentsev, A. I. (2013). Kolloidno-himicheskie svoistva neotverzhdennoi kompozitsii zashchitno-dekorativnogo pokrytiia. *Lakokrasochnye materialy i ih primenenie, 1-2,* 62–65.
29. Fridrihsberg, D. A. (1984). *Kurs kolloidnoi himii.* Leningrad: Himiia, 368.
30. In: Frolov, Yu. G., Grodskoy, A. S. (1986). *Laboratornye raboty i zadachi po kolloidnoi himii.* Moscow: Himiia, 216.
31. *Katalog oborudovaniia CZL.* Available: https://www.czl.ru/applications/contact-angle-measurement-technology/

ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

DOI: 10.15587/2312-8372.2017.102240

CIRCUIT SIMULATION OF ELECTRICAL BREAKDOWN IN AIR USING KIND'S EQUAL-AREA CRITERION

page 44–49

Trotsenko Yevgeniy, *PhD, Associate Professor, Department of High Voltage Engineering and Electrophysics, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: y.trotsenko@kpi.ua, ORCID: http://orcid.org/0000-0001-9379-0061*

Brzhezitsky Volodymyr, *Doctor of Technical Sciences, Professor, Department of High Voltage Engineering and Electrophysics, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: v.brzhezitsky@kpi.ua, ORCID: http://orcid.org/0000-0002-9768-7544*

Masluchenko Igor, *PhD, Associate Professor, Department of High Voltage Engineering and Electrophysics, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: i.masluchenko@kpi.ua, ORCID: http://orcid.org/0000-0001-6073-9649*

The object of the research is the circuit simulation model of a streamer breakdown of a rod-rod air gap when exposed to positive voltage pulses. One of the most problematic places in this task is determination of the time interval of the streamer propagation. The lower bound of this interval corresponds to the beginning of the streamer propagation, and the upper bound corresponds to the time when the streamer reaches the opposite electrode. To create such model, it is not enough to take into account only the functional relationship between the breakdown voltage and the spacing between the electrodes.

With the help of Kind's equal-area criterion in the circuit simulation programs it is possible to create the model of electrical breakdown of any air gap, including the rod-rod configuration.

The article shows how to create the model of electrical breakdown of the air gap in the evaluation version of the Micro-Cap 11 circuit simulator. Using the model, the breakdown time of the air gap is determined when subjected to the lightning pulses of positive polarity with different amplitudes. Wherein, the moments of breakdown of the air gap both at the front and at the tail of the applied voltage pulse are measured. Simulation results are compared with experimental data. It is determined that the simulation relative error does not exceed 10 %. As experimental data, the experimentally obtained expression for the volt-time characteristic of the rod-rod air gap subjected to the positive polarity voltage pulses is used.

The proposed model allows to predict the volt-time characteristic of various air gaps in a virtual experiment. The model can be used in scientific work or in the educational process as an auxiliary tool for visual demonstration of the conditions for the electric breakdown in long air gaps.

Keywords: circuit simulation, high voltage engineering, electrical breakdown, volt-time characteristic, equal-area criterion.

References

1. Kind, D. (1958). Die aufbauflache bei stossspannungsbeanspruchung technischer elektrodenanordnungen in luft. *ETZ-A, 79,* 65–69.
2. Kind, D., Kurrat, M., Kopp, T. H. (2016). Voltage-time characteristics of air gaps and insulation coordination – Survey of 100 years research. *2016 33rd International Conference on Lightning Protection (ICLP),* 1–8. doi:10.1109/iclp.2016.7791358
3. Suthar, J. L., Laghari, J. R., Saluzzo, T. J. (1991). Usefulness of SPICE in high voltage engineering education. *IEEE Transactions on Power Systems, 6 (3),* 1272–1278. doi:10.1109/59.119277
4. Veisheipl, K. (2016). Simulation of the high voltage impulse generator. *2016 17th International Scientific Conference on Electric Power Engineering (EPE),* 1–5. doi:10.1109/epe.2016.7521736
5. Rai, V., Pandey, K., Wadhwa, K. (2015). Designing of multistage impulse voltage generator using ATP software. *2015 International Conference on Recent Developments in Control, Automation and Power Engineering (RDCAPE),* 276–279. doi:10.1109/rdcape.2015.7281409
6. Elserougi, A., Ahmed, S., Massoud, A. (2016). High-voltage pulse generator based on capacitor-diode voltage multiplier centrally fed from DC-DC boost converter. *8th IET International Conference on Power Electronics, Machines and Drives (PEMD 2016),* 1–4. doi:10.1049/cp.2016.0278
7. Ge, Y., Xie, Y., Li, Z. (2016). Design of a 500 kV pulse generator with the rise time of nanosecond level. *2016 Asia-Pacific International Symposium on Electromagnetic Compatibility (APEMC), 01,* 811–813. doi:10.1109/apemc.2016.7522874
8. Vahidi, B., Beiza, J. (2005). Using PSpice in Teaching Impulse Voltage Testing of Power Transformers to Senior Undergraduate Students. *IEEE Transactions on Education, 48 (2),* 307–312. doi:10.1109/te.2004.842902
9. Wang, B., Fu, Z., Yan, N. (2014). Design of multi-component impulse current generator for practical lightning current simulation. *2014 International Conference on Lightning Protection (ICLP),* 278–282. doi:10.1109/iclp.2014.6973136
10. Babicheva, A. A., Protsenko, O. R., Trotsenko, Ye. O. (2016). Modeliuvannia proboiu izoliatsiinoho promizhku iz zadanoiu volt-sekundnoiu kharakterystykoiu. *Mizhnarodnyi naukovo-tekhnichnyi zhurnal molodykh uchenykh, aspirantiv i studentiv «Suchasni problemy elektroenerhotekhniky ta avtomatyky»,* 357–359.
11. Tao, J., Zhang, S., Zhang, W., Zhang, H., Wen, X. (2012). Application of virtual experiment in high-voltage engineering education. *Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE),* H3B-4-H3B-6. doi:10.1109/tale.2012.6360345
12. Brzhezitskiy, V. O., Isakova, A. V., Rudakov, V. V.; In: Brzhezitskiy, V. O., Mihaylov, V. M. (2005). *Tekhnika i elektrofizyka vysokykh napruh*. Kharkiv: NTU »KhPI»-Tornado, 930.
13. Beyer, M., Boeck, W., Moller, K., Zaengl, W. (1986). *Hochspannungstechnik: Theoretische und praktische Grundlagen*. Berlin: Springer-Verlag, 362. doi:10.1007/978-3-642-61633-4
14. Ierusalimov, M. E., Orlov, N. N.; In: Ierusalimov, M. E. (1967). *Tehnika vysokih napriazhenii*. Kyiv: Kyiv University, 445.
15. *Micro-Cap 11. Electronic Circuit Analysis Program. Reference Manual*. (2014). Sunnyvale, CA: Spectrum Software, 1040. Available: http://www.spectrum-soft.com/down/rm11.pdf

DOI: 10.15587/2312-8372.2017.105655

RESEARCH OF OPERATION OF ANISOTROPIC OPTICAL THERMOELEMENT WITH LATERAL TEMPERATURE REGULATION

page 49–53

Khabiuk Andrii, *Postgraduate Student, Department of Pscyhology, Pedagogics and Social Management, National University «Lviv Polytechnic», Ukraine, e-mail: kym-ua@ukr.net, ORCID: http://orcid.org/0000-0001-7151-9043*

Danalakiy Oleh, *PhD, Associate Professor, Department of Information Systems, Chernivtsi Faculty of the National Techni-*

cal University «Kharkiv Polytechnic Institute», Ukraine, e-mail: ogdanalaki@gmail.com, ORCID: http://orcid.org/0000-0002-6602-9506

The object of research is a direct mutual conversion of thermal and electrical energy using anisotropic optical thermoelectric elements (AOTE). Receivers of through-type radiant flux, containing optically transparent heat sinks, to which the AOTE attach with the help of an adhesive dielectric layer, lead to a significant distortion of the amplitude-phase characteristics of the transmitted radiant flux. This is limited the energy and timing characteristics of receivers. Therefore, the task of creating such design of the receiver, which would be free of these shortcomings, is necessary.

The design of a radiant flux receiver based on an anisotropic optical thermoelement is developed and tested, and the amplitude-phase characteristics of the flux do not change during its passage. The receiver can be used as a filter or a semitransparent mirror of an optical resonator. Such effect is due to the fact that at a thickness of 1 cm AOTE is selected with parameters $\alpha = 10^{-4}$ V/K, $\chi = 10^{-2}$ W/(cm·K), $\rho = 10^{-3}\Omega$, current $I=10$ A and temperature of the thermostat 300 K cm gives the minimum temperature of 239 K.

A separate anisotropic thermoelement, which is made of a material with the same kinetic parameters under the same conditions, yields 265 K. Thus AOTE leads to an increase in the temperature drop.

Keywords: anisotropic optical thermoelectric elements (AOTE), transverse thermoelectric power, AOTE with lateral temperature regulation.

References

1. Korn, G. A., Korn, T. M. (2000). *Mathematical Handbook for Scientists and Engineers: Definitions, Theorems, and Formulas for Reference and Review (Dover Civil and Mechanical Engineering)*. Dover Publications, 1152.
2. Lansberg, G. S. (1996). *Optika*. Moscow: Nauka, 927.
3. Ascheulov, A. A., Ohrem, V. G. (2014). Radiatsionnyi anizotropnyi optikotermoelement s bokovym termostatirovaniem. *TKEA, 1,* 45–47.
4. Ascheulov, A. A., Kondratenko, V. M., Piliavskii, Yu. B., Rarenko, I. M. (2014). EDS anizotropnogo termoelementa v rezhime opticheskogo propuskaniia. *FTP, 18 (7),* 1330–1331.
5. Samoilovich, A. G., Korenblit, L. L. (1984). Sovremennoe sostoianie termoelektricheskih i termomagnitnyh iavlenii v poluprovodnikah. Part 1. Termodinamicheskaia teoriia. *UFN, 49 (3),* 243–272.
6. Wolfe, R., Smith, G. E. (1963). Experimental Verification of the Kelvin Relation of Thermoelectricity in a Magnetic Field. *Physical Review, 129 (3),* 1086–1087. doi:10.1103/physrev.129.1086
7. Wolfe, R., Smith, G. E., Haszko, S. E. (1963). Negative thermoelectric figure of merit in a magnetic field. *Applied Physics Letters, 2 (8),* 157–159. doi:10.1063/1.1753823
8. Smith, G. E., Wolfe, R. (2016). Analysis of the transport phenomena in bismuth. *J. Phys. Soc. Japan Suppl., 21,* 651–656.
9. Goldsmith, H. J. (2014). *Thermoelectric refrigiration*. London, 246.
10. Harman, T. C., Honig, J. M. (2010). *Thermoelectric and thermomagnetic effects and applications*. New-York: Mc Graw-Hill book Company, 377.
11. Kooi, C. F., Horst, R. B., Cuff, K. F. (1968). Thermoelectric-Thermomagnetic Energy Converter Staging. *Journal of Applied Physics, 39 (9),* 4257–4263. doi:10.1063/1.1656957
12. Delves, R. T. (1962). The prospects for Ettingshausen and Peltier cooling at low temperatures. *British Journal of Applied Physics, 13 (9),* 440–445. doi:10.1088/0508-3443/13/9/302
13. Harman, T. C., Honig, J. M. (1963). Erratum: Operating characteristics of transverse (nernst) anisotropic galvano-thermomagnetic generators. *Applied Physics Letters, 2 (2),* 44–48. doi:10.1063/1.1753765
14. Ohrem, V. G. (2002). *Issledovaniia vliianiia inversii magnitnogo polia na termoEDS*. Chernovtsy, 98.
15. Ascheulov, A. A., Gutsul, I. V., Rarenko, I. M. (2003). Anizotropnyi termoelement vnutrennego opticheskogo otrazheniia. *UFZh, 38 (6),* 923–927
16. Ascheulov, A. A. (2015). Anizotropnyi radiatsionnyi termoelement dlia izmerenii prohodnoi moshchnosti. *Optiko-mehanicheskaia promyshlennost', 12,* 48–49.
17. Ascheulov, A. A., Ohrem, V. G. (15.01.2004). Anisotropic thermoelectric thermal radiation detector. *Patent of Ukraine № 63394 A, MKB 7 H101L32/02*. Available: http://uapatents.com/2-63394-anizotropnijj-termoelektrichnijj-prijjmach-viprominyuvannya.html
18. Danalakiy, O.; Institute of Thermoelectricity. (15.04.2014). *Patent of Ukraine*. Appl. № 200304264. Filed 11.042003. Bull. № 1, 6.

DOI: 10.15587/2312-8372.2017.105698

ANALYSIS OF MODERN GRAVIMETERS OF THE AVIATION GRAVIMETRIC SYSTEM

page 53–59

Bezvesilna Olena, *Doctor of Technical Sciences, Department of Instrumentation, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: tinfand@ukr.net, ORCID: http://orcid.org/0000-0002-6951-1242*

Chepyuk Larina, *PhD, Department of Automation and Computer-Integrated Technologies named after prof. B. B. Samotokin, Zhytomyr State Technological University, Ukraine, ORCID: http://orcid.org/0000-0002-8072-8186*

Tkachuk Andriy, *PhD, Department of Automation and Computer-Integrated Technologies named after prof. B. B. Samotokin, Zhytomyr State Technological University, Ukraine, e-mail: andrew_tkachuk@i.ua, ORCID: http://orcid.org/0000-0003-2466-6299*

Nechai Sergii, *PhD, Associate Professor, Department of Instrumentation, National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: snechai@mail.ru, ORCID http://orcid.org/0000-0002-7821-6472*

Khylchenko Tetiana, *Postgraduate Student, Department of Automation and Computer-Integrated Technologies named after prof. B. B. Samotokin, Zhytomyr State Technological University, Ukraine, e-mail: xvulunka@i.ua, ORCID: http://orcid.org/0000-0003-0029-2114*

The analysis of existing gravimeters of aviation gravimetric systems (AGS) is carried out. Their main disadvantages are identified: low accuracy of measurement (3–10 mGal), mandatory necessity of application of filtration procedure of output signal of AGS gravimeter; instability of the static transfer coefficient of the AGS gravimeter; low speed. The expediency of using AGS for carrying out gravimetric measurements and obtaining information about the Earth's gravitational field is substantiated. Aerogravimetric surveying requires a significant increase in the accuracy and speed of aviation gravity measurements. Therefore, the study of this issue remains an important problem. To date, there are already theoretical developments and prototypes that almost completely solve all the main disadvantages. Modern advanced developments in the field of aircraft gravimeters are considered: gyroscopic, ballistic, piezoelectric, capacitive, string gravimeters. They are distinguished by high accuracy (1–2 mGal) and speed. It is proposed to use a two-channel (differential) method for GA measurement in all gravimeter designs. Then the useful signal is doubled 2g, and the signals of the main disturbing vertical acceleration, instrumental errors from the influence of changes in temperature, pressure and other environmental factors are canceled.

Keywords: sensing element, gravimeter, gravity acceleration, gravitational field of the Earth.

References

1. Bezvesilna, O., Bezvesilna, O., Tkachuk, A., Nowicki, M., Szewczyk, R., Shadura, V. (2015). Aviation gravimetric system. *International Journal of Scientific & Engineering Research, 6 (7),* 1122–1126.
2. *Gravimetry.* Available: http://www.all-pribors.ru/groups/gravimetry-61. Last accessed: 21.01.2017.
3. Matveev, V. V. (2014). The engineering analysis of lapses of strapdown inertial navigational system. *Izvestiia Tul'skogo gosudarstvennogo universiteta. Tehnicheskie nauki, 9 (2),* 251–267.
4. Kaufman, A. A. (2011). *Printsipy metoda gravimetrii.* Tver', 360.
5. Bykovskii, A. V., Polynkov, A. V., Arseniev, V. D. (2013). Aerogravimetricheskii metod izmereniia gravitatsionnyh anomalii. *Aviakosmicheskoe priborostroenie, 12,* 11–19.
6. Mobil'nyi gravimetr «Chekan-AM». *State Research Center of the Russian Federation Concern CSRI Elektropribor, JSC.* Available: http://www.elektropribor.spb.ru/prod/rgydro_1. Last accessed: 26.10.2016.
7. Gravimetry. *JSC YUZHMORGEOLOGIYA – On land and at sea.* Available: http://www.ymg.ru/ru/content/gravimetr. Last accessed: 21.01.2017.
8. Inertsial'no-gravimetricheskii kompleks MAG-1A. *Federal'noe gosudarstvennoe unitarnoe nauchno-proizvodstvennoe predpriiatie «GEOLOGORAZVEDKA».* Available: http://geolraz.com/page/GSA-2010/. Last accessed: 18.10.2016.
9. Strunnyi aerogravimetr «Graviton-M». *GNPP «Aerogeophysica».* Available: http://www.aerogeo.ru/index.php?option=com_content&view=category&layout=blog&id=25&Itemid=17&lang=ru. Last accessed: 18.10.2016.
10. Bezvesilna, O., Kaminski, M. (2017). Gravimeters of Aviation Gravimetric System: Classification, Comparative Analysis, Prospects. *Automation 2017.* Springer International Publishing, 496–504. doi:10.1007/978-3-319-54042-9_48
11. Gravimetr CG-5 AutoGrav. *Geotsentr-Moskva.* Available: http://geocentr-msk.ru/content/view/441/137. Last accessed: 18.010.2016.
12. Aerogravimetr GT-2A. *GNPP «Aerogeophysica».* Available: http://www.aerogeo.ru/index.php?option=com_content&view=category&layout=blog&id=25&Itemid=17&lang=ru. Last accessed: 18.10.2016.
13. TAGS-6 Gravity Meter (Turnkey Airborne Gravity System) with Aerograv Data Processing Software. *Micro-g LaCoste, Inc.* Available: http://www.microglacoste.com/tags-6.php. Last accessed: 26.10.2016.
14. Bykovskii, A. V., Polynkov, A. V. (2013). K voprosu o razrabotke malogabaritnogo aerogravimetra. *Vestnik MGTU im. N. E. Baumana, 2 (14),* 32–41.
15. Osborne, I. S. (2016). An on-chip cold-atom gravimeter. *Science, 354(6317),* 1246–1247. doi:10.1126/science.354.6317.1246-f
16. Afonin, A. A., Sulakov, A. S., Yamashev, G. G., Mihailin, D. A., Mirzoian, L. A., Kurmakov, D. V. (2013). O vozmozhnosti postroeniia besplatformennogo upravliaiushchego navigatsionno-gravimetricheskogo kompleksa bespilotnogo letatel'nogo apparata. *Trudy MAI, 66,* 47–53.
17. Huang, Y., Olesen, A. V., Wu, M., Zhang, K. (2012). SGA-WZ: A New Strapdown Airborne Gravimeter. *Sensors, 12 (12),* 9336–9348. doi:10.3390/s120709336
18. Kazama, T., Hayakawa, H., Higashi, T., Ohsono, S., Iwanami, S., Hanyu, T., Ohta, H., Doi, K., Aoyama, Y., Fukudaa, Y., Nishijimag, J., Shibuya, K. (2013). Gravity measurements with a portable absolute gravimeter A10 in Syowa Station and Langhovde, East Antarctica. *Polar Science, 7 (3-4),* 260–277. doi:10.1016/j.polar.2013.07.001
19. Calvo, M., Hinderer, J., Rosat, S., Legros, H., Boy, J.-P., Ducarme, B., Zurn, W. (2014). Time stability of spring and superconducting gravimeters through the analysis of very long gravity records. *Journal of Geodynamics, 80,* 20–33. doi:10.1016/j.jog.2014.04.009
20. Agostino, G. D., Desogus, S., Germak, A., Origlia, C., Quagliotti, D., Berrino, G., Corrado, G., Derrico, V., Ricciardi, G. (2008). The new IMGC-02 transportable absolute gravimeter: measurement apparatus and applications in geophysics and volcanology. *Annals of geophysics, 51 (1),* 39–49.
21. Roussel, C., Verdun, J., Cali, J., Maia, M., d' EU, J. F. (2015). Integration of a strapdown gravimeter system in an autonomous underwater vehicle. *ISPRS – International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL-5/W5,* 199–206. doi:10.5194/isprsarchives-xl-5-w5-199-2015
22. Hudzinskiy, L. L., Bartashevich, L. M., Sorokin, V. L. (2002). Issledovanie absolyutnogo ballisticheskogo gravimetra i puti povysheniya tochnosti izmereniy. *Vseros. nauch. konf. Geologiya, geohimiya i geofizika na rubezhe XX i XXI vekav. Vol. 3.*
23. Bezvesilna, O., Tkachuk, A., Chepyuk, L., Nechai, S., Khylchenko, T. (2017). Introducing the principle of constructing an aviation gravimetric system with any type of gravimeter. *Eastern-European Journal of Enterprise Technologies, 1 (7 (85)),* 45–56. doi:10.15587/1729-4061.2017.92941
24. Bezvesilna, O., Nowicki, M., Szewczyk, R., Tkachuk, A. (2015). System of aviation gravimeter. *International Journal of Scientific&Engineering Research, 6 (8),* 956–958.
25. Bezvesilnaya, E. N., Tkachuk, A. H. (2014). Corrected gyrocompass synthesis as a system with changeable structure for aviation gravimetric system with piezoelectric gravimeter. *Aviation, 18 (3),* 134–140. doi:10.3846/16487788.2014.969878
26. Korobiichuk, I., Bezvesilna, O., Tkachuk, A., Chilchenko, T., Nowicki, M., Szewczyk, R. (2016). Design of Piezoelectric Gravimeter for Automated Aviation Gravimetric System. *Journal of Automation, Mobile Robotics & Intelligent Systems, 10 (1),* 43–47. doi:10.14313/jamris_1-2016/6
27. Korobiichuk, I., Bezvesilna, O., Kachniarz, M., Tkachuk, A., Chilchenko, T. (2016). Two-Channel MEMS Gravimeter of the Automated Aircraft Gravimetric System. *Advances in Intelligent Systems and Computing,* 481–487. doi:10.1007/978-3-319-48923-0_51
28. Korobiichuk, I., Bezvesilna, O., Nowicki, M., Szewczyk, R. (2015). Filtering of the output signal of dynamicallytuned gravimeters. *International Journal of Scientific & Engineering Research, 6 (7),* 1332–1338.
29. Korobiichuk, I., Bezvesilna, O., Nowicki, M., Szewczyk, R. (2015). The goniometeronlasergyrobase. *International Journal of Scientific&Engineering Research, 6 (9),* 256–258
30. Meurers, B. (2017). Scintrex CG5 used for superconducting gravimeter calibration. *Geodesy and Geodynamics.* doi:10.1016/j.geog.2017.02.009