ABSTRACT AND REFERENCES

APPLIED PHYSICS

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CYLINDRICAL HARMONIC ANALYSIS OF THE MAGNETIC FIELD IN THE APERTURE OF THE SUPERCONDUCTING WINDING OF AN ELECTROMAGNET (p. 4-9)

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It is of practical interest to create such models of the electromagnetic field of an electromagnet that help correct the mean integral coefficients of the harmonics of magnetic induction by the geometric parameters of the magnet. The aim of the study was to obtain analytical expressions for the coefficients of the mean integral lengths of the cylindrical harmonics of magnetic induction created by the current in the superconducting winding inside the aperture of a dipole or quadrupole direct electromagnet on the basis of the geometric parameters of the winding. The analytical solution found is based on the sectorial spherical harmonics of the internal solution of the Laplace equation for the scalar potential of the magnetic field and allows associating them with a series of polar harmonics. The study shows the proportionality between the mean integral contributions to the magnetic induction, produced by uncharacteristic harmonics, and the mean integral value of the ground field. It has been determined that the contribution to the mean integral values of the harmonics coefficients from the end elements of the winding appears only in the presence of the iron framework as a result of its saturation. The received analytical representations make it possible to calculate necessary correction of geometrical parameters of a current winding when optimizing the magnetic field inside the aperture of dipole and quadrupole electromagnets with given mean integral factors.

Keywords: particle beam, dipole electromagnet, quadrupole winding, cylindrical harmonic, magnetic induction.

References

1. Russenschuck, S., Tortschanoff, T. (1994). Mathematical optimization of superconducting accelerator magnets. IEEE Transactions on Magnetics, 30 (5), 3419–3422. doi: 10.1109/20.312673
2. Russenschuck, S. (2010). Differential Geometry Applied to Coil-End Design. Field computation for accelerator magnets. Wiley-VCH Verlag GmbH & Co. KGaA, 609–636. doi: 10.1002/9783527635467.ch19
3. Russenschuck, S., Auchmann, B., Perez, J. C., Ramos, D., Fessia, P., Karppinen, M. et. al. (2011). Design Challenges for a Wide-Aperture Insertion Quadrupole Magnet. IEEE Transactions on Applied Superconductivity, 21 (3), 1674–1678. doi: 10.1109/tasc.2011.2105453
4. Fischer, E., Khodzhibagiyan, H. G., Kovalenko, A. D. (2008). Full Size Model Magnets for the FAIR SIS100 Synchrotron. IEEE Transactions on Applied Superconductivity, 18 (2), 260–263. doi: 10.1109/tasc.2008.922261
5. Kovalenko, A., Agapov, N., Alfeev, A. et. al. (2008). Full size prototype magnets for heavy ion superconducting synchrotron SIS100 at GSI: status of manufacturing and test at JINR. EPAC'08. Genoa, 2443–2445.
6. Fischer, E., Schnizer, P., Kurnyshov, R., Schnizer, B., Shcherbakov, P. (2009). Numerical Analysis of the Operation Parameters of Fast Cycling Superconducting Magnets. IEEE Transactions on Applied Superconductivity, 19 (3), 1266–1269. doi: 10.1109/tasc.2009.2018746
7. Yang, W., Zhang, X., Han, S., Yang, J., Pei, C., Yang, L. et. al. (2014). Magnetic Field Measurement for Synchrotron Dipole Magnets of Heavy-Ion Therapy Facility in Lanzhou. IEEE Transactions on Applied Superconductivity, 24 (3), 1–4. doi: 10.1109/tasc.2013.2289953
8. Yao, Q. G., Ma, L. Z., Zhang, X. Q., He, Y., Wu, W., Moritz, G. et. al. (2010). Magnetic Field Design of the Dipole for Super-FRS at FAIR. IEEE Transactions on Applied Superconductivity, 20 (3), 172–175. doi: 10.1109/tasc.2009.2038890
9. Schnizer, P., Schnizer, B., Akishin, P., Fischer, E. (2008). Magnetic Field Analysis for Superferric Accelerator Magnets Using Elliptic Multipoles and Its Advantages. IEEE Transactions on Applied Superconductivity, 18 (2), 1605–1608. doi: 10.1109/tasc.2008.920636
10. Vanderlinde, J. (2005). Classical electromagnetic theory. Springer, 420. doi: 10.1007/1-4020-2700-1
11. Wolff, S. (1992). Superconducting accelerator magnet design. AIP Conference Proceedings, 249. doi: 10.1063/1.41989

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DESIGN AND STUDY OF PROTECTIVE PROPERTIES OF ELECTROMAGNETIC SCREENS BASED ON IRON ORE DUST (p. 10-17)

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The study of the chemical composition and dispersion of iron ore dust, which forms during the enrichment of iron ore, proved its suitability to be used as a screening filler in the production of metal-polymer electromagnetic screens of large areas. We developed the technology of production of protective screening material in the form of a foam-latex with different content of iron-ore dust of different dispersion. We determined the dependence of the coefficient of screening of material and contribution of the reflection coefficient of ultrahigh frequency electromagnetic waves to it on the weight content of iron ore dust. The study showed that an increase in dispersion of metal and metal-containing particles by 10–20 times increases the overall screening coefficient by 6–8 times. At the same time, the reflection coefficient decreases from 0.25 to 0.10. We established that the guaranteed screening coefficient of the magnetic field of the industrial frequency is 1.8–2.2 even for screening particles of 50–100 μm sizes. We determined that a sharp increase in protective properties of materials occurs at the content of iron-ore dust of 11–12 % in the polymer matrix. We investigated electrophysical properties (specific conductivity and dielectric permeability) of developed materials with different contents of metal and metal-containing substance. The obtained data are sufficient for calculational forecasting of protective properties of the electromagnetic screen based on the amplitude-frequency characteristics of the electromagnetic field, which needs to be screened.

Keywords: electromagnetic screen, iron-ore dust, screening coefficient, reflection coefficient, electrophysical properties.

References

1. Tsili Staloho Rozvytku: Ukraina. Natsionalna dopovid 2017. Predstavnytstvo Orhanizatsiyi Obiednanykh Natsiyi v Ukraini. Available at: http://www.un.org.ua/ua/tsili-rozvytku-tysiacholittia
2. Bogush, V. A., Borbot'ko, T. V., Nasonov, N. V. et. al. (2016). Ekrany elektromagnitnogo izlucheniya na osnove magnitnyh materialov. Tekhnologii. Konstrukcii. Primenenie. Minsk: Bestprint, 222.
3. Li, M., Xiao, S., Bai, Y.-Y., Wang, B.-Z. (2012). An Ultrathin and Broadband Radar Absorber Using Resistive FSS. IEEE Antennas and Wireless Propagation Letters, 11, 748–751. doi: 10.1109/lawp.2012.2206361
4. Singh, J. Computer Generated Energy Effects on Users and Shielding Interference. International Journal of. Innovative Research in Computer and Communication Engineering, 3 (10), 10022–10027.
5. Kasar, V., Pawar, A. (2014). A Novel Approach to Electromagnetic Interference Shielding for Cell Phones. International Journal of Science and Research, 3 (11), 1869–1872.
6. Jalali, M., Dauterstedt, S., Michaud, A., Wuthrich, R. (2011). Electromagnetic shielding of polymer–matrix composites with metallic nanoparticles. Composites Part B: Engineering, 42 (6), 1420–1426. doi: 10.1016/j.compositesb.2011.05.018
7. Mondal, S., Ganguly, S., Das, P., Khastgir, D., Das, N. C. (2017). Low percolation threshold and electromagnetic shielding effectiveness of nano-structured carbon based ethylene methyl acrylate nanocomposites. Composites Part B: Engineering, 119, 41–56. doi: 10.1016/j.compositesb.2017.03.022
8. Fionov, A. S., Yurkov, G. Y., Popkov, O. V., Kosobudskii, I. D., Taratanov, N. A., Potemkina, O. V. (2011). Polymer nanocomposites: synthesis and physical properties. Advances in Composite Materials or Medicine and Nanotechnology, 343–364.
9. Al'-Ademi, Ya. T. A., Ahmed, A. A. A., Pulko, T. A., Nasonova, N. V., Lyn'kov, L. N. (2014). Shirokodiapazonnye konstrukcii ekranov elektromagnitnogo izlucheniya na osnove vlagosoderzhashchey cellyulozy. Trudy MAI, 77.
10. Boyprav, O. V., Borbot'ko, T. V., Lin'kov, L. M., Sokolov, V. B. (2014). Ekran elektromagnitnogo izlucheniya na osnove poroshkoobraznyh othodov proizvodstva chuguna. Trudy MAI, 67, 3–19.
11. Bhingardive, V., Sharma, M., Suwas, S., Madras, G., Bose, S. (2015). Polyvinylidene fluoride based lightweight and corrosion resistant electromagnetic shielding materials. RSC Advances, 5 (45), 35909–35916. doi: 10.1039/c5ra05625j
12. Glyva, V., Kovalenko, V., Levchenko, L., Tykhenko, O. (2017). Research into protective properties of electromagnetic screens based on the metal-containing nanostructures. Eastern-European Journal of Enterprise Technologies, 3 (12 (87)), 50–56. doi: 10.15587/1729-4061.2017.103167
13. Hlyva, V. A., Lapshyn, O. Ye., Kovalenko, V. V., Khudyk, M. V. (2017). Doslidzhennia zakhysnykh vlastyvostei elektromahnitnykh ekraniv na osnovi dribnodyspersnoho zaliza ta yoho spoluk. Visti Donetskoho hirnychoho instytutu, 1 (40), 123–127.

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STUDY OF THE LAMB WAVES PROPAGATION ALONG A PLATE IN CONTACT WITH A RANDOMLY INHOMOGENEOUS HETEROGENEOUS MEDIUM (p. 18-27)

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We present results of research into the influence of characteristics of a heterogeneous medium on the Lamb wave propagation process parameters along a plate in contact with a given medium. A mathematical description of the Lamb wave propagation process in a metallic plate was formed. Analytical expressions are derived for determining the displacement potentials that describe, respectively, the longitudinal and transverse waves in a plate with a thickness of 2d at frequency ω. The possibility is shown of the existence under given conditions of a certain finite number of symmetric and antisymmetric Lamb waves. The mentioned waves are different one from another in phase and group velocities, as well as the distribution of displacements and stresses along the plate's thickness.

We have investigated dependence of the Lamb wave attenuation on the characteristics of fluid in contact with the propagation medium. In the case when the Lamb wave propagation medium borders the fluid and the speed of sound in liquid C_l is less than speed C of the wave in a plate, the Lamb wave will attenuate radiating energy into liquid. It was established that the attenuation is due to the density of the studied medium. Viscosity and motion speed of a gas-containing suspension, for example iron ore pulp, have almost no effect on the magnitude of attenuation of the Lamb waves.

The significance of the obtained results is emphasized by the fact that they could be used to develop improved methods and tools to control parameters of gas-containing suspensions. The use of Lamb waves makes it possible to avoid measurement errors associated with the presence of microdefects at the surface of propagation and gas bubbles in the examined liquid.

From a practical point of view, the results obtained could be used for the calculation of parameters for the sources of ultrasonic waves in the systems of ultrasonic testing. Thus, there is an opportunity to improve efficiency of technological processes in the mining and metallurgical industry, specifically, the enrichment of ore.

Keywords: gas-containing suspension, Lamb waves, ultrasound attenuation, fluid viscosity.

References

1. Viktorov, I. A. (1981). Zvukovye poverhnostnye volny v tverdyh telah. Moscow: Nauka, 286.
2. Lamb, H. (1917). On Waves in an Elastic Plate. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, 93 (648), 114–128. doi: 10.1098/rspa.1917.0008
3. Bogdanova, I. P., Nesterova, N. A., Fedorchenko, V. S., Gricay, Yu. L. (1989). Obogatimost' zheleznyh rud. Moscow: Nedra, 158.
4. Rzhevskiy, V. V., Yamshchikov, V. S. (1968). Ul'trazvukovoy kontrol' i issledovaniya v gornom dele. Moscow: Nedra, 120.
5. Seip, R., VanBaren, P., Cain, C. A., Ebbini, E. S. (1996). Noninvasive real-time multipoint temperature control for ultrasound phased array treatments. IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, 43 (6), 1063–1073. doi: 10.1109/58.542050
6. Brajnikov, N., Shavykina, N., Gordeev, A., Skripalov, V. (1975). The use of Lamb waves for level detection of liquid media. Instrumentation and control systems, 9, 31–32.
7. Gumanyuk, M. (1970). Ultrasound in mining automation. Kyiv: Tehnika, 192.
8. Yamschikov, V., Korobeynikov, N. (1967). The use of ultrasound in the mining industry: a review. Moscow: Nedra, 52.
9. Brajnikov, N. (1975). Ultrasonic methods. Moscow: Energiya, 91.
10. Kupin, A. (2014). Research of properties of conditionality of task to optimization of processes of concentrating technology is on the basis of application of neural networks. Metallurgical and Mining Industry, 4, 51–55.
11. Kupin, A. (2014). Application of neurocontrol principles and classification optimization in conditions of sophisticated technological processes of beneficiation complexes. Metallurgical and Mining Industry, 6, 16–24.
12. Louisnard, O. (2012). A simple model of ultrasound propagation in a cavitating liquid. Part I: Theory, nonlinear attenuation and traveling wave generation. Ultrasonics Sonochemistry, 19 (1), 56–65. doi: 10.1016/j.ultsonch.2011.06.007
13. Louisnard, O. (2012). A simple model of ultrasound propagation in a cavitating liquid. Part II: Primary Bjerknes force and bubble structures. Ultrasonics Sonochemistry, 19 (1), 66–76. doi: 10.1016/j.ultsonch.2011.06.008
14. Jamshidi, R., Brenner, G. (2013). Dissipation of ultrasonic wave propagation in bubbly liquids considering the effect of compressibility to the first order of acoustical Mach number. Ultrasonics, 53 (4), 842–848. doi: 10.1016/j.ultras.2012.12.004
15. Morkun, V., Morkun, N., Pikilnyak, A. (2014). Simulation of the Lamb waves propagation on the plate which contacts with gas containing iron ore pulp in Waveform Revealer toolbox. Metallurgical and Mining Industry, 5, 16–19.
16. Morkun, V., Morkun, N., Pikilnyak, A. (2014). Modeling of ultrasonic waves propagation in inhomogeneous medium using fibered spaces method (k-space). Metallurgical and Mining Industry, 2, 43–48.
17. Zhang, Y., Du, X. (2015). Influences of non-uniform pressure field outside bubbles on the propagation of acoustic waves in dilute bubbly liquids. Ultrasonics Sonochemistry, 26, 119–127. doi: 10.1016/j.ultsonch.2015.02.016
18. Tejedor Sastre, M. T., Vanhille, C. (2017). A numerical model for the study of the difference frequency generated from nonlinear mixing of standing ultrasonic waves in bubbly liquids. Ultrasonics Sonochemistry, 34, 881–888. doi: 10.1016/j.ultsonch.2016.07.020
19. Vanhille, C., Campos-Pozuelo, C. (2009). Nonlinear ultrasonic waves in bubbly liquids with nonhomogeneous bubble distribution: Numerical experiments. Ultrasonics Sonochemistry, 16 (5), 669–685. doi: 10.1016/j.ultsonch.2008.11.013
20. Morkun, V., Tron, V. (2014). Automation of iron ore raw materials beneficiation with the operational recognition of its varieties in process streams. Metallurgical and Mining Industry, 6, 4–7.
21. Morkun, V., Morkun, N., Pikilnyak, A. (2015). Adaptive control system of ore beneficiation process based on Kaczmarz projection algorithm. Metallurgical and Mining Industry, 2, 35–38.
22. Golik, V., Komashchenko, V., Morkun, V. (2015). Innovative technologies of metal extraction from the ore processing mill

tailings and their integrated use. Metallurgical and Mining Industry, 3, 49–52.
23. Ryden, N., B. Park, C., Ulriksen, P., D. Miller, R. (2003). Lamb wave analysis for non-destructive testing of concrete plate structures. 9th EAGE/EEGS Meeting. doi: 10.3997/2214-4609.201414477
24. Golik, V., Komashchenko, V., Morkun, V. (2015). Feasibility of using the mill tailings for preparation of self-hardening mixtures. Metallurgical and Mining Industry, 3, 38–41.
25. Morkun, V., Tron, V., Vita, R. (2017). Optimization of high-energy ultrasound source parameters for cavitation disintegration of ore floccules before floatation. 2017 IEEE International Young Scientists Forum on Applied Physics and Engineering (YSF). doi: 10.1109/ysf.2017.8126597
26. Debarnot, M., Le Letty, R., Lhermet, N. (2006). Ultrasonic NDT based on Lamb waves: Development of a dedicated drive and monitoring electronic. Proceedings of the 3rd European-Workshop on Structural Health Monitoring, 1207–1213.
27. Lee, B. C., Staszewski, W. J. (2003). Modelling of Lamb waves for damage detection in metallic structures: Part I. Wave propagation. Smart Materials and Structures, 12 (5), 804–814. doi: 10.1088/0964-1726/12/5/018
28. Subhash, N., Krishnan, B. (2011). Modelling and experiments for the development of a guided wave liquid level sensor. Proceedings of the National Seminar & Exhibition on Non-Destructive Evaluation, 240–244.
29. Morkun, V., Tron, V. (2014). Ore preparation multi-criteria energy-efficient automated control with considering the ecological and economic factors. Metallurgical and Mining Industry, 5, 4–7.
30. Morkun, V., Morkun, N., Tron, V. (2015). Distributed closed-loop control formation for technological line of iron ore raw materials beneficiation. Metallurgical and Mining Industry, 7, 16–19.
31. Golik, V., Komashchenko, V., Morkun, V., Burdzieva, O. (2015). Metal deposits combined development experience. Metallurgical and Mining Industry, 6, 591–594.
32. Tabei, M., Mast, T. D., Waag, R. C. (2002). Ak-space method for coupled first-order acoustic propagation equations. The Journal of the Acoustical Society of America, 111 (1), 53–63. doi: 10.1121/1.1421344
33. Church, C. C. (1995). The effects of an elastic solid surface layer on the radial pulsations of gas bubbles. The Journal of the Acoustical Society of America, 97 (3), 1510–1521. doi: 10.1121/1.412091
34. LAMSS Products: Software. Laboratory for active materials and smart structures. Available at: http://www.me.sc.edu/Research/lamss/html/software.html

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EXAMINING THE TECHNIQUE TO CONTROL THE STRUCTURE OF CURRENT IN VORTEX CHAMBERS BY WING VORTEX GENERATORS (p. 28-38)

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A new technique was studied aimed at controlling energy-intensive coherent vortex structures (ECVS) that define the processes of mass- and heat transfer in vortex chambers. This is important because the swirled flows are employed in a wide class of machines and devices. The basic principle of the method implies rational organization of targeted controlling actions on ECVS using the systems of ordered vortex cords that run down the end edges of a miniature thin wing. The wing is mounted in a flow-through tract of the inlet nozzle of the vortex chamber at different angles of attack. Using the wing with a small elongation significantly extends the range of continuous angles of attack. Combined with strict requirements to the streamlined surfaces (especially near the leading edge of the wing), it reduces the aerodynamic drag. We obtained data on aerodynamic blowing for three types of profiles. Relatively thin profiles were selected to ensure the permanence of lifting coefficient over a rather wide range of the Reynolds numbers. Controlling actions at the maximum value of Reynolds number at the inlet to a nozzle Re_{max}=95,000 and at the maximum continuous angles of attack of the wing MB253515 alsmost do not affect the chamber's aerodynamic drag. However, there is a growth of the relative intensity of velocity pulsation at the outlet of the chamber from 10 % to 22 % for the circular component, and from 47 % to 63 % for the axial component. We propose theoretical and experimental substantiation of the examined technique based on the principle of mutual susceptibility of vortex structures.

Keywords: coherent vortex structures, control over the structure of current, vortex chamber, wing vortex generator, mutual susceptibility of vortices.

References

1. Mochalin, I. V., Khalatov, A. A. (2015). Centrifugal instability and turbulence development in Taylor–Couette flow with forced radial throughflow of high intensity. Physics of Fluids, 27 (9), 094102. doi: 10.1063/1.4930605
2. Anikin, Yu. A., Anufriev, I. S., Shadrin, E. Yu., Sharypov, O. V. (2014). Diagnostika prostranstvennoy struktury zakruchennogo potoka v modeli vihrevoy topki. Teplofizika i aeromekhanika, 21 (6), 807–810.
3. Cerretelli, C., Wuerz, W., Gharaibah, E. (2010). Unsteady Separation Control on Wind Turbine Blades using Fluidic Oscillators. AIAA Journal, 48 (7), 1302–1311. doi: 10.2514/1.42836
4. Petel'chic, V. Yu., Halatov, A. A., Pis'menniy, D. N., Dashevskiy, Yu. Ya. (2016). Primenenie mestnyh uglubleniy pri plenochnom ohlazhdenii vhodnoy kromki lopatok gazovyh turbin. Teplofizika i aeromekhanika, 23 (5), 741–748.
5. Terekhov, V. I., Shishkin, N. E. (2013). Sposoby povysheniya effektivnosti plenochnogo ohlazhdeniya s pomoshch'yu

vihrevyh pristennyh struy. Teplofizika i aeromekhanika, 20 (6), 739–747.
6. Saha, P., Biswas, G., Mandal, A. C., Sarkar, S. (2017). Investigation of coherent structures in a turbulent channel with built-in longitudinal vortex generators. International Journal of Heat and Mass Transfer, 104, 178–198. doi: 10.1016/j.ijheatmasstransfer.2016.07.105
7. Chokphoemphun, S., Pimsarn, M., Thianpong, C., Promvonge, P. (2015). Heat transfer augmentation in a circular tube with winglet vortex generators. Chinese Journal of Chemical Engineering, 23 (4), 605–614. doi: 10.1016/j.cjche.2014.04.002
8. Babenko, V. V., Chun, H. H., Lee, I. (2010). Coherent vortical structures and methods of their control for drag reduction of bodies. Journal of Hydrodynamics, Ser. B, 22 (5), 45–50. doi: 10.1016/s1001-6058(09)60167-0
9. Babenko, V. V., Mahmud, A. F., Ishchenko, S. F. (2012). Upravlenie pogranichnogo sloya profilya kryla pri generirovanii trekhmernyh vozmushcheniy. Prikladgnaya gidromekhanika, 14 (1), 3–13.
10. Udartsev, Ye. P., Shcherbonos, O. H. (2010). Eksperymentalne doslidzhennia kryla z heneratoramy vykhoriv. Visnyk NAU, 1, 45–47.
11. Babenko, V. V., Turick, V. N. (2008). Maket vihrevyh struktur pri techenii potoka v vihrevoy kamere. Prykladna hidromekhanika, 10 (3), 3–19.
12. Turick, V. N., Kochin, V. O. (2015). Passive methods of coherent vortical structures control in vortex chambers. Part 1. Spectral evaluation of efficiency. Research Bulletin of the National Technical University of Ukraine "Kyiv Polytechnic Institute", 6, 54–65. doi: 10.20535/1810-0546.2015.6.56084
13. Turick, V. N., Kochin, V. O. (2016). Passive Methods of Coherent Vortical Structures Control in Vortex Chambers. Part 2. Dispersion Analysis of Efficiency. Research Bulletin of the National Technical University of Ukraine "Kyiv Polytechnic Institute", 5, 68–77. doi: 10.20535/1810-0546.2016.5.77463
14. Drela, M. (2014). Flight Vehicle Aerodynamics. USA: The MIT Press, 304. Available at: https://mitpress.mit.edu/books/flight-vehicle-aerodynamics
15. Tit'ens, O. (1935). Gidro- i aeromekhanika (po lekciyam prof. L. Prandtlya). Vol. 2. Dvizhenie zhidkostey s treniem i tekhnicheskie prilozheniya. Moscow-Leningtad: Ob'ed. nauch.-tekhn. izd-vo NKTP SSSR, 312.
16. Glauert, G.; Aleksandrov V. L. (Ed.) (1931). Osnovy teorii kryl'ev i vinta. Moscow-Leningtad: GNTI, 163.
17. Yur'ev, B. N. (1938). Eksperimental'naya aerodinamika. Ch. 2. Induktivnoe soprotivlenie. Moscow-Leningtad: OBORONGIZ, 275.
18. Spravochnik aviakonstruktora. Vol. 1 (1937). Aerodinamika samoleta. Moscow: Izd. CAGI im. prof. N. E. Zhukovskogo, 512.
19. Selig, M. S., Donovan, J. F., Fraser, D. B. (1989). Airfoils at Low Speeds. North Horseshoe Circle, Virginia Beach, USA, 398.
20. Selig, M. S., Guglielmo, J. J., Broeren, A. P., Giguère, P. (1995). Summary of Low-Speed Airfoil Data. Vol. 1. SoarTech Publications, Virginia Beach, Virginia, USA, 292.
21. Turick, V. N. (2006). O gidrodinamicheskoy neustoychivosti v vihrevyh kamerah. Promyslova hidravlika i pnevmatyka, 3 (13), 32–37.

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RESEARCH INTO RESONANCE PHENOMENA IN GAS-VAPOR BUBBLES (p. 39-47)

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In order to calculate resonating gas bubbles, the mathematical model was supplemented by taking into account phase-transition processes on the surface of a bubble in gas-vapor media, as well as the thermal effects at gas dissolution in fluid. A series of calculations of the resonance mode for bubbles of dimensions of 0.5–3 mm in water at temperatures from +1 to +99 °C and atmospheric pressure was performed. As a result of mathematical modeling, the possibility of resonance in gas-vapor bubbles in water in the frequency range of 0.5–5 kHz was established.

It was shown that in the resonance mode the amplitude of oscillations of the wall of a bubble first increases rapidly and then is stabilized at the level of 30–50 % of the radius. It was established that motion velocity of the walls of a bubble under resonance conditions can exceed 6 m/s. It was shown that in the compression mode internal pressure of a bubble can increase by three times or decrease by two times compared with ambient pressure. Dependence of approximation resonance frequency of air bubbles in water on their diameter was established. It was found that in the resonance mode, temperature of gas-vapor medium of a bubble periodically decreases by 6 °C and increases by 12 °C in comparison with the original one. In this case, the temperature of the surface of a bubble decreases by 1 °C and increases by 7 °C. It was shown that favorable conditions for water vapor condensation (fog formation) are created at the stage of the growth of a bubble.

The schematic of the research setup and the results of field observations of gas-vapor bubbles under condition of the influence of sound waves was presented. The existence of resonance of bubbles at calculation frequencies was proved and formation of bubbles was established experimentally. The phenomena of a bubble division and its explosion were illustrated. It was found that addition of surface active substances extends the frequency range of formation of multi-bubbles by five times and contributes to an increase in the number of small bubbles inside a large one.

The research results can be applied to intensification of various technological processes related to heat and mass exchange in gas-vapor systems.

Keywords: sound waves, gas-vapor bubble, resonance frequency, multi-bubble, surface active substances.

References

1. Shilyaev, M. I., Tolstyh, A. V. (2013). Modelirovanie processov absorbcii gazov v barbotazhnyh apparatah. Teplofizika i aeromekhanika, 20 (5).
2. Tolstoy, M. Yu., Shishelova, T. I., Shestov, R. A. (2015). Issledovaniya rastvorimosti kisloroda. Izvestiya vuzov. Prikladnaya himiya i biotekhnologiya, 1 (12), 86–90.
3. Kushnir, S. V., Kost, M. V., Kozak, R. P. (2016). Barbotazhni khimichni efekty: yikh vydy, mekhanizmy vynyknennia ta heokhimichni proiavy. Voda i vodoochysni tekhnolohiyi. Naukovo-tekhnichni visti, 3 (20), 30–47.
4. Konovalov, M. L., Rozanov, O. V. (2011). Effektivnost' vakuumnoy distillyacii v toke vodyanogo para. Vestnik Sibirskogo gosudarstvennogo aerokosmicheskogo universiteta imeni akademika M. F. Reshetneva, 1 (34), 39–41.
5. Zhezhera, N. I. (2012). Razmery i dvizhenie puzyr'kov gaza pri degazacii nefti v akusticheskom deaeratore. Al'manah sovremennoy nauki i obrazovaniya, 8, 50–53.
6. Medvedev, R. N., Chernov, A. A. (2012). The calculation of thermal grows of the toroidal bubble on current concentrator in electrolyte. Modern Science, 2 (10), 50–56.
7. Sribniuk, S. M., Zubricheva, L. L., Medvedovskyi, V. V. (2011). Analiz umov vynyknennia kavitatsiynoi eroziyi. Zbirnyk naukovykh prats (haluzeve mashynobuduvannia, budivnytstvo), 2 (30), 219–226.
8. Pavlenko, A., Koshlak, H. (2014). Basic principles of gas hydrate technologies. Metallurgical and Mining Industry, 3, 60–65.
9. Bulanov, V. A., Korskov, I. V., Popov, P. N., Storozhenko, A. V. (2016). Issledovaniya rasseyaniya i zatuhannya zvuka, akusticheskoy nelineynosti i kavitacionnoy prochnosti morskoy vody v pri poverhnostnom sloe moray. Podvodnye issledovaniya i robototekhnika, 2 (22), 56–66.
10. Alhelfi, A., Sunden, B. (2014). Numerical investigation of an oscillating gas bubble in an ultrasonic field. 10th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics. Orlando, 315–322. Available at: https://repository.up.ac.za/bitstream/handle/2263/44673/Alhelfi_Numerical_2014.pdf
11. Hmelev, V. N., Shalunov, A. V., Golyh, R. N., Shalunova, A. V. (2011). Viyavlenie optimal'nyh rezhimov i usloviy ul'trazvukovogo vozdeystviya dlya raspyleniya vyazkih zhidkostey. Tekhnicheskaya akustika, 10, 105–110.
12. Colonius, T., Hagmeijer, R., Ando, K., Brennen, C. E. (2008). Statistical equilibrium of bubble oscillations in dilute bubbly flows. Physics of Fluids, 20 (4), 040902. doi: 10.1063/1.2912517
13. Pavlenko, A., Koshlak, H. (2015). Design of processes of thermal bloating of silicates. Metallurgical and Mining Industry, 1, 118–122.
14. Veretel'nik, T. I., Difuchin, Yu. N. (2008). Matematicheskoe modelirovanie kavitacionnogo potoka zhidkosti v himikotekhnologicheskoy sisteme. Visnyk ChDTU, 3, 82–85.
15. Kulinchenko, V. R. (2012). Osnovy matematicheskogo modelirovaniya dinamiki rosta parovoy fazy. Available at: http://dspace.nuft.edu.ua/jspui/handle/123456789/2224
16. Hegedűs, F. (2014). Stable bubble oscillations beyond Blake's critical threshold. Ultrasonics, 54 (4), 1113–1121. doi: 10.1016/j.ultras.2014.01.006
17. Pavlenko, A., Kutnyi, B., Holik, Y. (2017). Study of the effect of thermobaric conditions on the process of formation of propane hydrate. Eastern-European Journal of Enterprise Technologies, 5 (5 (89)), 43–50. doi: 10.15587/1729-4061.2017.111409
18. Butcher, J. C. (2008). Numerical Methods for Ordinary Differential Equations. John Wiley & Sons, 482.
19. Koryagin, S. V., Yakovlev, A. A. (2016). Sravnitel'niy analiz metodov integrirovaniya s plavayushchim shagom. Cloud of Science, 3 (1), 95–103.
20. Zabolotskaya, E. A., Soluyan, S. I. (1972). Izluchenie garmonik i kombinacionnyh chastot vozdushnymi puzyr'kami. Akusticheskiy zhurnal, 18 (3), 472–474.

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ANALYSIS OF THE EFFECT OF ULTRAVIOLET IRRADIATION ON VARROA MITE (p. 47-52)

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We presented theoretical and experimental material on the influence of UV irradiation on a Varroa mite in the range of UVB and UVC in the study. We obtained mathematical expressions that simulate dependencies of electrical and structural characteristics of protective devices. Such devices implement the operation of HEA-1 hive entrance attachments equipped with LED modules of UV radiation powered by solar photocells. We substantiated parameters of protective devices, which provide a harmful effect of UV radiation on physiological functions of a Varroa mite. These parameters include power and an amount of UV light emitting diodes, their placement in a tunnel of a hive entrance attachment, a wavelength, exposure and geometric parameters of HEA-1 hive entrance attachment. A use of a hive entrance attachment ensures rejuvenation of bees from varroatosis without disrupting their natural rhythm of life, preventing a premature release of a bee colony to a first treatment flight under adverse temperature conditions. Extension of a path of bees from a hive entrance to an exit from a tunnel of an attachment make possible for bees to adapt to meteorological conditions and feel a low temperature of the outside air and return to a hive. In addition, the study of the proposed hive entrance attachment showed a functional ability to prevent penetration of wasps, hornets and rodents to a hive. This happens due to the presence of a tunnel with a calibrated internal

opening, which limits direct access to a hive entrance, from which an appealing flavor of honey products spreads.

The described device makes it possible to prevent the infection of bees of healthy bee colonies by the exception of possibility of penetration of ill bees-villains into hive entrance. This happens due to the presence of a grid tunnel. Sources of electromagnetic radiation of the optical range of the ultraviolet spectrum (LEDs) irradiate its inner surface.

Keywords: ultraviolet radiation, wavelength, dose of irradiation, Varroa mite, fight against varroatosis.

References

1. Klochko, R. T., Voronkov, I. M. (2009). Measures to combat varroatosis of bees. Beekeeping, 2, 28–30.
2. Romanchenko, N., Masliy, I., Kundenko, N., Sanin, Y., Tsekhmeister, O. (2015). Investigation of the disinfectant effect of UV in maintaining the biopotential of bee colonies. Scientific Bulletin of the National University of Bioresources and Natural Resources of Ukraine. Series: Tehnikahny production and processing of livestock products, 223, 162–167.
3. Priyamak, G. M., Palivoda, V. O., Metryuk, Yu. Yu. (2013). Varro's Prayer, the Way of the Struggle. Passion, 4, 17–19.
4. Makarov, S. (2013). Increasing the resistance of bee colonies to varroatosis. Veterinary of farm animals, 12, 30–35.
5. Hori, M., Shibuya, K., Sato, M., Saito, Y. (2014). Lethal effects of short-wavelength visible light on insects. Scientific Reports, 4 (1). doi: 10.1038/srep07383
6. Salmik, V. V., Skomorokha, D. P., Reushev, M. Yu. (2014). Effect of pulsed ultraviolet laser radiation on the functional activity of macroorganisms. Siberian Medical Education, 4, 39–44.
7. Pfeifer, G. P., Besaratinia, A. (2012). UV wavelength-dependent DNA damage and human non-melanoma and melanoma skin cancer. Photochem. Photobiol. Sci., 11 (1), 90–97. doi: 10.1039/c1pp05144j
8. Ohtsuka, K., Osakabe, M. (2009). Deleterious Effects of Uv-B Radiation on Herbivorous Spider Mites: They Can Avoid It by Remaining on Lower Leaf Surfaces. Environmental Entomology, 38 (3), 920–929. doi: 10.1603/022.038.0346
9. Nakai, K., Murata, Y., Osakabe, M. (2017). Effects of Low Temperature on Spider Mite Control by Intermittent Ultraviolet-B Irradiation for Practical Use in Greenhouse Strawberries. Environmental Entomology. doi: 10.1093/ee/nvx179
10. Chervinsky, L. S., Radko, I. P. (2011). A new approach to the quantitative assessment of the effect of ultraviolet radiation on irradiation of animals. Motorization and power industry in agriculture, MOTROL, 13D, 296–301.
11. Romanchenko, M. A., Nikitina, O. S., Sanin, Yu. K., Romanchenko, V. M., Nikitin, S. P., Chervinskyi, L. S. (2013). Pat. No. 82214. MPK: A01K 47/00. A beehive with a device for controlling varato-zooms of bees by physical method. No. u201301608; declareted: 11.02.2013; published: 25.07.2013, Bul. No. 14.
12. Zhang, C.-Y., Meng, J.-Y., Wang, X.-P., Zhu, F., Lei, C.-L. (2011). Effects of UV-A exposures on longevity and reproduction in Helicoverpa armigera, and on the development of its F1 generation. Insect Science, 18 (6), 697–702. doi: 10.1111/j.1744-7917.2010.01393.x

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DEVELOPMENT OF TECHNOLOGY OF SUPERCONDUCTING MULTILEVEL WIRING IN SPEED GaAs STRUCTURES OF LSI/VLSI (p. 53-62)

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Technological aspects of the use of superconducting materials are considered and the possibility of making targets for magnetron deposition of films for the formation of cryoconductive wiring in GaAs-based LSI-structures is shown. The technological methods and regimes are determined and high-performance technology of cryoalloys making based on Al, Nb, V with Si, Ge and rare-earth metal admixtures and magnetron formation of superconducting films from aluminum, niobium and vanadium alloys are developed. In particular, technological regimes (ion current, accelerating voltage, deposition rate, plasma composition, uniformity of components per silicon substrate diameter) have been established, which provide a thickness of films at the level of 0.6–1 μm. Insignificant thermomechanical stresses (about 1 kg/cm^2) and small grain size (~10 nm) will allow for excellent adhesion of deposited films and formation of a topological pattern of submicron sizes using photolithography.

The parameters and characteristics of the Schottky field GaAs transistors on homo- and heterostructures (Schottky barrier height 0.75–0.8 eV, non-ideality factor 1.2-2, breakdown voltage of Schottky barrier 15–30 V) are explored and methods for increasing the speed of the LSI-structures are defined. It is shown that increasing the speed of LSI/VLSI-structures on gallium arsenide is achieved by using ther-

mostable cryomaterials as gate electrodes, conductors and contacts of source-drain regions of the Schottky field-effect transistors.

Keywords: complementary structures, epitaxy, integrated circuits, carbon films, superconductivity, magnetron deposition.

References

1. Hezel, R. (2013). Silicon Nitride in Microelectronics and Solar Cells. Springer Science & Business Media, 401.
2. Edwards, P. (2012). Manufacturing Technology in the Electronics Industry: An introduction. Springer Science & Business Media, 248.
3. Colinge, J. P., Colinge, C. A. (2007). Physics of Semiconductor Devices. Springer Science & Business Media, 436.
4. Salazar, K., Marci, K. (2012). Mineral commodity summaries. U.S. Geological Survey, Reston, Virginia, 58–60.
5. Naumov, A. V. (2005). Obzor mirovogo rynka arsenida galliya. Tekhnologiya i konstruirovanie v elektronnoy apparature, 6, 53–57.
6. Kameineni, V. K., Raymond, M., Bersch, E. J., Doris, B. B. (2010). GaAs structures with a gate dielectric based on aluminum-oxide layers. J. of Appl. Phys., 107, 093525.
7. Yoshida, T., Hashizume, T. (2012). Insulated gate and surface passivation structures for GaN-based power transistors. Appl. Phys. Lett., 101, 102.
8. Ossi, P. M., Miotello, A. (2007). Control of cluster synthesis in nano-glassy carbon films. Journal of Non-Crystalline Solids, 353 (18-21), 1860–1864. doi: 10.1016/j.jnoncrysol.2007.02.016
9. Pizzini, S. (2015). Physical Chemistry of Semiconductor Materials and Processes. John Wiley & Sons. doi: 10.1002/9781118514610
10. Kogut, I. T., Holota, V. I., Druzhinin, A., Dovhij, V. V. (2016). The Device-Technological Simulation of Local 3D SOI-Structures. Journal of Nano Research, 39, 228–234. doi: 10.4028/www.scientific.net/jnanor.39.228
11. Rowell, J. M., Track, E. K., Brock, D. K. (2000). Superconductor ICs: the 100-GHz second generation. IEEE Spectrum, 37 (12), 40–46. doi: 10.1109/6.887595
12. Alfeev, V. N. (1985). Integral'nye skhemy i mikroelektronnye ustroystva na sverhprovodnikah. Moscow: Radio i svyaz', 232.
13. Weinstock, H. (Ed.) (2000). Applications of superconductivity. Springer. doi: 10.1007/978-94-017-0752-7
14. Merkulov, A. I., Merkulov, V. A. (2013). Osnovy konstruirovaniya integral'nyh mikroskhem. Samara: SGAU, 242.
15. Shmidt, V. V. (2000). Vvedenie v fiziku sverhprovodnikov. Moscow: MCNMO, 402.
16. Parinov, I. A. (2012). High-Temperature Superconductors. Overview. Microstructure and Properties of High-Temperature Superconductors. Springer-Verlag Berlin Heidelberg, 73–124. doi: 10.1007/978-3-642-34441-1_2
17. Malik, M. A., Malik, B. A. (2014). High Temperature Superconductivity: Materials, Mechanism and Applications. Bulg. J. Phys., 41, 305–314.
18. Novosiadlyi, S. P. (2010). Sub- i nanomikronna tekhnolohiya struktur VIS. Ivano-Frankivsk: Misto NV, 455.
19. Novosiadlyi, S. P., Terletskyi, A. I. (2016). Diahnostyka submikronnykh struktur VIS. Ivano-Frankivsk: Simyk, 478.
20. Novosyadlyj, S., Dzundza, B., Gryga, V., Novosyadlyj, S., Kotyk, M., Mandzyuk, V. (2017). Research into constructive and technological features of epitaxial gallium-arsenide structures formation on silicon substrates. Eastern-European Journal of Enterprise Technologies, 3 (5 (87)), 54–61. doi: 10.15587/1729-4061.2017.104563