ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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DETERMINING THE MAXIMALLY PERMISSIBLE VALUES FOR THE INDICATORS OF INSULATION OF SEALED ENTRANCE BUSHINGS WITH A VOLTAGE OF 110 kV USING THE METHOD OF MINIMAL RISK (p. 6–15)

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A method for determining the maximally permissible values for the indicators of insulation of high-voltage oil-filled entrance bushings that ensure the minimal risk value has been proposed. The proposed method differs in that the maximally permissible values for indicators are determined by minimizing the function of average risk, using the Newton's method, taking into consideration the actual operating conditions of equipment, which makes it possible to improve the operational reliability of entrance bushings.

We have derived an expression to determine the average risk with respect to the distribution law of indicators for the insulation of high-voltage entrance bushings (by Weibull), the minimization of which makes it possible to determine the maximally permissible values for the indicators, taking into consideration the duration of their operation, the values of load currents, the grade of a transformer oil, and other factors.

A comparative analysis was performed for risk values, which are accompanied by applying the maximally permissible values for indicators that are regulated in Ukraine, with the maximally permissible values for indicators, which were obtained by using different methods. The analysis revealed that the minimal risk value is ensured by the maximally permissible values for indicators, which are obtained by applying the method of minimal risk, taking into consideration the operating conditions for entrance bushings. We have performed an analysis of impact of the values for probabilities of the proper-functioning and faulty state of entrance bushings, the cost of incorrect decisions, as well as the value for a scale parameter and a shape parameter in the Weibull distribution, on the maximally permissible values for the indicators of insulation of high-voltage oil-filled entrance bushings in an airtight structure. It was established that an increase in the probability of a defect and its conditional cost, as well as prolonging the operation duration of entrance bushings and their loading, leads to a decrease in the maximally permissible values for the indicators. It has been proven that the maximally permissible values for the indicators of insulation of high-voltage entrance bushings, which ensure the minimal economic loss, are not constant. In order to practically implement the method of minimal risk during operation, it has been proposed to apply the likelihood ratios, which make it possible to diagnose the state of high-voltage entrance bushings at a minimal risk, but without determining the maximally permissible values for the indicators.

Keywords: high voltage entrance bushing, insulation indicators, minimal risk, probabilities of erroneous and correct decisions, Weibull distribution, likelihood ratios.

References

1. Alekseev, B. A. (2002). Kontrol' sostoyaniya (diagnostika) krupnyh silovyh transformatorov. Moscow: «Izdatel'stvo NC ENAS», 216.
2. Anglhuber, M., Velásquez, C. J. L. (2017). Dispersing the clouds – gain clear insight into your bushings using advanced diagnostics method. Transformers Magazine, 126–132.
3. Andrienko, P. D., Sahno, A. A., Konogray, S. P., Spica, A. G.,. Skrupskaya, L. S. (2014). Osobennosti monitoringa tekhnicheskogo sostoyaniya osnovnoy izolyacii vysokovol'tnyh vvodov i transformatorov toka. Elektrotekhnika ta elektroenerhetyka, 1, 43–48.
4. Rubanenko, O. Ye., Humeniuk, O. I. (2011). Vysokovoltni vvody. Konstruktsiya, ekspluatatsiya, diahnostyka i remont. Vinnytsia: VNTU, 183.
5. Dolya, O. E. (2013). Povyshenie nadezhnosti ekspluatacii vvodov. Materialy 10-oy ezhegodnoy konferencii «Metody i sredstva kontrolya izolyacii vysokovol'tnogo oborudovaniya». Perm': OOO «Dimrus».
6. Kassihin, S. D., Sipilkin, K. G., Slavinskiy, A. Z., Ustinov, V. N., Pintal', Yu. S., Vereshchagin, M. B. (2010). Ocenka effektivnosti i celesoobraznosti diagnostiki vysokovol'tnyh vvodov na osnove opyta ekspluatacii. Transformatory: ekspluataciya, diagnostirovanie, remont, prodlenie sroka sluzhby: materialy Mezhdunar. nauch.-prakt. konf., posvyashch. 70-letiyu Viktora Sokolova. Ekaterinburg: Izdatel'skiy dom «Avtograf».
7. Anikeeva, M. A., Arbuzov, R. S., Zhivodernikov, S. V., Lazareva, E. A., Ovsyannikov, A. G., Panov, M. A. (2009). Diagnosticheskie priznaki dlya otbrakovki vvodov vysokogo napryazheniya s bumazhno-maslyanoy izolyaciey. ELEKTRO, 1, 22–25.
8. Normy vyprobuvannia elektroobladnannia: SOU-N EE 20.302:2007 – Ofits. vyd., prykaz Minpalyvenerho 2007-01-15 h. No. 13 (2007). Kyiv: OEP «HRYFRE»: Minpalyvenerho palyva ta enerhetyky Ukrainy, 262.
9. Shutenko, O., Zagaynova, A., Serdyukova, G. (2018). Analysis of distribution laws of insulation indicators of high-voltage oil-fillled bushings of hermetic and non-hermetic execution. Technology audit and production reserves, 4 (1 (42)), 30–39. doi: https://doi.org/10.15587/2312-8372.2018.140873
10. Zahainova, O. A. (2015). Analiz vplyvu riznomanitnykh chynnykiv na intensyvnist starinnia izoliatsiyi kondensatornoho typu vysokovoltnykh vvodiv. Energosberezhenie. Energetika. Energoaudit, 10 (141), 17–25.
11. Santos, E., Schuette, T. (2016). Breakdown Mechanism of Bushings and Life-Cycle Oriented Maintenance Strategies. TechCon Asia-Pacific, 1–27.
12. Gubanski, S. M. et. al. (2010). Dielectric Response Diagnoses For Transformer Windings. CIGRE report 414.

13. Felea, I., Secui, D., Oltean, M. (2011). The impact analyze of electric stress level in content of insulating oil gases in power transforrmers. Journal of sustainable energy, 2 (4).
14. Lin, M.-J. (2015). Gaussian distribution Diagnoses in Transformer's Insulating Oil. Joint International Mechanical, Electronic and Information Technology Conference (JIMET 2015), 824–830.
15. Mirowski, P., LeCun, Y. (2012). Statistical Machine Learning and Dissolved Gas Analysis: A Review. IEEE Transactions on Power Delivery, 27 (4), 1791–1799. doi: https://doi.org/10.1109/tpwrd.2012.2197868
16. Besprozvannyh, A. V., Moskvitin, E. S. (2013). Kriterii ocenki stepeni stareniya silovyh kabeley s bumazhno-propitannoy izolyaciey. Elektrotekhnika i Elektromekhanika, 4, 32–36.
17. Davidenko, I. V. (2009). Opredelenie dopustimyh znacheniy kontroliruemyh parametrov maslonapolnennogo oborudovaniya na osnove massiva nablyudaemyh dannyh. Elektrichestvo, 6, 10–21.
18. Davidenko, I. V. (2006). Issledovanie pokazateley, opisyvayushchih rabochee sostoyanie maslonapolnennyh vvodov, metodami matematicheskoy statistiki. Izvestiya vysshih uchebnyh zavedeniy, 15, 31–33.
19. IEC Publication 60599. Interpretation of the analysis of gases in transformer and other oil med electrical equipment in &, Geneva, Switzerland, 1999.
20. Zaharov, A. V. (2001). Obnaruzhenie defektov silovyh maslonapolnennyh transformatorov kak procedura proverki statisticheskih gipotez. Novoe v rossiyskoy energetike, 2, 19–28.
21. Shutenko, O. V. (2017). Opredelenie znacheniy granichnyh koncentraciy rastvorennyh v masle gazov metodom minimal'nogo riska. Elektrichestvo, 8, 50–60. doi: http://dx.doi.org/10.24160/0013-5380-2017-8-50-60
22. Shutenko, O. (2017). Determine the boundary value of the concentration of gases dissolved in oil of method minimum risk. 2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON). doi: https://doi.org/10.1109/ukrcon.2017.8100533
23. Birger, I. A. (1978). Tekhnicheskaya diagnostika. Moscow: Mashinostroenie, 240.
24. Chernoruckiy, I. G. (2005). Metody prinyatiya resheniy. Sankt-Peterburg: BHV-Peterburg, 416.

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DEVELOPMENT OF THE SIMULATION MODEL OF THE INTERACTION OF AUTOMATIC CONTROLLERS IN THE CONTROL SYSTEM OF THE ENERGY COMPLEX (p. 16–23)

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The developed simulation model of the control system of the power plant operating in different modes is presented. Work on the development of the control system of the power plant, the physical control of which will be carried out with the help of automatic controllers that compensate for the influence of external factors and, thus, bring the deviated parameters to the given values was done. In particular, the optimum controllers for the main components of the power plant were selected.

Simulation of operating modes to minimize the control error, as well as for compliance of the established steam flow, temperature and other parameters with the set (rated) values was performed. As a result of the simulation, it was found that the controllers (P and PI) cope quite well with the problems of parameters stabilization under any perturbations, despite the mutual influence of deviations of parameters. Dynamic deviations from the established values of such quantities as the turbine flow and condenser flow, as well as the steam generator outlet pressure do not exceed ±0.1. The settling time of the turbine flow fluctuations does not exceed 5 minutes. The fluctuations of the remaining flows are almost similar to the turbine flow fluctuations.

The conducted studies will be useful for effective and high-quality (accurate) control of various energy complexes, intended for electric energy and heat generation. Control of such energy complexes is usually carried out by automatic systems for which proper tools and optimum controllers are needed. The present paper deals with simulation of interaction of such controllers.

Keywords: micro-energy complex, turbine plant, power plant, control system simulation model, optimum controller.

References

1. Parshukov, V. I., Efimov, N. N., Gorbachev, V. M., Kihtev, I. M., Bezuglov, R. V. (2016). Simulation Modelling of the Interaction Processes Between Automatic Regulators in the Control System of a Cogeneration Microturbine. International Journal of Applied Engineering Research, 11 (1), 297–303.
2. Panov, S. Yu., Chernetskaya, A. A., Zhuchkov, A. B., Ryazanov, A. N. (2013). Development of scientific bases of technology for food waste utilization by anaerobic digestion. Vestnik Voronezhskogo gosudarstvennogo universiteta inzhenernyh tekhnologiy, 4, 200–204.
3. Efimov, N. N., Papin, V. V., Bezuglov, R. V. (2016). Micro Energy Complex Based on Wet-SteamTurbine. Procedia Engineering, 150, 324–329. doi: https://doi.org/10.1016/j.proeng.2016.07.022
4. Bezuglov R. V. Dinamicheskie harakteristiki vertikal'nyh parovyh turboustanovok, rabotayushchih v sostave mikroenergokompleksov: dis. ... kand. tekhn. nauk. Novosibirsk, 2016. 177 p.

5. Efimov, N. N., Papin, V. V., Bezuglov, R. V. (2016). Determination of Rotor Surfacing Time for the Vertical Microturbine with Axial Gas-Dynamic Bearings. Procedia Engineering, 150, 294–299. doi: https://doi.org/10.1016/j.proeng.2016.07.006
6. Kozlov, O. S. (2008). The program complex «Modeling in technical devices» (PC «MVTU», version 3.7). Moscow: MGTU Bauman.
7. Yu, H., Solvang, W. (2016). An Improved Multi-Objective Programming with Augmented ε-Constraint Method for Hazardous Waste Location-Routing Problems. International Journal of Environmental Research and Public Health, 13 (6), 548. doi: https://doi.org/10.3390/ijerph13060548
8. Makisha, N., Gogina, E. (2017). Scientific approach and practical experience for reconstruction of waste water treatment plants in Russia. E3S Web of Conferences, 22, 00109. doi: https://doi.org/10.1051/e3sconf/20172200109
9. Arsenijevic, Z., Grbavcic, Z., Grbic, B., Radic, N., Garic-Grulovic, R., Djuris, M. (2011). Removal of ethylene oxide from waste gases by absorption. Hemijska Industrija, 65 (4), 389–395. doi: https://doi.org/10.2298/hemind110329026a
10. Rose, S. J., Wilson, J. N., Capellan, N., David, S., Guillemin, P., Ivanov, E. et. al. (2012). Minimization of actinide waste by multi-recycling of thoriated fuels in the EPR reactor. EPJ Web of Conferences, 21, 08010. doi: https://doi.org/10.1051/epjconf/20122108010
11. Szczerba, Z. (2012). Coordination of baseload power plant group control with static reactive power compensator control. Acta Energetica, 2 (11), 51–54.
12. Qin, J., Huang, J., Pan, M. (2017). An Optimal Augmented Monotonic Tracking Controller for Aircraft Engines with Output Constraints. Energies, 10 (1), 73. doi: https://doi.org/10.3390/en10010073
13. Białecki, M., Drutko, J., Izakiewicz, R., Kieleczawa, A., Pietras, P., Skakowski, R. et. al. (2014). Master Automatic Control System for the Power Industry. Acta Energetica, 12–21. doi: https://doi.org/10.12736/issn.2300-3022.2014202
14. Gutberlet, J., Baeder, A., Pontuschka, N., Felipone, S., dos Santos, T. (2013). Participatory Research Revealing the Work and Occupational Health Hazards of Cooperative Recyclers in Brazil. International Journal of Environmental Research and Public Health, 10 (10), 4607–4627. doi: https://doi.org/10.3390/ijerph10104607
15. Anufriev, D., Kholodov, A., Volkov, A. (2015). Simulation of queuing networks with a sequence of connected nodes. Vestnik MGSU, 10, 171–181. doi: https://doi.org/10.22227/1997-0935.2015.10.171-181
16. Sokolovskaya, Z. N., Yatsenko, N. V. (2013). Applied Imitation Modelling as an Analytical Basis for Managerial Decision Making. Business Inform, 6, 69–76.
17. Parshukov, V. I., Efimov, N. N., Gorbachev, V. M., Kikhtev, I. M., Bezuglov, R. V., Prytkina, V. S., Rusakevich, I. V. (2014). Simulation modeling of dynamic processes in the condenser of a cogeneration micro power plant. Journal of Alternative Energy and Ecology, 16 (156), 78–85.

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RESULTS OF RESEARCH INTO THERMAL-TECHNICAL CHARACTERISTICS OF SOLAR COLLECTOR (p. 23–32)

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We developed a new design of an air solar collector made in the form of an inseparable power unit, which includes a frame with heat-insulated walls, single glazing and a selective surface on its bottom. We defined a number of generalizing dependences for the determination of thermal efficiency of an air solar collector, namely, an influence of the mass air flow q_a on a temperature difference of the heat-transfer agent t_o and insulation E, on heat productivity q and the efficiency η of the solar collector.

Based on the experimental data, we obtained linear regression dependencies of the average daily ambient temperature t_{eat} on energy illumination E and the average temperature of the heat-transfer agent carrier t_{aat} of the average daily ambient temperature t_{eat}. We verified the adequacy of the results of theoretical and experimental studies.

We established that we achieve the maximum values of the efficiency of the solar collector η – from 65 to 80.6 % at a temperature of the outlet flow of the heat-transfer agent t_o from 30 to 60 °C and mass air flow, q_a from 170 to 190 m^3/h.

We determined that an increase in the level of insulation E from 100 to 1,000 W/m^2 makes it possible to increase heating productivity of the collector q from 320 to 1,260 W and the temperature of the heat-transfer agent at the collector outlet t_o from 10 to 60 °C.

We can use the obtained results in development and improvement of technical means for drying fruits, for improvement of technological and energy efficiency of the process.

Keywords: air solar collector, transparent coating, absorber, solar energy, temperature, heat exchange, heat loss.

References

1. Ho, C., Chang, H., Wang, R., Lin, C. (2013). Analytical and Experimental Study of Recycling Baffled Double-Pass Solar Air Heaters with Attached Fins. Energies, 6 (4), 1821–1842. doi: https://doi.org/10.3390/en6041821
2. Vishwakarma, A., Jaurker, A. R. (2014). Experimental Investigation for Enhancement of Heat Transfer in Double Pass Solar Air Heater Using Transverse Discrete Rib Geometry. International Journal of Emerging Trends in Engineering and Development, 4 (4), 366–377.
3. Chabane, F., Moummi, N., Benramache, S., Bensahal, D., Belahssen, O. (2013). Collector Efficiency by Single Pass of Solar Air Heaters with and without Using Fins. Engineering Journal, 17 (3), 43–55. doi: https://doi.org/10.4186/ej.2013.17.3.43
4. Amankwah, E. A. Y., Dzisi, K. A., van Straten, G., van Willigenburg, L. G., van Boxtel, A. J. B. (2017). Distributed mathematical model supporting design and construction of solar collectors for drying. Drying Technology, 35 (14), 1675–1687. doi: https://doi.org/10.1080/07373937.2016.1269806

5. Sharma, S. P., Saha, S. N. (2017). Thermohydraulic Performance of Double Flow Solar Air Heater with Corrugated Absorber. International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering, 11 (7), 855–861.
6. NASA Surface meteorology and Solar Energy. Available at: https://eosweb.larc.nasa.gov/
7. Yeh, H.-M. (2014). Effect of Pass Number on Collector Efficiency in Downward-Type Multipass Solar Air Heaters. Journal of Applied Science and Engineering, 17 (2), 175–184. doi: https://doi.org/10.6180/jase.2014.17.2.08
8. Karim, M. A., Amin, Z. M. (2015). Mathematical modelling and performance analysis of different solar air collectors. IIUM Engineering Journal, 16 (2), 43–55.
9. Solar energy – Solar thermal collectors – Test methods. International Standard. ISO/FDIS 9806:2013(E).
10. ASHRAE Standard 93-1986 (RA 91) Metods of Testing to Determine The Thermal Performance of Solar Collektors (2002). American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Atlanta, USA.
11. Korobka, S., Babych, M., Krygul, R., Zdobytskyj, A. (2018). Substantiation of parameters and operational modes of air solar collector. Eastern-European Journal of Enterprise Technologies, 3 (8 (93)), 16–28. doi: https://doi.org/10.15587/1729-4061.2018.132090
12. Syvoraksha, V. Yu., Markov, V. L., Petrov, B. Ye., Zolotko, K. Ye., Statsenko, I. M. (2003). Teplovi rozrakhunky heliosystem. Dnipropetrovsk: Vyd-vo DNU, 132.
13. Duffie, J. A., Beckman, W. A. (2013). Solar engineering of thermal processes. John Wiley & Sons, 936.

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SELECTION OF NEW WORKING FLUIDS FOR A HEAT-USING COMPRESSION REFRIGERATING MACHINE WITH THE BLOCK «TURBINE-COMPRESSOR» (p. 33–40)

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The compression heat-using refrigerating machines operating in the Chistiakov-Plotnikov cycle use recycled waste heat of power machines as primary energy for producing cold of various temperature potentials thus saving fuel and energy resources. Development and improvement of machines is associated with the use of new working fluids. A selecting method of working fluids for a machine with a block «turbine-compressor» was proposed from the standpoints of such fundamental characteristics as energy saving and environmental safety. Mutual influence of properties of R134a, R290, R401a, R410a, R407a, R507, R600, R717 working fluids and design values of the block «turbine-compressor» in the given temperature regime of the thermodynamic cycle were studied with observance of equality of turbine and compressor powers. Design values of the full-size block «turbine-compressor» sample and the results of its experimental studies with the use of previous working fluids were used for the study.

The method of selection of the working fluids for the cold supply system of a particular consumer (a fruit storage) equipped with a small power machine was demonstrated on a particular example for a given temperature regime of cold production and the design values of the block. Introduction of the dimensionless equilibrium criterion in the analysis has made it possible to establish and evaluate dependence of the block design values on thermodynamic properties of the working fluids and conditions of its work and the field of rational application of any working fluids for a particular block design. The compression heat-using refrigerating machine is capable of efficient cold production with the studied working fluids in the trigeneration system of a small power machine.

Keywords: heat-using refrigerating machine, block «turbine-compressor», working fluids, thermodynamic properties.

References

1. Berlitz, T., Satzger, P., Summerer, F., Ziegler, F., Alefeld, G. (1999). A contribution to the evaluation of the economic perspectives of absorption chillers. International Journal of Refrigeration, 22 (1), 67–76. doi: https://doi.org/10.1016/s0140-7007(98)00040-1
2. Aly, W. I. A., Abdo, M., Bedair, G., Hassaneen, A. E. (2017). Thermal performance of a diffusion absorption refrigeration system driven by waste heat from diesel engine exhaust gases. Applied Thermal Engineering, 114, 621–630. doi: https://doi.org/10.1016/j.applthermaleng.2016.12.019
3. Chen, Y., Han, W., Jin, H. (2016). Analysis of an absorption/absorption-compression refrigeration system for heat sources with large temperature change. Energy Conversion and Management, 113, 153–164. doi: https://doi.org/10.1016/j.enconman.2016.01.063
4. Jiang, L., Roskilly, A. P., Wang, R. Z., Wang, L. W. (2018). Analysis on innovative resorption cycle for power and refrigeration cogeneration. Applied Energy, 218, 10–21. doi: https://doi.org/10.1016/j.apenergy.2018.02.174
5. Chen, G., Volovyk, O., Zhu, D., Ierin, V., Shestopalov, K. (2017). Theoretical analysis and optimization of a hybrid CO_2 transcritical mechanical compression – ejector cooling cycle. International Journal of Refrigeration, 74, 86–94. doi: https://doi.org/10.1016/j.ijrefrig.2016.10.002
6. Petrenko, V. O., Huang, B. J., Ierin, V. O. (2011). Design-theoretical study of cascade CO_2 sub-critical mechanical compression/butane ejector cooling cycle. International Journal of Refrigeration, 34 (7), 1649–1656. doi: https://doi.org/10.1016/j.ijrefrig.2010.11.012
7. Barenboym, A. B. (1974). Maloraskhodnye freonovye turbokompressory. Moscow: Mashinostroenie, 224.
8. Barenboym, A. B. (2000). Maloraskhodnye turbokompressory dlya kondicionirovaniya vozduha i ohlazhdeniya apparatury v transporte. Odessa: Studiya «Negociant», 265.
9. Barenboym, A. B. (2001). Turbomashiny dlya ohlazhdeniya nadduvochnogo vozduha dvigateley vnutrennego sgoraniya. Odessa: Studiya «Negociant», 98.
10. Barenboym, A. B. (2004). Holodil'nye centrobezhnye kompressory: monografiya. Odessa, 208.
11. Barenboim, A. B., Morosuk, T. V., Morosuk, L. I. (1998). Heat – using refrigeration machines for agriculture. Refrigeration science and technology, 6, 216–220.

12. Morozyuk, L. I., Morozyuk, T. V., Gayduk, S. V. (2014). Thermodynamic analysis of heat-energized refrigeration machine with carbon dioxide. Eastern-European Journal of Enterprise Technologies, 2 (8 (68)), 36–44. doi: https://doi.org/10.15587/1729-4061.2014.22990
13. Moroziuk, L. I., Haiduk, S. V., Hrudka, B. H. (2016). Analysis of the schematics of the compression heat-driven refrigeration machine with R744. Eastern-European Journal of Enterprise Technologies, 1 (8 (79)), 29–39. doi: https://doi.org/10.15587/1729-4061.2016.59470
14. Morosuk, L. I., Gaiduk, S. V., Grudka, B. G., Korzhuk, D. V. (2017). Low-Temperature Heat-Driven Compression Refrigeration Machines with R744. Refrigeration engineering and technology, 53 (2), 4–13. doi: https://doi.org/10.15673/ret.v53i2.588
15. Morosuk, T. et. al. (2016). Study of a tri-generation system based on a supercritical CO2 cycle. Proceedings 1st European Seminar on Supercritical CO2 (sCO2) Power Systems. Vienna.
16. Stirlin, H. (1964). Beitragzumtheorie der absorption-kaeltemaschintn. Kaeltechnik 16.
17. Morozyuk, T. V. (2006). Teoriya holodil'nyh mashin i teplovyh nasosov. Odessa: Studiya «Negociant», 712.

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ANALYSIS OF DYNAMICS AND PREDICTION OF RELIABILITY INDICATORS OF A COOLING THERMOELEMENT WITH THE PREDEFINED GEOMETRY OF BRANCHES (p. 41–51)

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We have investigated the influence of structural and technological elements on the basic parameters, reliability indicators, and the dynamics of operation of thermoelectric cooling devices under various current modes within the operating range of temperature differences. We analyzed the ratios of correlation between the time required to enter a stationary mode and relative intensity of failures in a cooler, and energy indicators, thermoelectric parameters of thermoelements, structural and technological indicators.

An analysis of the time required to enter a stationary mode was performed for different modes of operation from the maximum cooling capacity to the minimum failure rate. It is shown that in order to reduce the time required for a cooler to enter a stationary mode, at the predefined geometry of thermoelements and temperature difference, it is necessary to employ the mode of maximum cooling capacity.

The quantitative analysis showed that at the predefined geometry of thermoelements branches the time required to enter a stationary working mode does not depend on the number of thermoelements in a thermoelectric cooler. At a difference of temperatures close to the maximum value, the time required to enter a stationary working mode differs slightly for all modes of operation. Comparative analysis of the basic parameters of reliability indicators and dynamical characteristics makes it possible to find compromise solutions when constructing thermoelectric devices taking into consideration the weight of each of the constraints.

From a practical point of view, the results obtained suggest that increasing the cooling rate does not require changes to the existing technology for making thermoelectric coolers. Control over performance speed during transition from one stationary state to another state is executed through the selection of current modes in the operation of a thermoelectric device. In this case, there is a possibility to choose the conditions under which reliability indicators match the permissible limit.

Keywords: thermoelectric cooler, geometry of thermoelements, time required to enter a stationary mode, reliability indicators.

References

1. Shalumova, N. A., Shalumov, A. S., Martynov, O. Yu., Bagayeva, T. A. (2011). Analysis and provision of thermal characteristics of radioelectronic facilities using the subsystem ASONIKA-T. Advances in modern radio electronics, 1, 42–49.
2. Zebarjadi, M., Esfarjani, K., Dresselhaus, M. S., Ren, Z. F., Chen, G. (2012). Perspectives on thermoelectrics: from fundamentals to device applications. Energy & Environmental Science, 5 (1), 5147–5162. doi: https://doi.org/10.1039/c1ee02497c
3. Kofanov, Yu. N. et. al. (2014). System problems of reliability, quality, mathematical modeling and intelligent technologies in innovative projects. Moscow: HRU HES, 532.
4. Ndao, S., Peles, Y., Jensen, M. K. (2009). Multi-objective thermal design optimization and comparative analysis of electronics cooling technologies. International Journal of Heat and Mass Transfer, 52 (19-20), 4317–4326. doi: https://doi.org/10.1016/j.ijheatmasstransfer.2009.03.069
5. Thermoelectric modules market. Analytical review (2009). RosBussinessConsalting, 92.
6. Sootsman, J. R., Chung, D. Y., Kanatzidis, M. G. (2009). New and Old Concepts in Thermoelectric Materials. Angewandte Chemie International Edition, 48 (46), 8616–8639. doi: https://doi.org/10.1002/anie.200900598
7. Rowe, D. M. (Ed.) (2012). Materials, Preparation, and Characterization in Thermoelectrics. Vol. 1. Boca Raton: CRC Press, 544.
8. Zhang, L., Wu, Z., Xu, X., Xu, H., Wu, Y., Li, P., Yang, P. (2010). Approach on thermoelectricity reliability of board-level backplane based on the orthogonal experiment design. International Journal of Materials and Structural Integrity, 4 (2/3/4), 170. doi: https://doi.org/10.1504/ijmsi.2010.035205
9. Choi, H.-S., Seo, W.-S., Choi, D.-K. (2011). Prediction of reliability on thermoelectric module through accelerated life test and Physics-of-failure. Electronic Materials Letters, 7 (3), 271–275. doi: https://doi.org/10.1007/s13391-011-0917-x
10. Wereszczak, A. A., Wang, H. (2011). Thermoelectric Mechanical Reliability. Vehicle Technologies Annual Merit Reviewand Peer Evaluation Meeting. Arlington, 18.
11. Singh. R. (2008). Experimental Characterization of Thin Film Thermoelectric Materials and Film Deposition VIA Molecular Beam Epitaxial. University of California, 54.

12. Zaykov, V., Mescheryakov, V., Zhuravlov, Y. (2017). Analysis of the possibility to control the inertia of the thermoelectric cooler. Eastern-European Journal of Enterprise Technologies, 6 (8 (90)), 17–24. doi: https://doi.org/10.15587/1729-4061.2017.116005
13. Zaykov, V. P., Kinshova, L. A., Moiseev, V. F. (2009). Prediction of reliability on thermoelectric cooling devices. Kn. 1 Single-stage devices. Odessa: Politehperiodika, 120.

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EFFECT OF EVAPORATOR-CONDENSER DIAMETER RATIO (D/D) ON THERMAL PERFORMANCE OF THE TAPERING HEAT PIPE WITH VARIOUS HEAT SOURCES (p. 52–57)

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Various design heat pipes had been developed in previous research to enhance thermal performance. In this study, tapering heat pipe is developed. The method used true experimental to observe temperature distribution in the heat pipe. Geometric design is set as the ratio of diameter evaporator (d) and condenser (D) which are $d/D=1/1$, 1/2, 1/3 and 1/4. Heat source (Q) is varied by using DC power supply of 25, 30, 35, 40, 45 and 50 Watt. The temperature was measured by using k-type thermocouple with NI-9211 and c-DAQ 9271 module. Wick heat pipe is set as screen mesh with 56.5 μm wire diameter with one single layer. Wick screen mesh material used is stainless steel with 40 W/(m·K) thermal conductivity on layer shape. Thermal resistance decrease, high evaporation time, and stable temperature distribution are indicator performance to determine the best thermal performance. Based on the results, it can be denoted that d/D and Q affected to thermal performance difference. Both of d/D and Q increased, thermal performance increases. The tapering heat pipe with $d/D=1/4$ and $Q=50$ Watt provide the better thermal performance.

Keywords: Tapering Heat Pipe, Thermal Performance, Evaporator to Condenser Diameter Ratio, Heat Source.

References

1. Brautsch, A., Kew, P. A. (2002). Examination and visualisation of heat transfer processes during evaporation in capillary porous structures. Applied Thermal Engineering, 22 (7), 815–824. doi: https://doi.org/10.1016/s1359-4311(02)00027-3
2. Li, C., Peterson, G. P., Wang, Y. (2006). Evaporation/Boiling in Thin Capillary Wicks (l) – Wick Thickness Effects. Journal of Heat Transfer, 128 (12), 1312. doi: https://doi.org/10.1115/1.2349507
3. Faghri, A. (1995). Heat pipe science and technology. Global Digital Press, 874.
4. Zhang, H., Zhuang, J. (2003). Research, development and industrial application of heat pipe technology in China. Applied Thermal Engineering, 23 (9), 1067–1083. doi: https://doi.org/10.1016/s1359-4311(03)00037-1
5. Liang, T. S., Hung, Y. M. (2010). Experimental investigation on the thermal performance and optimization of heat sink with U-shape heat pipes. Energy Conversion and Management, 51 (11), 2109–2116. doi: https://doi.org/10.1016/j.enconman.2010.03.003
6. Vasiliev, L. L. (2005). Heat pipes in modern heat exchangers. Applied Thermal Engineering, 25 (1), 1–19. doi: https://doi.org/10.1016/j.applthermaleng.2003.12.004
7. Vasiliev, L. L. (2008). Micro and miniature heat pipes – Electronic component coolers. Applied Thermal Engineering, 28 (4), 266–273. doi: https://doi.org/10.1016/j.applthermaleng.2006.02.023
8. Putra, N., Septiadi, W. N., Rahman, H., Irwansyah, R. (2012). Thermal performance of screen mesh wick heat pipes with nanofluids. Experimental Thermal and Fluid Science, 40, 10–17. doi: https://doi.org/10.1016/j.expthermflusci.2012.01.007
9. Reay, D., McGlen, R., Kew, P. (2006). Heat Pipe Theory Design and Applications. 5th ed. Elsevier, 384.
10. Solomon, A. B., Ramachandran, K., Pillai, B. C. (2012). Thermal performance of a heat pipe with nanoparticles coated wick. Applied Thermal Engineering, 36, 106–112. doi: https://doi.org/10.1016/j.applthermaleng.2011.12.004
11. Russel, M. K., Young, C., Cotton, J. S., Ching, C. Y. (2011). The effect of orientation on U-shaped grooved and sintered wick heat pipes. Applied Thermal Engineering, 31 (1), 69–76. doi: https://doi.org/10.1016/j.applthermaleng.2010.08.013
12. Senthilkumar, R., Vaidyanathan, S., Sivaraman, B. (2012). Effect of Inclination Angle in Heat Pipe Performance Using Copper Nanofluid. Procedia Engineering, 38, 3715–3721. doi: https://doi.org/10.1016/j.proeng.2012.06.427
13. Kim, S. J., Ki Seo, J., Hyung Do, K. (2003). Analytical and experimental investigation on the operational characteristics and the thermal optimization of a miniature heat pipe with a grooved wick structure. International Journal of Heat and Mass Transfer, 46 (11), 2051–2063. doi: https://doi.org/10.1016/s0017-9310(02)00504-5
14. Moon, S. H., Hwang, G., Yun, H. G., Choy, T. G., Kang, Y. I. (2002). Improving thermal performance of miniature heat pipe for notebook PC cooling. Microelectronics Reliability, 42 (1), 135–140. doi: https://doi.org/10.1016/s0026-2714(01)00226-8
15. Sarip, Soeparman, S., Yuliati, L., Agus Choiron, M. (2018). Visualization of Bubbles Formation on the Boiling Process in Tapering Heat Pipe With Variation Of Evaporator To Condenser Diameter Ratio. Eastern-European Journal of Enterprise Technologies, 3 (8 (93)), 35–40. https://doi.org/10.15587/1729-4061.2018.133973
16. Peyghambarzadeh, S. M., Shahpouri, S., Aslanzadeh, N., Rahimnejad, M. (2013). Thermal performance of different working fluids in a dual diameter circular heat pipe. Ain Shams Engineering Journal, 4 (4), 855–861. doi: https://doi.org/10.1016/j.asej.2013.03.001
17. Thuchayapong, N., Nakano, A., Sakulchangsatjatai, P., Terdtoon, P. (2012). Effect of capillary pressure on performance of a heat pipe: Numerical approach with FEM. Applied Thermal Engineering, 32, 93–99. doi: https://doi.org/10.1016/j.applthermaleng.2011.08.034

18. Pastukhov, V. G., Maidanik, Y. F., Vershinin, C. V., Korukov, M. A. (2003). Miniature loop heat pipes for electronics cooling. Applied Thermal Engineering, 23 (9), 1125–1135. doi: https://doi.org/10.1016/s1359-4311(03)00046-2
19. Chen, Y., Groll, M., Mertz, R., Maydanik, Y. F., Vershinin, S. V. (2006). Steady-state and transient performance of a miniature loop heat pipe. International Journal of Thermal Sciences, 45 (11), 1084–1090. doi: https://doi.org/10.1016/j.ijthermalsci.2006.02.003

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RESEARCH INTO THE IMPACT OF STRUCTURAL FEATURES OF COMBUSTION CHAMBER IN ENERGY-TECHNOLOGICAL UNITS ON THEIR OPERATIONAL EFFICIENCY (p. 58–64)

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The experimental studies of the influence of the degree of masonry development (geometry) and aerodynamics of the combustion chambers (circuits of combustion products removal) on the energy-technological indicators of the processes in the system gas-solid (in combustion chambers) were carried out.

The experimental research into the influence of geometry and aerodynamics of the combustion chamber on the energy-technological indicators in the system gas – solid body was conducted at the industrial large-scale fire bench.

It was shown that a decrease in the height of the working space of the combustion chamber, equipped with flat flame burners, affects the use of fuel due to heat exchange intensification, including direct convection. The dependence is caused by a decrease in heat losses with flue gases and due to a decrease in losses through the masonry.

It was established that at the height of the working space of 800÷1,000 mm of the combustion furnace, fuel consumption decreases by 20÷30 %.

The design of the combustion space of the furnace of continuous operation mode was developed. The distinctive feature of the furnace of the developed design is the elimination of discreteness and implementation of the stable continuous operation mode of the heating unit. The longitudinal channels were made on the lateral surfaces of the cars and the furnace along the entire length of the latter, which makes it possible to implement the continuous removal of combustion products from the combustion space through canalized hearth of the cars into the longitudinal lateral channels, made in the walls of the furnace. Additional aerodynamic compaction of the working space of the furnace is ensured at any speed of the motion of the cars.

It was found that energy-technological efficiency at the arch heating of the combustion units with flat flame burners and combustion products removal under the workpiece (lower smoke removal) is on average by 1.3 times higher than at use of the circuit of products removal above the workpiece (lateral smoke removal), which is used in currently operating furnaces.

The design was developed and the tunnel furnace was put into operation. It was for chemical and thermal treatment of metallic and non-metallic materials and products during their heating by the assigned schedule.

Keywords: combustion chamber, aerodynamics, flat flame burner, tunnel furnace, temperature of combustion products.

References

1. Kapustin, V. M., Rudin, M. G., Kudinov, A. M. (2012). Osnovy proektirovaniya neftepererabatyvayushchih i neftekhimicheskih predpriyatiy. Moscow: Himiya, 440.
2. Eynard, J., Grieu, S., Polit, M. (2011). Modular approach for modeling a multi-energy district boiler. Applied Mathematical Modelling, 35 (8), 3926–3957. doi: https://doi.org/10.1016/j.apm.2011.02.006
3. Reddy, A., Kreider, J. F., Curtiss, P. S., Rabl, A. (2016). Heating and Cooling of Buildings: Principles and Practice of Energy Efficient Design. CRC Press, 862.
4. Muhutdinov, A. R., Vahidova, Z. R., Efimov, M. G. (2014). Modelirovanie processa goreniya tverdogo topliva v topochnom ustroystve. Vestnik Kazanskogo tekhnologicheskogo universiteta, 17 (20), 114–116.
5. Rabaçal, M., Fernandes, U., Costa, M. (2013). Combustion and emission characteristics of a domestic boiler fired with pellets of pine, industrial wood wastes and peach stones. Renewable Energy, 51, 220–226. doi: https://doi.org/10.1016/j.renene.2012.09.020
6. Iguchi, M., Ilegbusi, O. J. (2010). The Coanda Effect. Modeling Multiphase Materials Processes, 41–88. doi: https://doi.org/10.1007/978-1-4419-7479-2_3
7. Nikolsky, V., Yariz, V., Reshetnyak, I. (2017). Improvement of energy efficiency in the operation of a thermal reactor with submerged combustion apparatus through the cyclic input of energy. Eastern-European Journal of Enterprise Technologies, 2 (8 (86)), 39–44. doi: https://doi.org/10.15587/1729-4061.2017.97914
8. Nikolsky, V., Oliynyk, O., Ved, V., Svietkina, O., Pugach, A., Shvachka, A. (2018). Design and study of the energyefficient unified apparatuses for energytechnological manufacturing. Eastern-European Journal of Enterprise Technologies, 3 (8 (93)), 59–65. doi: https://doi.org/10.15587/1729-4061.2018.132572

9. Nikolsky, V., Oliynyk, O., Shvachka, A., Nachovnyy, I. (2017). Thermal treatment of concentrated liquid toxic waste and automatic control of process efficiency. Eastern-European Journal of Enterprise Technologies, 5 (10 (89)), 26–31. doi: https://doi.org/10.15587/1729-4061.2017.111846
10. Li, L., Peng, X. F., Liu, T. (2006). Combustion and cooling performance in an aero-engine annular combustor. Applied Thermal Engineering, 26 (16), 1771–1779. doi: https://doi.org/10.1016/j.applthermaleng.2005.11.023
11. Askarova, A. S., Bekmukhamet, A., Bolegenova, S. A., Beketayeva, M. T., Maximov, Yu. V. Ospanova, Sh. S., Gabitova, Z. K. (2014). Investigation of turbulence characteristics of burning process of the solid fuel in BKZ 420 combustion chamber. WSEAS Transactions on Heat and Mass Transfer, 9, 39–50.
12. Yarkova, V. S., Matyuhin, V. I. (2016). Vybor sposoba utilizacii tepla podtelezhechnogo prostranstva tunnel'noy pechi. Teplotekhnika i informatika v obrazovanii, nauke i proizvodstve (TIM'2016). Ekaterinburg, 134–137.
13. Szego, G., Dally, B., Nathan, G. (2009). Operational characteristics of a parallel jet MILD combustion burner system. Combustion and Flame, 156 (2), 429–438. doi: https://doi.org/10.1016/j.combustflame.2008.08.009
14. Parente, A., Galletti, C., Tognotti, L. (2008). Effect of the combustion model and kinetic mechanism on the MILD combustion in an industrial burner fed with hydrogen enriched fuels. International Journal of Hydrogen Energy, 33 (24), 7553–7564. doi: https://doi.org/10.1016/j.ijhydene.2008.09.058
15. Syred, N., Giles, A., Lewis, J., Abdulsada, M., Valera Medina, A., Marsh, R. et. al. (2014). Effect of inlet and outlet configurations on blow-off and flashback with premixed combustion for methane and a high hydrogen content fuel in a generic swirl burner. Applied Energy, 116, 288–296. doi: https://doi.org/10.1016/j.apenergy.2013.11.071
16. Askarova, A. S., Bolegenova, S. A., Maksimov, V. Y., Bekmuhamet, A., Ospanova, S. S. (2012). Numerical Research of Aerodynamic Characteristics of Combustion Chamber BKZ-75 Mining Thermal Power Station. Procedia Engineering, 42, 1250–1259. doi: https://doi.org/10.1016/j.proeng.2012.07.517
17. Bulat, G., Jones, W. P., Marquis, A. J. (2013). Large Eddy Simulation of an industrial gas-turbine combustion chamber using the sub-grid PDF method. Proceedings of the Combustion Institute, 34 (2), 3155–3164. doi: https://doi.org/10.1016/j.proci.2012.07.031
18. Oleynik, O. Yu., Taranenko, Yu. K. (2017). Vibrosterzhnevye chastotnye preobrazovateli temperatury. Vymiriuvalna ta obchysliuvalna tekhnika v tekhnolohichnykh protsesakh, 3, 58–64.
19. Oliynyk, O., Taranenko, Y., Losikhin, D., Shvachka, A. (2018). Examining the Kalman Filter in the field of noise and interference with the non-Gaussian distribution. Eastern-European Journal of Enterprise Technologies, 4 (4 (94)), 36–42. doi: https://doi.org/10.15587/1729-4061.2018.140649

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THE ROLE OF FATTY ACID STRUCTURE IN VARIOUS PURE VEGETABLE OILS ON FLAME CHARACTERISTICS AND STABILITY BEHAVIOR FOR INDUSTRIAL FURNACE (p. 65–75)

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This study investigates the effects of the fatty acid composition of various vegetable oils on the behavior of flames in the combustion process. The research is important for the substitution of fossil fuel using environmentally friendly vegetable oil. Five oils were tested including coconut oil, palm kernel oil, cotton seed oil, ceiba petandra oil and jatropha curcas oil. The oils were burned on an open tray at various air speeds performing three combustion regions, i. e., premixed combustion at the upstream region followed by transition region and diffusion combustion region at the downstream. Flame stability was tested at an air speed of 49 cm/s, 55 cm/s, and 64 cm/s. The image of the flame was recorded using a high-speed video camera at the rate of 200 frames per second. The flame temperature was measured by the K-type thermocouple. The results show that the higher saturated fatty acid content makes the flame brighter and more wavelet numbers present at the flame front maintaining the flame stability at a wide range of air speeds. The saturated fatty acid has a high flash point which is difficult to be burned at the flame front and escaping to burn as diffusion flame at the downstream region. The fatty acid content also affects the flame color which is evident in jatropha curcas oil with mostly a premixed/blue flame color and producing the highest thermal energy, while coconut oil is mostly a diffusion flame/yellow color. The longer ignition delay is shown in coconut oil because of the high saturated fatty acid content. The higher the unsaturated fatty acid content makes the flame more unstable. This shows that the bright yellow diffusion flame color is a good source of radiation thermal energy for flame stability. The flame color and the flame stability data are very valuable for designing efficient and stable industrial furnace with vegetable oil. This study gives insight into the influence of fatty acid chemical structure and physical properties on the combustion characteristics for thermal energy production. When high-temperature gas is needed in the industrial furnace, vegetable oil with unsaturated fatty acids is the choice by keeping the lower air speed. But when the industrial furnace with stable combustion process is the goal, the oil with saturated fatty acids is the best for a wide range of air speeds.

Keywords: vegetable oil, fatty acid content, combustion process, flame color, flame stability

References

1. Demirbas, A. (2009). Biofuels securing the planet's future energy needs. Energy Conversion and Management, 50 (9), 2239–2249. doi: https://doi.org/10.1016/j.enconman.2009.05.010
2. Natarajan, R., Karthikeyan, N. S., Agarwaal, A., Sathiyanarayanan, K. (2008). Use of vegetable oil as fuel to improve the efficiency of cooking stove. Renewable Energy, 33 (11), 2423–2427. doi: https://doi.org/10.1016/j.renene.2008.01.022
3. Wardana, I. N. G. (2010). Combustion characteristics of jatropha oil droplet at various oil temperatures. Fuel, 89 (3), 659–664. doi: https://doi.org/10.1016/j.fuel.2009.07.002

4. Sherena, K. M., Thangaraj, T. (2009). Biodiesel an alternative efuel produced from plant oils by transesterifikasi. Electronic Journal of Biology, 5 (3), 67–74.
5. McCarthy, P., Rasul, M. G., Moazzem, S. (2011). Analysis and comparison of performance and emissions of an internal combustion engine fuelled with petroleum diesel and different bio-diesels. Fuel, 90 (6), 2147–2157. doi: https://doi.org/10.1016/j.fuel.2011.02.010
6. Nanlohy, H. Y., Wardana, I. N. G., Hamidi, N., Yuliati, L., Ueda, T. (2018). The effect of Rh 3+ catalyst on the combustion characteristics of crude vegetable oil droplets. Fuel, 220, 220–232. doi: https://doi.org/10.1016/j.fuel.2018.02.001
7. Hellier, P., Ladommatos, N., Yusaf, T. (2015). The influence of straight vegetable oil fatty acid composition on compression ignition combustion and emissions. Fuel, 143, 131–143. doi: https://doi.org/10.1016/j.fuel.2014.11.021
8. Balat, M. (2007). Production of Biodiesel from Vegetable Oils: A Survey. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 29 (10), 895–913. doi: https://doi.org/10.1080/00908310500283359
9. Myo, T. (2008). The Effect of Fatty Acid Composition on the Combustion Characteristics of Biodiesel. The Research Reports of the Faculty of Engineering. No. 50. Kagoshima University.
10. Gopinath, A., Puhan, S., Nagarajan, G. (2010). Effect of unsaturated fatty acid esters of biodiesel fuels on combustion, performance and emission characteristics of a DI diesel engine. International journal of energy and environment, 1 (3), 411–430.
11. Puhan, S., Saravanan, N., Nagarajan, G., Vedaraman, N. (2010). Effect of biodiesel unsaturated fatty acid on combustion characteristics of a DI compression ignition engine. Biomass and Bioenergy, 34 (8), 1079–1088. doi: https://doi.org/10.1016/j.biombioe.2010.02.017
12. Redel-Macías, M. D., Pinzi, S., Leiva-Candia, D. E., Cubero-Atienza, A. J., Dorado, M. P. (2013). Influence of fatty acid unsaturation degree over exhaust and noise emissions through biodiesel combustion. Fuel, 109, 248–255. doi: https://doi.org/10.1016/j.fuel.2012.12.019
13. Wahyudi, Wardana, I. N. G., Widodo, A., Wijayanti, W. (2018). Improving Vegetable Oil Properties by Transforming Fatty Acid Chain Length in Jatropha Oil and Coconut Oil Blends. Energies, 11 (2), 394. doi: https://doi.org/10.3390/en11020394
14. Herbinet, O., Pitz, W. J., Westbrook, C. K. (2008). Detailed chemical kinetic oxidation mechanism for a biodiesel surrogate. Combustion and Flame, 154 (3), 507–528. doi: https://doi.org/10.1016/j.combustflame.2008.03.003
15. Wang, Y. L., Feng, Q., Egolfopoulos, F. N., Tsotsis, T. T. (2011). Studies of C4 and C10 methyl ester flames. Combustion and Flame, 158 (8), 1507–1519. doi: https://doi.org/10.1016/j.combustflame.2010.12.032

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EXPERIMENTAL STUDY INTO THE INFLUENCE OF STRAW CONTENT IN FUEL ON PARAMETERS OF GENERATOR GAS (p. 76–86)

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A gasifier of specific design was proposed for gasification of straw containing fuels. Combustion and regeneration zones of this gasifier have the same diameter. A mixture of wood and straw pellets was used as a fuel. It was established that when using up to 40 % or less straw pellets in the fuel for 360 hours of the gasifier operation, there were no deposits on the grate.

A study was conducted to assess the effect of content of straw pellets in fuel on concentration and volume of CO in the gas, total gas yield, amount of gas produced per kilogram of fuel and duration of the proposed gasifier operation. The study result is represented by a one-factor equation. A two-factor experiment was carried out to establish the effect of content of straw pellets in the fuel on dynamics of changes in CO concentration in the gas in the course of the gasifier operation. A 2 kg portion of fuel was charged in each series of experiments, operation time and CO content in the gas were recorded at equal time intervals. The content of straw pellets in the fuel was increased from 0 % to 100 % in 20 % increments with each charge of the gasifier with fuel.

It has been established that for efficient gasification of straw-containing fuel without formation of solid deposits, it is rationally to add no more than 40 % of straw pellets to the fuel. When 40 % of straw was used in the fuel, concentration and volume of produced CO increased by 25 %, however, the gas yield decreased by 5.3 % compared to the use of wood. Although the 100 % content of straw pellets in the fuel resulted in a 44.3 % increase in CO concentration in the generator gas and a 40 % growth of CO volume, the total gas yield has reduced by 7.7 %. Duration of the gasifier operation (at a 2 kg fuel charge) has increased by 2.8 %. The growth of CO content at a 100 % content of straw in fuel has indicated a 13–18 % increase in the calorific value of the resulting gas compared to a 100 % wood content.

Therefore, it is rational to use up to 100 % content of straw in the fuel although this requires the gasifier design preventing formation of stable deposits on the working surfaces.

Keywords: gasifier, generator gas, straw pellets, concentration and volume of CO, agglomeration.

References

1. Golub, G., Kukharets, S., Yarosh, Y., Kukharets, V. (2017). Integrated use of bioenergy conversion technologies in agroecosystems. INMATEH – Agricultural Engineering, 51 (1), 93–100.

2. Europe 2020 indicators – climate change and energy (2016). EUROSTAT, State explain, 1–16.
3. Zolotovs'ka, O., Kharytonov, M., Onyshchenko, O. (2016). Agricultural residues gasification, dependency of main operational parameters of the process on feedstock characteristics. INMATEH – Agricultural Engineering, 50 (3), 119–126.
4. Tsyvenkova, N. M., Golubenko, A. A., Kukharets, S. M., Biletsky, V. R. (2016). The research of downdraft gas producer heat productivity on straw. Annals of the Faculty of Engineering Hunedoara, 15 (3), 213–218.
5. Dubrovin, V. O., Korchemnyi, M. O., Maslo, I. P. et. al. (2004). Biopalyva (tekhnolohiyi, mashyny i obladnannia). Kyiv: TsTI «Enerhetyka i elektryfikatsiya», 256.
6. Basu, P. (2013). Biomass gasification, pyrolysis and torrefaction: practical design and theory. Elsevier, 548. doi: https://doi.org/10.1016/c2011-0-07564-6
7. EU Energy in Figures. Statistical Pocketbook 2012. Available at: https://publications.europa.eu/en/publication-detail/-/publication/4fbba65f-6690-4c3f-878a-e4ce0bc3515c/language-en/format-PDF/source-42292403
8. Reed, T. B., Das, A. (1988). Handbook of biomass downdraft gasifier engine systems. Golden: Solar Energy Research Institute. doi: https://doi.org/10.2172/5206099
9. Susastriawan, A. A. P., Saptoadi, H., Purnomo. (2017). Small-scale downdraft gasifiers for biomass gasification: A review. Renewable and Sustainable Energy Reviews, 76, 989–1003. doi: https://doi.org/10.1016/j.rser.2017.03.112
10. Sheth, P. N., Babu, B. V. (2009). Experimental studies on producer gas generation from wood waste in a downdraft biomass gasifier. Bioresource Technology, 100 (12), 3127–3133. doi: https://doi.org/10.1016/j.biortech.2009.01.024
11. Gai, C., Dong, Y., Zhang, T. (2014). Downdraft gasification of corn straw as a non-woody biomass: Effects of operating conditions on chlorides distribution. Energy, 71, 638–644. doi: https://doi.org/10.1016/j.energy.2014.05.009
12. Mysak, J., Lys, S., Martynyak-Andrushko, M. (2017). Research on gasification of low-grade fuels in a continuous layer. Eastern-European Journal of Enterprise Technologies, 2 (8 (86)), 16–23. doi: https://doi.org/10.15587/1729-4061.2017.96995
13. Mac an Bhaird, S. T., Walsh, E., Hemmingway, P., Maglinao, A. L., Capareda, S. C., McDonnell, K. P. (2014). Analysis of bed agglomeration during gasification of wheat straw in a bubbling fluidised bed gasifier using mullite as bed material. Powder Technology, 254, 448–459. doi: https://doi.org/10.1016/j.powtec.2014.01.049
14. Wu, Z., Meng, H., Luo, Z., Chen, L., Zhao, J., Wang, S. (2017). Performance evaluation on co-gasification of bituminous coal and wheat straw in entrained flow gasification system. International Journal of Hydrogen Energy, 42 (30), 18884–18893. doi: https://doi.org/10.1016/j.ijhydene.2017.05.144
15. Sarker, S., Arauzo, J., Nielsen, H. K. (2015). Semi-continuous feeding and gasification of alfalfa and wheat straw pellets in a lab-scale fluidized bed reactor. Energy Conversion and Management, 99, 50–61. doi: https://doi.org/10.1016/j.enconman.2015.04.015
16. Vares, V., Kasyk, Yu., Muyste, P. et. al. (2005). Spravochnik potrebitelya biotopliva. Tallinn: Tallinnskiy tekhnicheskiy universitet, 183.
17. Cerone, N., Zimbardi, F., Contuzzi, L., Prestipino, M., Carnevale, M. O., Valerio, V. (2017). Air-steam and oxy-steam gasification of hydrolytic residues from biorefinery. Fuel Processing Technology, 167, 451–461. doi: https://doi.org/10.1016/j.fuproc.2017.07.027
18. Ferreira, S. D., Lazzarotto, I. P., Junges, J., Manera, C., Godinho, M., Osório, E. (2017). Steam gasification of biochar derived from elephant grass pyrolysis in a screw reactor. Energy Conversion and Management, 153, 163–174. doi: https://doi.org/10.1016/j.enconman.2017.10.006
19. Niu, M., Jin, B., Huang, Y., Wang, H., Dong, Q., Gu, H., Yang, J. (2018). Co-gasification of High-ash Sewage Sludge and Straw in a Bubbling Fluidized Bed with Oxygen-enriched Air. International Journal of Chemical Reactor Engineering, 16 (5). doi: https://doi.org/10.1515/ijcre-2017-0044
20. Poltavets, V. I., Yaziev, A. S. (2006). Pat. No. 75529 UA. Hazohenerator dlia hazyfikatsiyi tverdoho palyva. No. 20040907430; declareted: 10.09.2004; published: 7.04.2006, Bul. No. 4.
21. Tsyvenkova, N. M., Holubenko, A. A. (2012). Pat. No. 107219 UA. Sposib formuvannia zony horinnia i hazyfikatsiyi ta hazohenerator dlia yoho zdiysnennia. No. a201211797; declareted: 12.10.2012; published: 10.12.2014, Bul. No. 23.
22. Kukharets, S. M., Yarosh, Ya. D., Biletskyi, V. R., Holub, H. A. (2016). Osoblyvosti vykorystannia malohabarytnykh hazoheneratornykh moduliv. Tekhniko-tekhnolohichni aspekty rozvytku ta vyprobuvannia novoi tekhniky i tekhnolohii dlia silskoho hospodarstva Ukrainy. 2016. Issue 20 (34). P. 457–464.
23. Tokarev, G. G. (1955). Gazogeneratornye avtomobili. Moscow: Mashgiz, 207.
24. Kollerov, L. K. (1951). Gazomotornye ustanovki. Leningrad: Mashgiz, 239.
25. Pylypchuk, M. I., Hryhoriev, A. S., Shostak, V. V. (2007). Osnovy naukovykh doslidzhen. Lviv: Znannia, 234.
26. Dejtrakulwong, C., Patumsawad, S. (2014). Four Zones Modeling of the Downdraft Biomass Gasification Process: Effects of Moisture Content and Air to Fuel Ratio. Energy Procedia, 52, 142–149. doi: https://doi.org/10.1016/j.egypro.2014.07.064
27. Jiansheng, Z., Junfu, L., Xin, W., Hai, Z., Guangxi, Y., Toshiyuki, S., Junichi, S. (2007). Characterization of Pressure Signals in Fluidized Beds Loaded with Large Particles Using Wigner Distribution Analysis: Feasibility of Diagnosis of Agglomeration. Chinese Journal of Chemical Engineering, 15 (1), 24–29. doi: https://doi.org/10.1016/s1004-9541(07)60029-9