ABSTRACT AND REFERENCES

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EXPERIMENTAL ANALYSIS IN THE TEST RIG TO DETECT TEMPERATURE AT THE SURFACE DISC BRAKE ROTOR USING RUBBING THERMOCOUPLE (p. 6–11)

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Brake failure is one of the causes of fatal accidents because the vehicle cannot be controlled properly. Therefore, research on improving brake safety needs to be assessed immediately. Brake temperature is used as an indicator of brake performance. If the temperature signal reads is different from the normal brake signal then it becomes an indication of a brake fault. How to measure the temperature of the rotating brake rotors and what sensors allow it to be used in real vehicles is the main question in this study. In this paper, there are two types of sensors that allow detecting brake temperature, namely rubbing thermocouple and a thermocouple sensor inserted in a pad with holes. The rubbing thermocouple sensor is expected to produce a higher heat because there is a friction effect between the rubbing steel and the rotor disc, whereas the sensor in the pad hole will show the real value. However, in the use of an actual vehicle, measuring the temperature by punching holes is not recommended because it can cause potential damage to the pad itself. When an infrared sensor is used, the installation is easier but this is not suitable because dirty conditions such as dust or sticky mud on the sensor surface will hinder the sensor reading. So the use of a rubbing thermocouple will be better in real vehicles. Therefore, the measurement of temperature by rubbing thermocouple must be made a correction factor that refers to the actual temperature. From the tests conducted, the results of measurements with rubbing thermocouple (T_4) can be converted to the equation $T=-0{,}0058T_4^2+2{,}7668T_4-81{,}257$. So how to make this equation can be proposed for the development of a safety warning system related to brake performance detection devices

Keywords: rubbing thermocouple, disc brake, detection temperature brake

References

1. Lismartini, E., Nugraha, B. (2020). More than 27 Thousands of Lives Hovered on the Street. Available at: https://www.viva.co.id/berita/nasional/
2. Day, A. (2014). Braking of Road Vehicles. Elsevier, 488. doi: https://doi.org/10.1016/c2011-0-07386-6
3. Sumarsono, D. A., Siregar, R., Adhitya, M. (2018). Algorithm For Determining The Feasibility of Braking Systems Operation Of Passengers Car In Matlab Simulink. Prosiding Seminar Nasional Tahunan Teknik Mesin (SNTTM), 17, 1–5.
4. Owusu-Ansah, P., Alhassan, T., Frimpong, A., Agyei Agyemang, A. (2014). Survey of the Causes of Brake Failure in Commercial Minibuses in Kumasi. Research Journal of Applied Sciences, Engineering and Technology, 7 (23), 4877–4882. doi: https://doi.org/10.19026/rjaset.7.878
5. Chandra Verma, P., Menapace, L., Bonfanti, A., Ciudin, R., Gialanella, S., Straffelini, G. (2015). Braking pad-disc system: Wear mechanisms and formation of wear fragments. Wear, 322-323, 251–258. doi: https://doi.org/10.1016/j.wear.2014.11.019
6. Road vehicles Braking systems - Temperature measuring methods (2010). SASO.
7. Husaini, M., Krishnan, P., Yaacob, S. (2018). Data Analysis for Braking System in Time Domain for Fault Diagnosis. International Research Journal of Engineering and Technology, 05 (08), 348–354.
8. Jegadeeshwaran, R., Sugumaran, V. (2015). Brake fault diagnosis using Clonal Selection Classification Algorithm (CSCA) – A statistical learning approach. Engineering Science and Technology, an International Journal, 18 (1), 14–23. doi: https://doi.org/10.1016/j.jestch.2014.08.001

9. Chaudhary, A., Jariya, K., Sharma, M. K., Kumar, M. V. (2016). Automatic brake failure indicator. International Journal of Engineering Sciences & Research Technology, 5 (4), 928–933.
10. Siva, G. V., Reddy, B. C. M. (2018). Automobile Brake Failure Indicator, 4 (7), 322–326.
11. Agudelo, C. E., Ferro, E. (2005). Technical overview of brake performance testing for Original Equipment and Aftermarket industries in the US and European markets. Link Eng.
12. Sarip, S. (2013). Design Development of Lightweight Disc Brake for Regenerative Braking – Finite Element Analysis. International Journal of Applied Physics and Mathematics, 52–58. doi: https://doi.org/10.7763/ijapm.2013.v3.173
13. Neis, P. D., Kruze, G. A. S., Ferreira, N. F. (2009). Relation between the temperature of the disc measured with thermocouple and by thermography using a reduced scale dynamometer. 20th International Congress of Mechanical Engineering.
14. Pevec, M., Lerher, T., Potrc, I., Vranesevic, D. (2010). Numerical temperature analysis of brake disc considering cooling. Advanced Engineering, 4 (1), 55–64.
15. Km, K. R., Bashir, Q., Dar, R. A., Rather, Y. M. (2014). Experimental Test Rig for Surface Temperature Measurements in Disc Brakes. J. Appl. Eng., 2 (11).
16. Siregar, R., Zainuri, F., Adhitya, M., Sumarsono, R. D. A. (2017). Design a New Generation of Synchromesh Mechanism to Optimization Manual Transmission's Electric Vehicle. Paper presented at The 15th International Conference on Quality in Research (QiR 2017). Bali.
17. Nazaruddin, N., Zainuri, F., Siregar, R., Heryana, G., Adhitya, M., Sumarsono, D. (2019). Electric power steering: an overview of dynamics equation and how it's developed for large vehicle. IOP Conference Series: Materials Science and Engineering, 673, 012112. doi: https://doi.org/10.1088/1757-899x/673/1/012112
18. Adhitya, M., Soemarsono, D. A., Zainuri, F., Prasetyo, S., Fachruddin, Apriana, A. et. al. (2018). Devepolment model of synchromesh mechanism to optimization transmission's electric vehicle. Paper presented at 31st International Electric Vehicle Symposium and Exhibition, EVS 2018 and International Electric Vehicle Technology Conference 2018, EVTeC 2018. Kobe City.
19. Brake testing, Braking of Road Vehicles 2012 (2012). University of Bradford U.K., 662.

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CFD MODELING OF MULTIPHASE FLOWS IN THE GAS TURBINE ENGINES OIL CAVITIES (p. 12–20)

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The choice of the structure of the mathematical model of thermal-hydraulic processes in the oil cavities of the GTE rotor supports has been substantiated. A three-dimensional CFD model has been built to calculate multiphase currents involving information on the flow distribution and heat exchange given in the scientific literature. We have considered the approaches and individual models used for these purposes. The resulting solutions are consistent with the results of the experiment on a model support and generally accepted ideas about the processes in a given class of devices. The distribution of oil in the chamber, the phase current lines, the temperature and velocity fields have been given, as well as the velocity vectors for various CFD models (VOF, Euler, Inhomogeneous) and solver types (steady and non-steady). Based on the analysis of the results obtained, it has been found that the Euler model involving a non-steady solver yields the smallest difference with the experimental values for a heat transfer coefficient. In all cases, when gravity is considered, there is an asymmetrical distribution of the oil film. The result is a change in the thermal resistance of the boundary layer and, consequently, in the heat transfer coefficient along the bearing chamber circumference. This largely determines the heat flow through the chamber wall. The proposed method of modeling workflow in the support's oil cavity is based on a mathematical notation of the heterogeneous monodisperse oil-air flow with an algorithm of inversion of the structure of two-phase flow in the near-wall region from the drip into the bubble. That makes it possible to more accurately calculate the temperature states of the GTE rotor support elements and the system that ensures the proper operation of the bearing by correctly determining the heat transfer coefficient on the part of the oil-air mixture. The constructed model makes it possible to numerically investigate the applicability of those known and to derive the new correlation dependences for the mean value of a heat transfer coefficient in the oil cavity of rotor support that is used in engineering calculations. The model also makes it possible to numerically investigate the impact of the geometry, the rotor rotation frequency, and the phases flow rates on heat output in the oil cavity

Keywords: numerical simulation, multiphase streams, oil cavity, oil-air mixture, heat transfer coefficient

References

1. Wang, Y., Eastwick, C. N., Simmons, K., Hibberd, S., Care, I. (2001). Numerical study of the turbulent air flow field and droplet trajectories in a geometrically simplified bearing chamber with the presence of an oil-air separator. International Journal of Rotating Machinery, 112, 521–532.
2. Wang, Y., Hibberd, S., Simmons, K., Eastwick, C. et. al. (2001). Application of CFD to Modelling Two-Phase Flow in a High-Speed Aero-Engine Transmission Chamber. Proc. of ASME FEDSM'01: ASME 2001 Fluids Engineering Division Summer Meeting. New Orleans, Louisiana. Available at: https://www.researchgate.net/profile/Ian_Care/publication/268215106_Application_of_CFD_to_modelling_two-phase_flow_in_a_high-speed_aero-engine_transmission_chamber/links/5464f8c10cf2052b509f296c/Application-of-CFD-to-modelling-two-phase-flow-in-a-high-speed-aero-engine-transmission-chamber.pdf
3. Simmons, K., Hibberd, S., Wang, Y., Care, I. (2002). Numerical Study of the Two-Phase Air/Oil Flow Within an Aero-Engine Bearing Chamber Model Using a Coupled Lagrangian Droplet Tracking Method. Computational Technologies for Fluid/Thermal/Structural/Chemical Systems With Industrial Applications, Volume 1. doi: https://doi.org/10.1115/pvp2002-1568

4. Adeniyi, A., Morvan, H., Simmons, K. (2013). Droplet-Film Impact Modelling Using a Coupled DPM-VoF Approach. Air Breathing Engines: 21st Intern. symp. Vol. 2. Busan, 1021–1029.
5. Adeniyi, A. A., Morvan, H. P., Simmons, K. A. (2014). A Transient CFD Simulation of the Flow in a Test Rig of an Aeroengine Bearing Chamber. Volume 5C: Heat Transfer. doi: https://doi.org/10.1115/gt2014-26399
6. Hirt, C. W., Nichols, B. D. (1981). Volume of fluid (VOF) method for the dynamics of free boundaries. Journal of Computational Physics, 39 (1), 201–225. doi: https://doi.org/10.1016/0021-9991(81)90145-5
7. Kakimpa, B., Morvan, H. P., Hibberd, S. (2017). A Coupled 1D Film Hydrodynamics and Core Gas Flow Model for Air-Oil Flows in Aero-Engine Bearing Chambers. Volume 2B: Turbomachinery. doi: https://doi.org/10.1115/gt2017-64693
8. Kakimpa, B., Morvan, H. P., Hibberd, S. (2015). Solution Strategies for Thin Film Rimming Flow Modelling. Volume 5C: Heat Transfer. doi: https://doi.org/10.1115/gt2015-43503
9. Kay, E. D., Hibberd, S., Power, H. (2014). A depth-averaged model for non-isothermal thin-film rimming flow. International Journal of Heat and Mass Transfer, 70, 1003–1015. doi: https://doi.org/10.1016/j.ijheatmasstransfer.2013.11.040
10. Gorse, P., Busam, S., Dullenkopf, K. (2004). Influence of Operating Condition and Geometry on the Oil Film Thickness in Aeroengine Bearing Chambers. Journal of Engineering for Gas Turbines and Power, 128 (1), 103–110. doi: https://doi.org/10.1115/1.1924485
11. Lisitcin, A. N., Badernikov, A. V., Pechenik, E. V. (2014). Results of numerical modeling of two-phase liquid/gas flow on the basis of a simplifield model of oil chamber. VESTNIK of the Samara State Aerospace University, 5-2 (47), 135–142. doi: https://doi.org/10.18287/1998-6629-2014-0-5-2(47)-135-142
12. Peyton-Bruhl, A., Belton, D., Walker, A. D., Snowsill, G., Young, C. (2019). Development of a CFD Based Methodology for Predicting Oil Auto-Ignition in Gas Turbine Bearing Chambers. Volume 5B: Heat Transfer. doi: https://doi.org/10.1115/gt2019-92050
13. Bristot, A., Morvan, H. P., Simmons, K. A. (2016). Evaluation of a Volume of Fluid CFD Methodology for the Oil Film Thickness Estimation in an Aero-Engine Bearing Chamber. Volume 2C: Turbomachinery. doi: https://doi.org/10.1115/gt2016-56237
14. Von Plehwe, F. C., Krug, M. B., Höfler, C., Bauer, H.-J. (2016). Experimental and Numerical Investigations on Oil Leakage Across Labyrinth Seals in Aero Engine Bearing Chambers. Volume 1: Aircraft Engine; Fans and Blowers; Marine. doi: https://doi.org/10.1115/gt2016-56297
15. Kakimpa, B., Morvan, H. P., Hibberd, S. (2016). The Numerical Simulation of Multi-Scale Oil Films Using Coupled VOF and Eulerian Thin-Film Models. Volume 1: Aircraft Engine; Fans and Blowers; Marine. doi: https://doi.org/10.1115/gt2016-56747
16. Glahn, A., Busam, S., Wittig, S. (1997). Local and Mean Heat Transfer Coefficients Along the Internal Housing Walls of Aero Engine Bearing Chambers. Volume 3: Heat Transfer; Electric Power; Industrial and Cogeneration. doi: https://doi.org/10.1115/97-gt-261
17. Busam, S., Glahn, A., Wittig, S. (2000). Internal Bearing Chamber Wall Heat Transfer as a Function of Operating Conditions and Chamber Geometry. Journal of Engineering for Gas Turbines and Power, 122 (2), 314–320. doi: https://doi.org/10.1115/1.483209
18. Berthold, M., Morvan, H., Jefferson-Loveday, R., Rothwell, B. C., Young, C. (2018). Multiphase CFD Modeling of External Oil Flow From a Journal Bearing. Volume 1: Aircraft Engine; Fans and Blowers; Marine. doi: https://doi.org/10.1115/gt2018-77130
19. Tatar, V., Piskin, A. (2018). Numerical Investigation on Bearing Chamber Wall Heat Transfer. Volume 1: Aircraft Engine; Fans and Blowers; Marine. doi: https://doi.org/10.1115/gt2018-75721
20. Prabhakar, A., Ambrose, S., Morvan, H. (2019). Numerical Investigation of Two Phase Flow in a Dual Drive Booster (DDB). Volume 1: Aircraft Engine; Fans and Blowers; Marine; Honors and Awards. doi: https://doi.org/10.1115/gt2019-90347
21. Douaissia Omar Hadj Aissa, Mykhailenko, T. P., Nemchenko, D. A., Petukhov, I. I. (2017). Fluid flows simulation in the bearing chamber of GTE. Vestnik dvigatelestroeniya, 2, 59–65.
22. Douaissia Omar Hadj Aissa, Mykhailenko, T. P., Lysytsia, O. Y., Petukhov, I. I. (2018). Numerical investigation of thermal and hydraulic processes in the GTE bearing chamber. Vestnik dvigatelestroeniya, 2, 70–76.
23. Douaissia Omar Hadj Aissa (2018). Numerical Investigation of Heat Transfer in the GTE bearing chamber. Open Information and Computer Integrated Technologies, 81, 92–103. doi: https://doi.org/10.32620/oikit.2018.81.10
24. Douaissia Omar Hadj Aissa, Petrovich, M. T. (2018). Features of heat transfer in the gas turbine engine bearing chamber. Aerospace technic and technology, 6 (150), 19–28. doi: https://doi.org/10.32620/aktt.2018.6.03
25. ANSYS Fluent Theory Guide. Release 2019 R2. Canonsburg, PA.
26. Kurz, W., Dullenkopf, K., Bauer, H.-J. (2012). Influences on the Oil Split Between the Offtakes of an Aero-Engine Bearing Chamber. Volume 4: Heat Transfer, Parts A and B. doi: https://doi.org/10.1115/gt2012-69412

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ESTABLISHING PATTERNS IN THE TEMPERATURE DISTRIBUTION WITHIN A DEFORMATION ZONE DURING THIN STRIP ROLLING (p. 21–28)

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To improve the strip rolling technology, it is important to know components of the thermal state of both the strip being rolled and the tool used, that is, rolls at each point of different layers of the strip and rolls, in any section of the deformation zone. It was established that for the numerical solution of thermal problems of heat transfer in the strip-roll system described by equations of unsteady heat conduction, the finite difference method is the most effective. For the further numerical solution of the problems of unsteady thermal conductivity of the strip and rolls during hot rolling, the sections of slabs and rolls were divided by a conditional mesh. Energy balance equations with subsequent finite-difference Fourier approximation for possible options of the mesh nodes occurring in solving the two-dimensional problem of unsteady heat conduction.

When solving the heat balance problems for both the strip and the rolls, the performed transformations make it possible to switch from solving the nonlinear heat conduction problem to solving the linearized problem. It was also shown that when calculating the thermal state of the active zone in which cyclic temperature changes occur during one revolution, it becomes possible to switch from solving a problem in a cylindrical coordinate system to solving it in a rectangular coordinate system. Transition to solving a one-dimensional strip-roll system greatly simplifies the calculation. The solution of the III boundary-value problem for the roll and comparison of the obtained results with the results of solutions for the strip-roll system enables the theoretical determination of the heat transfer coefficient in the deformation zone.

The study results can be used to determine temperature and speed mode of cooling a thin strip during its rolling as well as set tasks for designing special equipment for accelerated cooling in a production stream of strip rolling mills

Keywords: slab, roll, hot rolling, accelerated cooling, thermal state, non-stationary thermal conductivity, energy balance

References

1. Jiang, L. Y., Yuan, G., Li, Z. L., Wu, D., Wang, G. D. (2014). Research on Ultra-Fast Cooling Heat Transfer Coefficient Affecting Law for Hot Strip Mill. Materials Science Forum, 788, 346–350. doi: https://doi.org/10.4028/www.scientific.net/msf.788.346
2. Lipunov, Y. I., Eismondt, K. Y., Nekrasova, E. V., Zakharchenko, M. V., Yaroshenko, Y. G., Abramov, E. V. (2015). Water-jet cooling in the thermal strengthening of asymmetric profiles. Steel in Translation, 45 (3), 226–230. doi: https://doi.org/10.3103/s0967091215030122
3. Mohapatra, S. S., Chakraborty, S., Pal, S. K. (2012). Experimental Studies on Different Cooling Processes to Achieve Ultra-Fast Cooling Rate for Hot Steel Plate. Experimental Heat Transfer, 25 (2), 111–126. doi: https://doi.org/10.1080/08916152.2011.582567
4. Mohapatra, S. S., Ravikumar, S. V., Jha, J. M., Singh, A. K., Bhattacharya, C., Pal, S. K., Chakraborty, S. (2013). Ultra fast cooling of hot steel plate by air atomized spray with salt solution. Heat and Mass Transfer, 50 (5), 587–601. doi: https://doi.org/10.1007/s00231-013-1260-6
5. Telin, N. V., Sinitsyn, N. N. (2016). Roller temperature in metallurgical machines with scale formation. Steel in Translation, 46 (7), 463–466. doi: https://doi.org/10.3103/s0967091216070147
6. Ostapenko, A. L., Beygelzimer, E. E., Kozlenko, D. A., Gritsenko, S. A., Goncharov, N. V. (2016). Sheet cooling in a roller quenching machine. Steel in Translation, 46 (5), 349–355. doi: https://doi.org/10.3103/s0967091216050119
7. Sokolov, S. F., Ogol'tsov, A. A., Sokolov, D. F., Vasil'ev, A. A. (2017). Matematicheskaya model' dlya rascheta temperatury polosy pri goryachey prokatke na stane 2000 PAO «Severstal'». Stal', 2, 35–41.
8. Trishevskii, O. I., Saltavets, N. V. (2009). Mathematical model of the thermal state of strip in rolling. Steel in Translation, 39 (2), 158–160. doi: https://doi.org/10.3103/s0967091209020168
9. Trishevskii, O. I., Saltavets, N. V. (2015). Thermal state of strip in ultrafast cooling. Steel in Translation, 45 (6), 443–446. doi: https://doi.org/10.3103/s0967091215060133
10. Muhin, U., Belskij, S., Makarov, E., Koynov, T. (2016). Simulation of accelerated strip cooling on the hot rolling mill run-out roller table. Frattura Ed Integrità Strutturale, 10 (37), 305–311. doi: https://doi.org/10.3221/igf-esis.37.40
11. Sosedkova, M. A., Radionova, L. V., Lisovskaya, T. A. (2017). Mathematical Model of Hot Rolling Temperature Parameters. Solid State Phenomena, 265, 1026–1033. doi: https://doi.org/10.4028/www.scientific.net/ssp.265.1026
12. Colas, R. (1995). Modelling heat transfer during hot rolling of steel strip. Modelling and Simulation in Materials Science and Engineering, 3 (4), 437–453. doi: https://doi.org/10.1088/0965-0393/3/4/002
13. Lienhard IV, J. H., Lienhard V, J. H. (2017). A Heat Transfer Textbook. Phlogiston Press, Cambridge Massachusetts, 768.
14. Pitts, D. R., Sissom, L. E. (1998). Theory and Problems of Heat Transfer. McGraw-Hill, 365.
15. Rudd, K. (2013). Solving Partial Differential Equations Using Artificial Neural Networks. Dissertation, Duke University, 130.
16. Tselikov, A. I., Grishkov, A. I. (1979). Teoriya prokatki. Moscow: Metallurgiya, 358.
17. Konovalov, Yu. V., Ostapenko, A. L. (1974). Temperaturniy rezhim shirokopolosnyh stanov goryachey prokatki. Moscow: Metallurgi-ya, 176.
18. Gelei, Sh. (1958). Raschety usiliy i energii pri plasticheskoy deformatsii metalla. Moscow: Metallurgiya, 420.
19. Trinks, V. (1934). Kalibrovka prokatnyh valkov. Moscow: ONTI, 144.
20. Ventsel', H. (1965). Prokatka i prokatnoe oborudovanie. VNIITI. Ekspress-informatsiya, 27, 8–43.
21. Tryshevskyi, O. I., Saltavets, M. V. (2018). Podil sliabiv sitkoiu pry rishenni dvomirnoi zadachi nestatsionarnoi teploprovidnosti yavnym kintsevo –vidiemnym metodom. Innovatsiyni tekhnolohiyi ta obladnannia obrobky materialiv u mashynobuduvanni ta metalurhiyi. Visnyk NTU «KhPI», 48 (1167), 45–49.
22. Trishevskiy, O. I., Saltavets, N. V. (2017). Ispol'zovanie metoda yavnyh konechnyh raznostey dlya resheniya zadach teploobmena pri goryachey prokatke. Stal', 3, 33–36.
23. Abbaspour, M., Saboonchi, A. (2008). Work roll thermal expansion control in hot strip mill. Applied Mathematical Modelling, 32 (12), 2652–2669. doi: https://doi.org/10.1016/j.apm.2007.09.011
24. Serajzadeh, S. (2006). Effects of rolling parameters on work-roll temperature distribution in the hot rolling of steels. The International Journal of Advanced Manufacturing Technology, 35 (9-10), 859–866. doi: https://doi.org/10.1007/s00170-006-0764-3
25. Ginzburg, V. B. (2009). Flat-Rolled Steel Processes: Advanced Technologies. CRC Press, 384.
26. Tanenbaum, A. S., Maarten, V. S. (2007). Distributed Systems: Principles and Paradigms. Prentice Hall of India.

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CONTROL OF A HIGH-VOLTAGE DISCHARGE-PULSE INSTALLATION WHEN IMPLEMENTING TECHNOLOGICAL MODES OF AN ELECTROCHEMICAL EXPLOSION (p. 29–38)

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Studying the high-voltage electrochemical explosion as a control object has established a significant impact exerted by the modes of controlled energy input into a discharge channel on the efficiency of exothermal energy conversion. Dependence has been derived of the specific energy efficiency of the release of chemical energy by an exothermic mixture on the distribution of the total introduced electrical energy among successive discharge pulses. This has made it possible, based on the rules proposed here, to determine the initial conditions for the control algorithm of a discharge-pulse installation, which implements the high-voltage electrochemical explosion technological modes, providing maximum effectiveness of exothermal transformations.

It has been shown that the considerable stochasticity of processes during exothermal transformations under a mode of explosive combustion does not make it possible to use control systems that regulate only the initial conditions for an electrochemical explosion. Such systems do not ensure the preset discharge modes at each implementation. The need for ongoing control over the process of exothermal transformations has been substantiated, in order to prevent the reduction of pressure in a discharge channel below the allowable value that maintains the exothermic reaction of explosive combustion. The performed correlation analysis of the relationship between the values of current pressure in a discharge channel and the discharge electrical characteristics has revealed that there is a dense enough information interrelation between them. Therefore, it has been proposed to use, as the information signals that indirectly determine the pressure in a discharge channel, the operationally defined electrical characteristics of a discharge.

An algorithm has been built and a system has been developed to control a high-voltage discharge-pulse installation that implements a high-voltage electrochemical explosion. Control over the mode of energy input in the process of explosive transformation makes it possible to avoid the extinction of the exothermal reaction at an accidental, due to the stochasticity of the process, reduction in pressure to the maximum allowable value in the period between the discharge pulses. Due to this, the unproductive losses of an exothermic mixture are eliminated, the losses of chemical and electrical energy are reduced, and the amount of total energy released is increased, without increasing the introduced electric energy, at each implementation of a high-voltage electrochemical explosion

Keywords: discharge-pulse installation, control algorithm, information signals, high-voltage electrochemical explosion

References

1. Guliy, G. A. (1990). Nauchnye osnovy razryadnoimpul'snyh tehnologiy. Kyiv: Naukova dumka, 208.
2. Rizun, A. R., Goleni, Y. V., Denisyuk, T. D. (2008). Seismically safe distances for bottom ground loosening by high-voltage electrochemical explosion. Surface Engineering and Applied Electrochemistry, 44 (3), 240–242. doi: https://doi.org/10.3103/s1068375508030125
3. Rytov, S. A. (2010). Effektivnost' primeneniya elektrorazryadnyh tehnologiy dlya ustroystva geotehnicheskih konstruktsiy. Zhilishchnoe stroitel'stvo, 5, 47–50.
4. Vovchenko, A. I., Posohov, A. A. (1992). Upravlyaemye elektrovzryvnye protsessy preobrazovaniya energii v kondensirovannyh sredah. Kyiv: Naukova dumka, 168.
5. Krutikov, V. S., Rizun, A. R., Golen', Yu. V. (2014). Metod otsenki poley davleniy pri vysokovol'tnom elektrohimicheskom vzryve v zakrytyh obemah. Elektronnaya obrabotka materialov, 50 (5), 84–87.
6. Rizun, A. R., Posdeev, V. A., Golen', Y. V. (2010). One-shot electrode systems for high-voltage electrochemical destruction of natural and artificial lumps. Surface Engineering and Applied Electrochemistry, 46 (3), 263–265. doi: https://doi.org/10.3103/s1068375510030129
7. Korostovenko, V. V., Korostovenko, L. P., Strekalova, T. A., Strekalova, V. A. (2013). Features of physical processes within the combined razryadnoimpulsnyh mineral processing. Mezhdunarodniy zhurnal eksperimental'nogo obrazovaniya, 10, 129–132.
8. Rizun, A. R., Golen', Y. V., Denisyuk, T. D. (2007). Initiation of electrical discharge by exothermal compositions at destruction of firm soils. Surface Engineering and Applied Electrochemistry, 43 (2), 116–118. doi: https://doi.org/10.3103/s1068375507020093
9. Vovchenko, A. I., Shomko, V. V., Barbashova, G. A., Kamenskaya, L. A. (2014). Investigation of hydrodynamic processes at multipulse power input into the channel of an electric discharge in liquid. Surface Engineering and Applied Electrochemistry, 50 (1), 72–77. doi: https://doi.org/10.3103/s1068375514010153
10. Barbashova, G. A., Shomko, V. V. (2007). Cyclicity effect of the electrical energy input in a channel of the underwater spark discharge. Surface Engineering and Applied Electrochemistry, 43 (2), 110–115. doi: https://doi.org/10.3103/s1068375507020081
11. Barbashova, G. A. (2010). Restoration of the characteristics of the cavity formed upon explosion of a microconductor according to the specified two-pulse temperature dependence of the pressure at a point in a liquid. Surface Engineering and Applied Electrochemistry, 46 (1), 53–56. doi: https://doi.org/10.3103/s1068375510010096
12. Kozyrev, S. (2019). Control System of Discharge-Pulse Installation with Elements of Artificial Intelligence. 2019 IEEE 2nd Ukraine Conference on Electrical and Computer Engineering (UKRCON). doi: https://doi.org/10.1109/ukrcon.2019.8879816
13. Tertilov, R. V. (2011). Optimization of discharge technologies on applying base of pulse current generator with two discharge circuits. Tekhnichna elektrodynamika, 3, 67–72.
14. Blashchenko, A. D., Polovinka, V. D., Tertilov, R. V. (2013). Dvuhkonturniy generator impul'snyh tokov s reguliruemym vklyucheniem konturov. Elektronnaya obrabotka materialov, 49 (1), 97–101.
15. Vovchenko, O. I., Demydenko, L. Y., Blashchenko, O. D., Starkov, I. M. (2019). Improving the efficiency of high-voltage electric discharge installations which use exothermal dispersed media. Tekh-

nichna Elektrodynamika, 5, 77–82. doi: https://doi.org/10.15407/techned2019.05.077

16. Kozyrev, S., Nazarova, N., Vinnichenko, D. (2018). Adaptive Filter of Input Information Signal for Discharge Pulse Installation Control System. 2018 IEEE 3rd International Conference on Intelligent Energy and Power Systems (IEPS). doi: https://doi.org/10.1109/ieps.2018.8559558
17. Venttsel, E. S., Ovcharov, L. A. (1988). Teoriya veroyatnostey i ee inzhenernye prilozheniya. Moscow: Nauka, 477.

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DETERMINING THE CHARACTERISTICS FOR THE RATIONAL ADJUSTING OF AN FUEL-AIR MIXTURE COMPOSITION IN A TWO-STROKE ENGINE WITH INTERNAL CARBURATION (p. 39–52)

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An operating process for engines with spark ignition and direct fuel injection engines which ensures the formation of a stratified lean fuel-air charge under the modes of partial loads and the power composition of the fuel-air mixture at high loads has been developed.

The design of a two-stroke spark-ignition engine was modernized by installing a direct fuel injection system, placing the nozzle in the cylinder wall, and changing the combustion chamber shape.

A procedure of adjustment of the composition of the fuel-air mixture in the cylinder of a two-stroke spark-ignition engine has been developed. The procedure features the recording of engine parameters and indicators at a constant cycle fuel feed and intake air adjustment. The proposed procedure makes it possible to more accurately adjust the composition of the fuel-air mixture due to a more accurate dosage of air than the cycle fuel feed.

Experimental studies were carried out and adjustment characteristics were constructed in terms of the air-fuel mixture composition in the cylinder of a two-stroke engine with a developed operating process.

Load characteristics (at n=3,000 rpm) of rational adjustment in terms of economy and maximum power were constructed based on data on the adjustment characteristics for the composition of the fuel-air mixture.

It was found that in terms of the load characteristic of rational economy adjustment, the composition of the fuel-air mixture in the engine cylinder ($\lambda_{cyl.ec}$) varied from 1.31 to 1.94 and the minimum fuel consumption was $g_{e\ min}$=259 g/(kWh). In terms of the load characteristic of rational power adjustment, the composition of the fuel-air mixture in the engine cylinder ($\lambda_{cyl.pow}$) varied from 1.31 to 1.7, and the fuel consumption at partial loads was g_e=270 g/kWh.

Characteristics of airflow rate depending on the cycle fuel feed can be used to change the composition of the fuel-air mixture with automatic adjustment of the engine load

Keywords: spark-ignition engine, operating process, internal mixture formation, fuel-air mixture

References

1. International Energy Outlook 2019 with projections to 2050. U.S. (2019). Energy Information Administration. Available at: https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf
2. Panchuk, M., Kryshtopa, S., Panchuk, A., Kryshtopa, L., Dolishnii, B., Mandryk, I., Sladkowski, A. (2019). Perspectives for developing and using the torrefaction technology in Ukraine. International Journal of Energy for a Clean Environment, 20 (2), 113–134. doi: https://doi.org/10.1615/interjenercleanenv.2019026643
3. World Energy Outlook 2019 (2019). International Energy Agency, 810.
4. Panchuk, M., Kryshtopa, S., Shlapak, L., Kryshtopa, L., Panchuk, A., Yarovyi, V., Sładkowski, A. (2018). Main trends of biofuels production in Ukraine. Transport Problems, 12 (4), 15–26. doi: https://doi.org/10.20858/tp.2017.12.4.2
5. Kryshtopa, S., Kryshtopa, L., Melnyk, V., Dolishnii, B., Prunko, I., Demianchuk, Y. (2017). Experimental research on diesel engine working on a mixture of diesel fuel and fusel oils. Transport Problems, 12 (2), 53–63. doi: https://doi.org/10.20858/tp.2017.12.2.6
6. Liu, W. (2017). Energy Management Strategies for Hybrid Electric Vehicles. Hybrid Electric Vehicle System Modeling and Control, 243–287. doi: https://doi.org/10.1002/9781119278924.ch6
7. Polivyanchuk, A., Ahieiev, M., Kagramanian, A., Baranovskis, A., Samarin, O. (2020). Features of Environmental Diagnostics of Heat Motors and Boiler Plants by Information Methods. Lecture Notes in Intelligent Transportation and Infrastructure, 360–367. doi: https://doi.org/10.1007/978-3-030-39688-6_45
8. Kryshtopa, S., Panchuk, M., Kozak, F., Dolishnii, B., Mykytii, I., Skalatska, O. (2018). Fuel economy raising of alternative fuel converted diesel engines. Eastern-European Journal of Enterprise

Technologies, 4 (8 (94)), 6–13. doi: https://doi.org/10.15587/1729-4061.2018.139358

9. Dumenko, P., Kravchenko, S., Prokhorenko, A., Talanin, D. (2019). Formation and Study of Static and Dynamic Characteristics of Electronically Controlled Diesel Engine. Latvian Journal of Physics and Technical Sciences, 56 (2), 12–23. doi: https://doi.org/10.2478/lpts-2019-0009
10. Prohorenko, A., Dumenko, P. (2018). Software Algorithm Synthesis for Diesel Electronic Control Unit. Latvian Journal of Physics and Technical Sciences, 55 (3), 16–26. doi: https://doi.org/10.2478/lpts-2018-0017
11. Nüesch, T., Elbert, P., Flankl, M., Onder, C., Guzzella, L. (2014). Convex Optimization for the Energy Management of Hybrid Electric Vehicles Considering Engine Start and Gearshift Costs. Energies, 7 (2), 834–856. doi: https://doi.org/10.3390/en7020834
12. Polivyanchuk, A., Gritsuk, I., Skuridina, E. (2019). Improving the accuracy of the gravimetric method for control particulate matter in diesel exhaust. New Stages of Development of Modern Science in Ukraine and EU Countries. doi: https://doi.org/10.30525/978-9934-588-15-0-59
13. Kryshtopa, S., Melnyk, V., Dolishnii, B., Korohodskyi, V., Prunko, I., Kryshtopa, L. et. al. (2019). Improvement of the model of forecasting heavy metals of exhaust gases of motor vehicles in the soil. Eastern-European Journal of Enterprise Technologies, 4 (10 (100)), 44–51. doi: https://doi.org/10.15587/1729-4061.2019.175892
14. Arena, F., Mezzana, L. (2014). The Automotive CO2 Emissions Challenge. 2020 Regulatory Scenario for Passenger Cars. Arthur D. Little. Available at: https://www.adlittle.com/sites/default/files/viewpoints/ADL_AMG_2014_Automotive_CO2_Emissions_Challenge.pdf
15. Meyer, S., Kölmel, A., Gegg, T., Trattner, A., Grassberger, H., Schögl, O. et. al. (2015). Advantages and challenges of lean operation of two-stroke engines for hand-held power tools. 15. Internationales Stuttgarter Symposium, 247–261. doi: https://doi.org/10.1007/978-3-658-08844-6_17
16. Kryshtopa, S., Panchuk, M., Dolishnii, B., Kryshtopa, L., Hnyp, M., Skalatska, O. (2018). Research into emissions of nitrogen oxides when converting the diesel engines to alternative fuels. Eastern-European Journal of Enterprise Technologies, 1 (10 (91)), 16–22. doi: https://doi.org/10.15587/1729-4061.2018.124045
17. Marouf Wani, M., Mursaleen, M., Parvez, S. (2013). Investigations on a Two Stroke Cycle Spark Ignition Engine Using Gasoline Direct Injection. Energy and Power, 2 (7), 116–122. doi: https://doi.org/10.5923/j.ep.20120207.01
18. Mattarelli, E., Rinaldini, C. A. (2015). Two-Stroke Gasoline Engines for Small-Medium Passenger Cars. SAE Technical Paper Series. doi: https://doi.org/10.4271/2015-01-1284
19. Zhang, Y., Zhao, H. (2014). Optimisation of boosting strategy for controlled auto-ignition combustion in a four-valve camless gasoline direct injection engine running in two-stroke cycle. International Journal of Engine Research, 15 (7), 850–861. doi: https://doi.org/10.1177/1468087413519991
20. Wang, X., Ma, J., Zhao, H. (2017). Analysis of scavenge port designs and exhaust valve profiles on the in-cylinder flow and scavenging performance in a two-stroke boosted uniflow scavenged direct injection gasoline engine. International Journal of Engine Research, 19 (5), 509–527. doi: https://doi.org/10.1177/1468087417724977
21. Zhang, G., Xu, M., Zhang, Y., Hung, D. L. S. (2012). Characteristics of Flash Boiling Fuel Sprays from Three Types of Injector for Spark Ignition Direct Injection (SIDI) Engines. Proceedings of the FISITA 2012 World Automotive Congress, 443–454. doi: https://doi.org/10.1007/978-3-642-33841-0_33
22. Zhang, Y., Zhao, H., Ojapah, M., Cairns, A. (2013). CAI combustion of gasoline and its mixture with ethanol in a 2-stroke poppet valve DI gasoline engine. Fuel, 109, 661–668. doi: https://doi.org/10.1016/j.fuel.2013.03.002
23. Wang, X., Zhao, H., Xie, H. (2016). Effect of dilution strategies and direct injection ratios on stratified flame ignition (SFI) hybrid combustion in a PFI/DI gasoline engine. Applied Energy, 165, 801–814. doi: https://doi.org/10.1016/j.apenergy.2015.12.116
24. Mahmoudzadeh Andwari, A., Pesyridis, A., Esfahanian, V., Said, M. (2019). Combustion and Emission Enhancement of a Spark Ignition Two-Stroke Cycle Engine Utilizing Internal and External Exhaust Gas Recirculation Approach at Low-Load Operation. Energies, 12 (4), 609. doi: https://doi.org/10.3390/en12040609
25. Andwari, A. M., Abdul Aziz, A., Muhamad Said, M. F., Esfahanian, V. et. al. (2017). Effect of internal and external EGR on cyclic variability and emissions of a spark ignition two-stroke cycle gasoline engine. Journal of mechanical engineering and sciences, 11 (4), 3004–3014. doi: https://doi.org/10.15282/jmes.11.4.2017.4.0270
26. Gombosuren, N., Yoshifumi, O., Hiroyuki, A. (2020). A Charge Possibility of an Unfueled Prechamber and Its Fluctuating Phenomenon for the Spark Ignited Engine. Energies, 13 (2), 303. doi: https://doi.org/10.3390/en13020303
27. Wang, X., Zhao, H. (2019). A High-Efficiency Two-Stroke Engine Concept: The Boosted Uniflow Scavenged Direct-Injection Gasoline (BUSDIG) Engine with Air Hybrid Operation. Engineering, 5 (3), 535–547. doi: https://doi.org/10.1016/j.eng.2019.03.008
28. Schnittger, W., Königstein, A., Pritze, S., Pöpperl, M., Rothenberger, P., Samstag, M. (2003). 2.2 Direct Ecotec. MTZ Worldwide, 64 (12), 2–7. doi: https://doi.org/10.1007/bf03227635
29. Voss, E., Schmittger, W., Königstein, A., Scholten, I., Pöpperl, M., Pritze, St., Rothenberger, P., Samstag, M. (2003). 2,2 l ECOTEC DIRECT – Der neue Vollaluminiummotor mit Benzindirekteinspritzung für den Opel Signum. 24. Internationales Wiener Motorensymposium.
30. Krebs, R., Böhme, J., Dornhöfer, R., Wurms, R., Friedmann, K., Helbig, J., Hatz, W. (2004). Der neue Audi 2,0T FSI Motor Der erste direkteinspritzende Turbo Ottomotor bei Audi. 25. Wiener Motorensymposium. Available at: https://www.tib.eu/en/search/id/dkf%3A0409DKF189515/Der-neue-Audi-2-0T-FSI-Motor-Der-erste-direkteinspritzende/
31. Jägerbauer, E., Fröhlich, K., Fischer, H. (2003). Der neue 6,0-l-Zwölfzylindermotor von BMW. MTZ - Motortechnische Zeitschrift, 64 (7-8), 546–555. doi: https://doi.org/10.1007/bf03227108
32. Tsuji, N., Sugiyama, M., Abe, S. (2006). Der neue 3.5L V6 Benzinmotor mit dem innovativen stöchiometrischen Direkteinspritzsystem D-4S. 27. Internationales Wiener Motorensymposium.
33. Kettner, M., Fischer, J., Nauwerck, A., Spicher, U., Velji, A., Kuhnert, D., Latsch, R. (2003). Ein neues Brennverfahren mit Mehrfacheinspritzung für Ottomotoren mit Direkteinspritzung. 9. Tagung: Der Arbeitsprozess des Verbrennungsmotors. Available at: http://www.sfb606.kit.edu/index.pl/Haupt_Menu_Forschungsprogramm_M08/projekte/c3/Veroeffentlichung/Sept2003_BPi.pdf
34. Kettner, M., Fischer, J., Nauwerck, A., Tribulowski, J., Spicher, U., Velji, A. et. al. (2004). The BPI Flame Jet Concept to Improve the

Inflammation of Lean Burn Mixtures in Spark Ignited Engines. SAE Technical Paper Series. doi: https://doi.org/10.4271/2004-01-0035

35. Herden, W., Vogel, M. (2002). Visionen idealer strahlgeführter BDE-Brennverfahren. Dieselund Benzindirekteinspritzung. Essen: Expert-Verlag.
36. Kemmler, R., Frommelt, A., Kaiser, T., Schaupp, U., Schommers, J., Waltner, A. (2002). Thermodynamischer Vergleich ottomotorischer Brennverfahren unter dem Fokus minimalen Kraftstoffverbrauchs. 11. Aachener Kolloquium Fahrzeug- und Motorentechnik.
37. Specifications engines Evinrude® E-TEC® G2™ 200 HO, 225 HP, 225 HO, 250 HP, 250 HO, 300 HP. Fuel inductions: E-TEC Direct Injection with stratified low RPM combustion mode / Bombardier Recreational Products Inc. 2003-2015. Available at: http://www.evinrude.com/en-US/engines/e-tec-g2/200-ho-300-hp.html#tab=0
38. Technical Details ROTAX 600 E-TEC. Available at: https://www.rotax.com/en/products/rotax-powertrains/details/rotax-600-ho-e-tec.html
39. Arcoumanis, C., Kamimoto, T. (Eds.) (2009). Flow and Combustion in Reciprocating Engines. Springer. doi: https://doi.org/10.1007/978-3-540-68901-0
40. Schumann, F., Sarikoc, F., Buri, S., Kubach, H., Spicher, U. (2012). Potential of spray-guided gasoline direct injection for reduction of fuel consumption and simultaneous compliance with stricter emissions regulations. International Journal of Engine Research, 14 (1), 80–91. doi: https://doi.org/10.1177/1468087412451695
41. Korogodskyj, V. A., Kyrylyuk, I. O., Lomov, S. G. (2007). Pat. No. WO2009044225A1. A Method of Mixing in a Combustion Chamber of an Internal Combustion Engine and a Spark-Ignition Direct-Injection Stratified Fuel-Air Charge Internal Combustion Engine. No. PCT/IB 2007/004105; declareted: 03.10.2007; published: 09.04.2009. Available at: https://patentimages.storage.googleapis.com/71/bb/f0/2d600f599211e0/WO2009044225A1.pdf
42. Korohodskyi, V., Khandrymailov, A., Stetsenko, O. (2016). Dependence of the coefficients of residual gases on the type of mixture formation and the shape of a combustion chamber. Eastern-European Journal of Enterprise Technologies, 1 (5 (79)), 4–12. doi: https://doi.org/10.15587/1729-4061.2016.59789
43. Reif, K. (Ed.) (2015). Ottomotor-Management im Überblick. Springer. doi: https://doi.org/10.1007/978-3-658-09524-6
44. Pesiridis, A. (Ed.) (2014). Automotive Exhaust Emissions and Energy Recovery. En-vironmental, Science, Engineering and Technology. N.Y.: Nova Science Publ. Inc., 293. Available at: https://novapublishers.com/shop/automotive-exhaust-emissions-and-energy-recovery/
45. Korohodskyi, V. A., Vasylenko, O. V., Tsykra, S. A., Oboznyi, S. V. (2010). Eksperymentalne vyznachennia koefitsienta vytoku robochoho tila pry produvtsi tsylindra u dvotaktnomu dvyhuni z iskrovym zapaliuvanniam. Zbirnyk naukovykh prats UkrDAZT, 112, 203–208.
46. Martyr, A., Plint, M. (2012). Engine Testing: The Design, Building, Modification and Use of Powertrain Test Facilities. Butterworth-Heinemann, 600. doi: https://doi.org/10.1016/c2010-0-66322-x
47. Rogovyi, A. (2018). Energy performances of the vortex chamber supercharger. Energy, 163, 52–60. doi: https://doi.org/10.1016/j.energy.2018.08.075
48. Van Basshuysen, R., Schäfer, F. (Eds.) (2017). Handbuch Verbrennungsmotor. Grundlagen, Komponenten, Systeme, Perspektiven. Springer. doi: https://doi.org/10.1007/978-3-658-10902-8
49. Reif, K. (Ed.) (2015). Gasoline Engine Management Systems and Components. Springer. doi: https://doi.org/10.1007/978-3-658-03964-6
50. Song, J., Kim, T., Jang, J., Park, S. (2015). Effects of the injection strategy on the mixture formation and combustion characteristics in a DISI (direct injection spark ignition) optical engine. Energy, 93, 1758–1768. doi: https://doi.org/10.1016/j.energy.2015.10.058
51. Korogodskiy, V. A., Vasilenko, O. V. (2007). The defenition of combustion parameters under indicator diagrams of a two-stroke engine with the carburettor and direct fuel ingection. Visnyk Kharkivskoho natsionalnoho avtomobilno-dorozhnoho universytetu, 37, 60–67. Available at: https://cyberleninka.ru/article/n/opredelenie-pokazateley-sgoraniya-po-indikatornym-diagrammam-dvuhtaktnogo-dvigatelya-s-karbyuratorom-i-neposredstvennym-vpryskom
52. Korohodskiy, V. A., Stetsenko, O. N., Tkachenko, E. A. (2015). The influence stratification of fuel and air charge on combustionindicators two-stroke engines with spark ignition. Zbirnyk naukovykh prats UkrDUZT, 154, 142–148. Available at: http://webcache.googleusercontent.com/search?q=cache:aE7Jtb7Nqr4J:irbis-nbuv.gov.ua/cgi-bin/irbis_nbuv/cgiirbis_64.exe%3FC21COM%3D2%26I21DBN%3DUJRN%26P21DBN%3DUJRN%26IMAGE_FILE_DOWNLOAD%3D1%26Image_file_name%3DPDF/Znpudazt_2015_154_25.pdf+&cd=2&hl=ru&ct=clnk&gl=ua

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DETERMINING THE FACTORS THAT AFFECT THE QUALITY OF TEST PRINTS AT FLEXOGRAPHIC PRINTING (p. 53–63)

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The intensive use of flexographic printing for packaging decoration and the increased consumer demands for it require an in-depth study of the factors that influence the prints' quality. In this paper, we examined the test prints obtained at a flexographic proofer. Images on cardboard were printed by the environmentally friendly inks made by a Ukrainian manufacturer. The effect of the cardboard surface layer on the microgeometry of the prints created by cyan, yellow, black, and magenta inks has been shown. It has been established that the roughness parameter Ra for a two-layer coated cardboard is reduced by 3 times as compared to the uncoated cardboard. The photographs of the microstructure of the prints' surface, their profile demonstrate a significant effect of the chalked coating on the image quality. It has been confirmed that the ink layer smooths out the micro-roughness of the print surface. However, when printed on the uncoated cardboard, the ink particles penetrate deeper into the structure and do not com-

pletely smooth out its micro-roughness. If the size of the printing element is smaller than the size of the cell on a raster roller, it falls into this cell and the ink is applied beyond the boundaries of the image. As a result, a spot of an arbitrary shape is formed on the print instead of a raster dot of a certain size, that is, the so-called "inverse tone transfer" occurs. We have measured the densitometric indicators of prints (optical density, gray balance), which significantly affect the quality of the product. Based on a Harrington's desirability function, the maximum permissible values of optical density, evenness of printing, contrast, dot gain of raster elements, and trapping, have been calculated. According to the generalized optimization criterion, a comprehensive index of the prints' quality has been determined, which could ensure the predicted quality of a would-be run of the printed products, and would make it possible to adjust the printing process if necessary

Keywords: flexographic printing, test print, cardboard, surface topography, densitometric quality indicators

References

1. Label and package printing industry predictions for 2020 (2019). Labels & Labeling. Available at: https://www.labelsandlabeling.com/news/industry-updates/label-and-package-printing-industry-predictions-2020
2. James, A. (2013). Anilox technology applications. FlexoTech, 36–37.
3. Liu, X., Guthrie, J. T. (2003). A review of flexographic printing plate development. Surface Coatings International Part B: Coatings Transactions, 86 (2), 91–99. doi: https://doi.org/10.1007/bf02699619
4. Flexographic Printing Inks Market Analysis & Trends 2019-2024. Available at: https://www.gminsights.com/industry-analysis/flexographic-printing-inks-market
5. Yusof, M. S., Claypole, T. C., Gethin, D. T., Ahmad Zaidi, A. M. (2008). Application of finite elements on non-linear deformation of flexographic photopolymer printing plate. Proceedings of the World Congress on Engineering. Vol. II. London.
6. Sinyak, M., Mayson, P. (2008). Problemy vosproizvedeniya 1%-noy tochki vo fleksografii. Komp'yuArt, 7, 21–25.
7. Andy, T. (2011). Industry team delivers stunning cover. Labels & Labeling, 9.
8. Doziruyushchie aniloksovye valy GTT. FleksoPlyus.
9. Chepurna, K. O. (2012). Researching of the influence of the print-technical properties of inking rollers on the optical density of impressions. Polihrafiya i vydavnycha sprava, 3, 74–79.
10. Olsson, R., Yang, L., van Stam, J., Lestelius, M. (2007). Effects of elevated temperature on flexographic printing. Conference: Advances in Printing and Medio Technology.
11. Low Migration Inks Market by Process (Gravure, Flexography, Off-Set, Digital), End-Use Industry (Food & Beverages, Pharmaceutical, Cosmetics), and Region (North America, Asia Pacific, Europe, Rest of the World) - Global Forecast to 2022. Available at: https://www.marketsandmarkets.com/Market-Reports/low-migration-ink-market-63935492.html
12. Shibanov, V. V. (2015). UF-kraski dlya pishchevoy upakovki: radikal'nye ili kationnye? Korotko ob additsionnoy polimerizatsii. Flekso Plyus, 2, 31–38.
13. Studer, K., Decker, C., Beck, E., Schwalm, R. (2003). Overcoming oxygen inhibition in UV-curing of acrylate coatings by carbon dioxide inerting, Part I. Progress in Organic Coatings, 48 (1), 92–100. doi: https://doi.org/10.1016/s0300-9440(03)00120-6
14. Stępień, K., Khadzynowa, S., Leks-Stępień, J. (2007). Czynniki wpływające na przenoszenie farby we fleksografii. Opakowanie, 3.
15. Senkivskyi, V. M., Kokhan, V. F., Melnykov, O. V., Nazarenko, O. M., Lazarenko, O. V. (2012). Factors predicting quality flexographic printing. Polihrafiya i vydavnycha sprava, 3 (59), 53–58.
16. ISO 12647-6:2012. Graphic technology - Process control for the production of half-tone colour separations, proofs and production prints - Part 6: Flexographic printing.
17. Ahnazarova, S. L., Gordeev, L. S. (2003). Ispol'zovanie funktsii zhelatel'nosti Harringtona pri reshenii optimizatsionnyh zadach himicheskoy tehnologii. Moscow: RHTU im. D. S. Mendeleeva, 76.
18. Minenkova, O. V. (2017). Estimation of activity of enterprise on basis of integral index of quality of balanced scorecard. Naukovyi visnyk Khersonskoho derzhavnoho universytetu, 25, 187–194.
19. Del Castillo, E., Montgomery, D. C., McCarville, D. R. (1996). Modified Desirability Functions for Multiple Response Optimization. Journal of Quality Technology, 28 (3), 337–345. doi: https://doi.org/10.1080/00224065.1996.11979684

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TESTING A MICROWAVE DEVICE FOR THE TREATMENT OF PLANT MATERIALS BY VARIOUS TECHNOLOGIES (p. 64–71)

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We have tested the microwave device of continuous operation for the thermal treatment of plant materials, which was developed and designed to implement microwave technologies in the industry. The purpose of the tests was to assess the effectiveness of the micro-

wave device by the indicators of quality of the obtained material and energy consumption determined by the efficiency of the conversion of microwave energy into the internal energy of the material. The effects of microwave treatment of a straw substrate for tree-destroying fungi were studied. The treatment quality was determined by the yield of Oyster (Pleurotus) mushrooms, grown on the obtained substrate. Microwave treatment was carried out in various modes, which differed in the value of specific power. When analyzing the effectiveness of microwave treatment, the results were compared with the data obtained during the application of the traditional technology of straw sterilization. It was shown that the harvest of Oyster mushrooms increased by 11 %. It was found that under the optimal mode, specific power was $q_v=8.68\cdot10^5$ W/m^3, final temperature was t=96 °C, duration of treatment was 180 s. Based on the thermal calculations, the values of the microwave chamber efficiency η_c were calculated; under the optimal mode, $\eta_c=62$ %. The influence of the microwave treatment on the sowing characteristics of seed wheat grain was studied. The effectiveness of the microwave treatment was determined by the values of laboratory germination and seed germination energy. Under the optimal mode, the output power of magnetrons was $\Sigma P_{out}=0.6$ kW, the grain consumption was $G=2.1\cdot10^{-2}$ kg/s. The study of the microwave device operation showed that for this design, in order to ensure stable and uniform movement of the material along the product pipeline, it is necessary to maintain the movement speed that is not higher than 0.5 m/min. It is recommended to apply the tested microwave device of continuous operation on specialized farms

Keywords: microwave device, thermal treatment, straw material, seeds, optimal mode, energy efficiency

References

1. Feng, H., Yin, Y., Tang, J. (2012). Microwave Drying of Food and Agricultural Materials: Basics and Heat and Mass Transfer Modeling. Food Engineering Reviews, 4 (2), 89–106. doi: https://doi.org/10.1007/s12393-012-9048-x
2. Kappe, C. O. (2004). Controlled Microwave Heating in Modern Organic Synthesis. Angewandte Chemie International Edition, 43 (46), 6250–6284. doi: https://doi.org/10.1002/anie.200400655
3. Leonelli, C., Veronesi, P. (2014). Microwave Reactors for Chemical Synthesis and Biofuels Preparation. Biofuels and Biorefineries, 17–40. doi: https://doi.org/10.1007/978-94-017-9612-5_2
4. Burlutskiy, D. S., Kaleeva, Zh. G. (2011). Izmenenie fizicheskih svoystv materialov v rezul'tate eksperimental'nogo vozdeystviya sharovogo elektricheskogo razryada, poluchennogo s pomoshch'yu sverhvysokochastotnogo izlucheniya. Sovremennye naukoemkie tehnologii, 5, 22–32.
5. Agrawal, D. (2010). Microwave sintering of ceramics, composites and metal powders. Sintering of Advanced Materials, 222–248. doi: https://doi.org/10.1533/9781845699949.2.222
6. Srinath, M. S., Sharma, A. K., Kumar, P. (2011). A new approach to joining of bulk copper using microwave energy. Materials & Design, 32 (5), 2685–2694. doi: https://doi.org/10.1016/j.matdes.2011.01.023
7. Kalinin, L. G., Boshkova, I. L. (2003). Physical model of the plant tissue response to exposure to the microwave electromagnetic field. Biophysics, 48 (1), 111–113.
8. Moskovskiy, M. N., Fridrikh, R. A., Gulyayev, A. A. (2010). Structural analysis of culmiferous material surface under microwave radiation treatment. Vestnik Donskogo gosudarstvennogo tehnicheskogo universiteta, 10 (5 (48)), 648–654.
9. Sapunov, G. S. (1998). Remont mikrovolnovyh pechey. Moscow: Solon, 268.
10. Lukina, D., Belov, V., Lukina, O., Volkov, A., Mayorov, A., Smirnova, I. (2018). Increasing the Efficiency of the Operation of the Facilities for the Thermal Processing of Raw Materials by Exposure to Electromagnetic Radiation. Key Engineering Materials, 781, 185–189. doi: https://doi.org/10.4028/www.scientific.net/kem.781.185
11. Okeke, C. Abioye, A. E., Omosun, Y. (2014). Microwave Heating Applications in Food Processing. IOSR Journal of Electrical and Electronics Engineering, 9 (4), 29–34.
12. Puligundla, P. (2013). Potentials of Microwave Heating Technology for Select Food Processing Applications - a Brief Overview and Update. Journal of Food Processing & Technology, 04 (11). doi: https://doi.org/10.4172/2157-7110.1000278
13. Volgusheva, N., Altman, E., Boshkova, I., Titlov, A., Boshkov, L. (2017). Study into effects of a microwave field on the plant tissue. Eastern-European Journal of Enterprise Technologies, 6 (8 (90)), 47–54. doi: https://doi.org/10.15587/1729-4061.2017.115118
14. Boshkova, I., Volgusheva, N., Titlov, A., Titar, S., Boshkov, L. (2019). Assessment of efficiency of drying grain materials using microwave heating. Eastern-European Journal of Enterprise Technologies, 1 (8 (97)), 78–85. doi: https://doi.org/10.15587/1729-4061.2019.154527
15. Pedro, J. C., Cunha, T. R. (2014). Behavioral Models for Microwave Circuit Design. Microwave De-Embedding, 255–315. doi: https://doi.org/10.1016/b978-0-12-401700-9.00007-0
16. Loharkar, P. K., Ingle, A., Jhavar, S. (2019). Parametric review of microwave-based materials processing and its applications. Journal of Materials Research and Technology, 8 (3), 3306–3326. doi: https://doi.org/10.1016/j.jmrt.2019.04.004
17. Cherbański, R., Rudniak, L. (2013). Modelling of microwave heating of water in a monomode applicator – Influence of operating conditions. International Journal of Thermal Sciences, 74, 214–229. doi: https://doi.org/10.1016/j.ijthermalsci.2013.07.001
18. Ye, J., Hong, T., Wu, Y., Wu, L., Liao, Y., Zhu, H. et. al. (2017). Model Stirrer Based on a Multi-Material Turntable for Microwave Processing Materials. Materials, 10 (2), 95. doi: https://doi.org/10.3390/ma10020095
19. Efremova, E. N., Karpacheva, E. A. (2015). Hranenie i pererabotka produktsii rastenievodstva. Volgograd: GAU, 148.

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DEVELOPMENT A MATHEMATICAL MODEL OF ACOUSTIC SIGNALS FOR THE IMPLEMENTATION OF A UNIVERSAL LEAK DETECTION METHOD (p. 72–79)

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A universal mathematical model of a noise signal in pipeline systems from the point of its origin to the observation point was presented. Due to the indicator function introduced into it, the model makes it possible to use different types of components and perform appropriate actions depending on the task, and the indicator function in some cases will be zero.

The developed model advantage consists in that it is universal for the leak detection methods which use two signal receivers regardless of their physical nature. This model was implemented in the study on an example of a method of acoustic leakage detection, which uses the inter-correlation function. A block diagram of an acoustic system for detecting leakage location, its main blocks, and their parameters were presented. To test the working capacity of the mathematical model, a computer measuring experiment was conducted in the MATLAB software system. The algorithm of the computer experiment with indicator function was presented and the results of detecting leakage location according to the corresponding sample were given.

A universal formula for calculating coordinates of the fluid leakage location both along the axis of the pipeline and the pipeline circumference was presented. This formula features accounting of the distance from the transducer to the possible leakage location and the sample number. This formula serves a universal model of the noise signal and confirms the results of the computer experiment.

As a result of the experiment, dependences of the values of the fluid leakage location on the sample number and the distance to the receiver of the acoustic noise signal were obtained. To test the model adequacy, a diagram of influential factors was constructed in a form of Ishikawa diagram. The diagram shows the cause-and-effect relationships that affect the computer experiment built on the proposed mathematical model of acoustic signals to implement the universal method of leak detection. Adequacy of the proposed universal model was verified and confirmed by statistical methods.

The results obtained can be used in technical diagnostics of pipelines and for reducing costs of repair and restoration of technological systems by identifying breakdown sites

Keywords: acoustic signal of leakage, universal mathematical model of noise signal, computerized leak detection system

References

1. Sheltami, T. R., Bala, A., Shakshuki, E. M. (2016). Wireless sensor networks for leak detection in pipelines: a survey. Journal of Ambient Intelligence and Humanized Computing, 7 (3), 347–356. doi: https://doi.org/10.1007/s12652-016-0362-7
2. Yazdekhasti, S., Piratla, K. R., Matthews, J. C., Khan, A., Atamturktur, S. (2018). Optimal selection of acoustic leak detection techniques for water pipelines using multi-criteria decision analysis. Management of Environmental Quality: An International Journal, 29 (2), 255–277. doi: https://doi.org/10.1108/meq-05-2017-0043
3. Liu, C. W., Li, Y. X., Meng, L. Y., Sun, Y. P. (2014). Time–frequency analysis of acoustic leakage signal for natural gas pipelines based on Hilbert–Huang transform. Journal of Vibration and Shock, 33 (16), 42–49.
4. Hamilton, S., Charalambous, B. (2013). Leak Detection: Technology and Implementation. IWA Publishing, 112. doi: https://doi.org/10.26530/oapen_578133
5. Martyniuk, G., Onykiienko, Y., Scherbak, L. (2016). Analysis of the pseudorandom number generators by the metrological characteristics. Eastern-European Journal of Enterprise Technologies, 1 (9 (79)), 25–30. doi: https://doi.org/10.15587/1729-4061.2016.60608
6. Zagirnyak, M., Manko, R., Kovalchuk, V., Korenkova, T. (2017). Assessment of pipeline network leakage influence on dynamic characteristics of the pump complex. 2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON). doi: https://doi.org/10.1109/ukrcon.2017.8100534
7. Tee, K. F., Pesinis, K. (2017). Reliability prediction for corroding natural gas pipelines. Tunnelling and Underground Space Technology, 65, 91–105. doi: https://doi.org/10.1016/j.tust.2017.02.009
8. Sarker, N. R., Breakey, D. E. S., Islam, M. A., Sun, S., Fleck, B. A., Sanders, R. S. (2020). Performance and hydrodynamics analysis of a Toroid Wear Tester to predict erosion in slurry pipelines. Wear, 450-451, 203068. doi: https://doi.org/10.1016/j.wear.2019.203068
9. Ostapkowicz, P., Bratek, A. (2015). Leak Detection in Liquid Transmission Pipelines During Transient State Related to a Change of Operating Point. Advanced and Intelligent Computations in Diagnosis and Control, 253–265. doi: https://doi.org/10.1007/978-3-319-23180-8_18
10. Zhang, G., Zhu, J., Song, Y., Peng, C., Song, G. (2018). A Time Reversal Based Pipeline Leakage Localization Method With the Adjustable Resolution. IEEE Access, 6, 26993–27000. doi: https://doi.org/10.1109/access.2018.2829984
11. Li, Y., Wang, L., Guan, J. (2017). A Spectrum Detection Approach for Bearing Fault Signal Based on Spectral Kurtosis. Shock and Vibration, 2017, 1–9. doi: https://doi.org/10.1155/2017/6106103
12. Martyniuk, H. V., Shcherbak, L. M. (2018). Shumovi syhnaly ta yikh kharakterystyky. LAP Lambert Academic Publishing, 112.