ABSTRACT AND REFERENCES
ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

DOI: 10.15587/1729-4061.2018.133570

DEVELOPMENT OF A MODEL FOR DETERMINING A PRIORITY SEQUENCE OF POWER TRANSFORMERS OUT OF SERVICE (p. 6-15)

Eugen Bardyk
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-5776-1500

Nickolai Bolotnyi
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-7366-2430

The research is devoted to the development of a model and algorithm for making decisions on determining the priority of power transformers out of service. Reducing the reliability of EPS operation, caused by the objectively existing aging of power transformer equipment, requires consideration of equipment significance when planning the power transformers out of service. For this purpose, it is proposed to use the theory of fuzzy sets and the Pareto method. The result of solving the optimization problem for multicriteria analysis is a vector of the best alternatives, built on the principle of dominance. The developed algorithm of complex simulation of the EPS state and technical condition of the power transformer for making decisions on the determination of priority of power transformers out of service allows for effective decision-making. The results of probabilistic and statistical simulation of EES states using the Monte Carlo method allow us to take into account the probabilistic nature of emergency situations in the EPS when determining its weakest elements that require priority replacement. The advantage of the proposed approach is taking into account the technical condition of electrical equipment for risk assessment of the EPS emergency situation. A comparative analysis of ranking results of power transformers based on the risk assessment of the EPS emergency situation confirmed the high efficiency of planning of EPS states when solving the problems of preventive control. The developed model will be used for further research and development of the algorithm for making effective decisions regarding the operation strategy of the power transformer and preventive control of the subsystem operation of the electric power system. The obtained results of complex simulation of the EPS state and technical condition of the power transformer give grounds to assert the possibility of software implementation of operation risk analysis of the electric power system for power supply companies.

Keywords: power transformer, risk, Pareto method, out of service, failure probability.

References

1. Sun, H.-C., Huang, Y.-C., Huang, C.-M. (2012). Fault Diagnosis of Power Transformers Using Computational Intelligence: A Review. Energy Procedia, 14, 1226–1231. doi: 10.1016/j.egypro.2011.12.1080
2. Velasquez, R. M. A., Lara, J. V. M. (2017). Expert system for power transformer diagnosis. 2017 IEEE XXIV International Conference on Electronics, Electrical Engineering and Computing (INTERCON). doi: 10.1109/intercon.2017.8079640
3. Lin, D., Xu, Y.-Y., Liang, Y., Li, Y., Liu, N., Zhang, G.-J. (2017). A risk assessment method of transformer considering the economy and reliability of power network. 2017 1st International Conference on Electrical Materials and Power Equipment (ICEMPE). doi: 10.1109/icempe.2017.7982167
4. Shiwen, Y., Hui, H., Chengzhi, W., Hao, G., Hao, F. (2017). Review on Risk Assessment of Power System. Procedia Computer Science, 109, 1200–1205. doi: 10.1016/j.procs.2017.05.399
5. Ciapessoni, E., Cirio, D., Gagleoti, E. (2008). A probabilistic approach for operational risk assessment of power systems. CIGRE, 4–114.
6. Leite da Silva, A. M., Rezende, L. S., Manso, L. A. F., Anders, G. J. (2010). Transmission expansion planning: A discussion on reliability and "N–1" security criteria. 2010 IEEE 11th International Conference on Probabilistic Methods Applied to Power Systems. doi: 10.1109/pmaps.2010.5528652
7. Handschin, E., Jurgens, I., Neumann, C. (2008). Long term optimization for risk-oriented asset management. 16th Power Systems Computation Conference. Glasgow.
8. Goerdin, S. A. V., Smit, J. J., Mehairjan, R. P. Y. (2015). Monte Carlo simulation applied to support risk-based decision making in electricity distribution networks. 2015 IEEE Eindhoven PowerTech. doi: 10.1109/ptc.2015.7232494
9. Duarte, E., Falla, D., Gavin, J., Lawrence, M., McGrail, T., Miller, D. et. al. (2010). A practical approach to condition and risk based power transformer asset replacement. 2010 IEEE International Symposium on Electrical Insulation. doi: 10.1109/elinsl.2010.5549580
10. Wang, B., Li, Y., Watada, J. (2011). A New MOPSO to Solve a Multi-Objective Portfolio Selection Model with Fuzzy Value-at-Risk. Lecture Notes in Computer Science, 217–226. doi: 10.1007/978-3-642-23854-3_23
11. Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International journal of services sciences, 1 (1), 83–98.
12. Yang, H., Zhang, Z., Yin, X. (2018). A novel method of decision-making for power transformer maintenance based on failure-probability-analysis. IEEJ Transactions on Electrical and Electronic Engineering, 13 (5), 689–695. doi: 10.1002/tee.22618
13. Bardyk, Ye. I. (2014). Modelling and assessment of chances of failure of power systems electrical equipment taking into account the after repair resource restoration level. Visnyk of National Mining University, 3, 82–90.
14. Bardyk, E. I. (2014). Models of reliability assessing of electricity supply of auxiliary NPP from external sources with fuzzy defined parametrs of failures of equipments. Proceedings of the Institute of Electrodynamics of National Academy of Sciences of Ukraine, 34–38.
15. Kosterev, N. V., Bardyk, E. I., Litvinov, V. V. (2015). Preventive risk-management of power system for its reliability increasing. WSEAS TRANSACTIONS on POWER SYSTEMS, 10, 251–258.
16. Bardyk, E., Bolotnyi, N. (2017). Parametric identification of fuzzy model for power transformer based on real operation data. Eastern-

European Journal of Enterprise Technologies, 6 (8 (90)), 4–10. doi: 10.15587/1729-4061.2017.118632

17. Bardyk, E. I., Bolotnyi, N. P. (2017). Electric power system simulation for risk assessment of power transformer failure under external short-circuit conditions. 2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON). doi: 10.1109/ukrcon.2017.8100527

DOI: 10.15587/1729-4061.2018.132090

SUBSTANTIATION OF PARAMETERS AND OPERATIONAL MODES OF AIR SOLAR COLLECTOR (p. 16-28)

Serhiy Korobka
Lviv National Agrarian University, Dublyany, Ukraine
ORCID: http://orcid.org/0000-0002-4717-509X

Babych Mykhailo
Lviv National Agrarian University, Dublyany, Ukraine
ORCID: http://orcid.org/0000-0003-1295-4162

Roman Krygul
Lviv National Agrarian University, Dublyany, Ukraine
ORCID: http://orcid.org/0000-0002-3061-9176

Andriy Zdobytskyj
Lviv National Agrarian University, Dublyany, Ukraine
ORCID: http://orcid.org/0000-0001-8044-9593

We developed a new design of an air solar collector for a fruit dryer including double glazing and a selective surface made of a thin metal substrate with inlet and outlet openings on its bottom. We established that it is necessary to use a glass with a heat-reflecting coating of a solid K-glass type with a radiation coefficient ε=0.1...0.15 for a double-glazing substrate. This makes it possible to obtain the widest possible spectrum of direct sunlight rays that irradiate a surface of an absorbing plate and reduces a diffuse component of radiation, which ensures an increase in efficiency of a solar collector.

We determined regularities of the influence of a change in flow speed of a heat-transfer agent, a temperature drop, and radiation intensity on power of a solar collector. We developed a model of heat exchange processes occurring in an air solar collector. We presented the methodology for estimation of heat loss of an air solar collector with passive use of solar energy.

We established that energy illumination E, which is from 377 to 1,223 W/m^2, affects heat output of an air collector Q=117...480 W significantly. We established that a use of a non-selective absorbing surface in an air solar collector with a low insolation level E=377 W/m^2 makes it possible to increase efficiency by η=70.7 % more for selective, and at a large energy illumination of E=1,000 W/m^2, on the contrary small η=54.6 %. This makes it possible to explain how redistribution of the ratio of the maximum current thermal power (N_{SC}=48.8...100 W) and efficiency of an air solar collector occurs.

One can use the obtained results in development and improvement of technical means for fruit drying to improve technological and energy efficiency of the process.

Keywords: air solar collector, transparent coating, temperature field, heat flow, heat exchange, heat loss.

References

1. Englmair, G., Dannemand, M., Johansen, J. B., Kong, W., Dragsted, J., Furbo, S., Fan, J. (2016). Testing of PCM Heat Storage Modules with Solar Collectors as Heat Source. Energy Procedia, 91, 138–144. doi: 10.1016/j.egypro.2016.06.189
2. Horta, P., Osório, T. (2014). Optical Characterization Parameters for Line-focusing Solar Concentrators: Measurement Procedures and Extended Simulation Results. Energy Procedia, 49, 98–108. doi: 10.1016/j.egypro.2014.03.011
3. Chamoli, S. (2013). Exergy analysis of a flat plate solar collector. Journal of Energy in Southern Africa, 24 (3), 8–13.
4. NASA Surface meteorology and Solar Energy. Available at: http://eosweb.larc.nasa.gov
5. Vishwakarma, D., Kale, J. (2017). Experimental study and analysis of solar air heater using of various inlet temperatures. International Journal of Research, 5 (10), 76–80. doi: 10.5281/zenodo.1039619
6. Sabiha, M. A., Saidur, R., Mekhilef, S., Mahian, O. (2015). Progress and latest developments of evacuated tube solar collectors. Renewable and Sustainable Energy Reviews, 51, 1038–1054. doi: 10.1016/j.rser.2015.07.016
7. Solar energy – Solar thermal collectors – Test methods. International Standard. ISO/FDIS 9806:2013(E).
8. Syvoraksha, V. Yu. et. al. (2003). Teplovi rozrakhunky heliosystem. Dnipropetrovsk: Vyd-vo DNU, 132.
9. Daffi, Dzh., Bekman, U. A. (1987). Teplovye processy s ispol'zovaniem solnechnoy energii. Moscow: Mir, 420.
10. Duffie J. A., Beckman W. A. Solar engineering of thermal processes. John Wiley & Sons, 2013. 910 p. doi: 10.1002/9781118671603
11. ASHRAE Standard 93-1986 (RA 91) Metods of Testing to Determine The Thermal Performance of Solar Collektors, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc (2002). Atlanta, USA.
12. Hematian, A., Ajabshirchi, Y., Bakhtiari, A. (2012). Experimental analysis of flat plate solar air collector efficiency. Indian Journal of Science and Technology, 5 (8), 3183–3187.
13. Shemelin, V., Matuska, T. (2017). Detailed Modeling of Flat Plate Solar Collector with Vacuum Glazing. International Journal of Photoenergy, 2017, 1–9. doi: 10.1155/2017/1587592
14. Vega, E. V., Noh-Pat, F. (2014). Validation of the Simulation of Solar Air Collector Prototypes. Energy Procedia, 57, 2295–2304. doi: 10.1016/j.egypro.2014.10.237
15. Ondieki, H. O., Koech, R. K., Tonui, J. K., Rotich, S. K. (2014). Mathematical Modeling Of Solar Air Collector With a Trapezoidal Corrugated Absorber Plate. International Journal of Scientific & Technology Research, 3 (8), 51–56.
16. Labai, V. Y. (2004). Teplomasoobmin. Lviv: Triada Plius, 260.
17. Miheev, M. A., Miheeva, I. M. (1977). Osnovy teploperedachi. Moscow: Energiya, 344.
18. Fokin, V. M., Boykov, G. P. Vidin, Yu. V. (2005). Osnovy energosberezheniya v voprosah teploobmena. Moscow: Mashinostroenie, 192.

DOI: 10.15587/1729-4061.2018.131159

A METHOD OF DESIGNING OF TORQUEFLOW PUMP IMPELLER WITH CURVILINEAR BLADE PROFILE (p. 29-35)

Vladyslav Kondus
Sumy State University, Sumy, Ukraine
ORCID: http://orcid.org/0000-0003-3116-7455

Pavlo Kalinichenko
Sumy State University, Sumy, Ukraine
ORCID: http://orcid.org/0000-0002-4609-7640

Olexandr Gusak
Sumy State University, Sumy, Ukraine
ORCID: http://orcid.org/0000-0002-4737-3838

The research is devoted to energy efficiency increasing of a "Turo" type torque-flow pump by improving its impeller. This allows minimizing the total pump installation life cycle cost as a result of reducing the costs of electricity.

The application of the real fluid flow physical model in a torque-flow pump allowed developing the energy distribution mathematical model in its flowing part. In the proposed mathematical model, the ratio of component flows was defined. These include the toroidal vortex, the flow coming from the impeller intervane channels directly to the outlet (through-flow), and the flow that does not contact with the blades (flowing stream). As a result, it is found that the maximum possible energy efficiency of the torque-flow pump operating process without taking into account hydraulic losses is η_{top}=0.67.

The method of designing the torque-flow pump impeller with a curvilinear blade profile is developed. The method is based on the proposed mathematical model of energy distribution in the torque-flow pump flowing part. The blade inlet angle β_1 and the angle on the calculated impeller radius β_r are proposed to be carried out in accordance with the fluid flow in the impeller intervane channels. The radius $r<r_2$ is chosen for which there is a radial motion of the fluid in the intervane channels of the impeller.

The numerical investigation made it possible to estimate the fluid flow structure in the torque-flow pump flowing part. Using the proposed impeller has minimized losses at the inlet and in its intervane channels as a result of coordination of the fluid flow and the impeller skeleton geometry. Increasing the blade part and reducing the vortex part of the operating process allowed increasing the energy efficiency of the torque-flow pump.

The proposed geometry of the impeller allows increasing the energy efficiency of existing torque-flow pumps by 4–5 %.

Keywords: torque-flow pump, impeller, flowing part, energy efficiency, investment costs.

References

1. Kotenko, A., Herman, V., Kotenko, A. (2014). Rationalisation of Ukrainian industrial enterprises in a context of using torque flow pumps on the basis of valuation of the life cycle of pumping equipment. Nauka i Studia, 16 (126), 83–91.
2. Gao, X., Shi, W., Zhang, D. et. al. (2014). Optimization design and test of vortex pump based on CFD orthogonal test. Nongye Jixie Xuebao/Transactions of the Chinese Society for Agricultural Machinery, 45 (5), 101–106.
3. Gerlach, A., Thamsen, P., Wulff, S., Jacobsen, C. (2017). Design Parameters of Vortex Pumps: A Meta-Analysis of Experimental Studies. Energies, 10 (1), 58. doi: 10.3390/en10010058
4. Kondus, V., Kotenko, A. (2017). Investigation of the impact of the geometric dimensions of the impeller on the torque flow pump characteristics. Eastern-European Journal of Enterprise Technologies, 4 (1 (88)), 25–31. doi: 10.15587/1729-4061.2017.107112
5. Gerlach, A., Thamsen, P., Lykholt-Ustrup, F. (2016). Experimental Investigation on the Performance of a Vortex Pump using Winglets. ISROMAC 2016. International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, 10–15.
6. Chervinka, M. (2012). Computational Study of Sludge Pump Design with Vortex Impeller. 18th International Conference ENGINEERING MECHANICS 2012, 191–201.
7. Krishtop, I. (2015). Creating the flowing part of the high energy-efficiency torque flow pump. Eastern-European Journal of Enterprise Technologies, 2 (7 (74)), 31–37. doi: 10.15587/1729-4061.2015.39934
8. Kudo, H., Kawahara, T., Kanai, H., Miyagawa, K., Saito, S., Isono, M. et. al. (2014). Study on clogging mechanism of fibrous materials in a pump by experimental and computational approaches. IOP Conference Series: Earth and Environmental Science, 22 (1), 012011. doi: 10.1088/1755-1315/22/1/012011
9. Evtushenko, A. A. (2002). Osnovy teorii rabochego protsessa vihrevyih gidromashin. Tehnologicheskie sistemy, 2 (13), 110–113.
10. Kotenko, A., Nikolaenko, L., Lugova, S. (2011). The computational model of the emergence and development of cavitation in torque flow pump. 4th International Meeting on Cavitation and Dynamic Problems in Hydraulic Machinery and Systems, 87–94.
11. Krishtop, I., German, V., Gusak, A., Lugova, S., Kochevsky, A. (2014). Numerical Approach for Simulation of Fluid Flow in Torque Flow Pumps. Applied Mechanics and Materials, 630, 43–51. doi: 10.4028/www.scientific.net/amm.630.43
12. Grabow, G. (1972). Einfluss der Beschaufelung auf das Kennlinie Verhalten von Freistrompumpen. Pumpen und Verdichter, 2, 18–21.

DOI: 10.15587/1729-4061.2018.133973

VISUALIZATION OF BUBBLES FORMATION ON THE BOILING PROCESS IN TAPERING HEAT PIPE WITH VARIATION OF EVAPORATOR TO CONDENSER DIAMETER RATIO (p. 35-40)

Sarip
Ronggolawe Technology High School, Cepu, Indonesia
ORCID: http://orcid.org/0000-0001-7675-1984

Sudjito Soeparman
University of Brawijaya Malang, Malang, Indonesia
ORCID: http://orcid.org/0000-0003-3490-7543

Lilis Yuliati
University of Brawijaya Malang, Malang, Indonesia
ORCID: http://orcid.org/0000-0002-2224-2241

Moch. Agus Choiron
University of Brawijaya Malang, Malang, Indonesia
ORCID: http://orcid.org/0000-0002-4052-4832

In the present study, a new tapering heat pipe design had been developed to enhance the thermal performances. Boiling visualization in the tapering heat pipe is investigated to provide the detailed information of bubbles nucleation. Experiment was conducted in the tapering heat pipe with variation of the evaporator (d) to condenser (D) diameter ratio. The values of d/D are varied at 1/1; 1/2; 1/3 and 1/4. Heat load was generated at the evaporator section using heater DC-Power supply at 30, 40 and 50 Watt. The visualization technique was developed by using a transparent glass tube and the images of boiling bubbles were captured by SLR camera. The glass tube inclination is 45° and integrated with the NI-9211 and c-DAQ 9271 module. K-type thermocouple was set at the evaporator and condenser sections for measurement of boiling temperatures in the tapering heat pipe. Based on the results, it can be noted that variations of heat load and diameter ratio (d/D) of the evaporator and condenser affect the size and shape of boiling bubbles, as well as the nucleation temperature on the tapering heat pipe. The heat transfer coefficient tends to increase at a heat load of 50 W and diameter ratio d/D=1/4.

Keywords: boiling visualization, bubbles formation, tapering heat pipe, evaporator to condenser diameter ratio.

References

1. Rao, R. V., More, K. C. (2015). Optimal design of the heat pipe using TLBO (teaching–learning-based optimization) algorithm. Energy, 80, 535–544. doi: 10.1016/j.energy.2014.12.008
2. Liou, J.-H., Chang, C.-W., Chao, C., Wong, S.-C. (2010). Visualization and thermal resistance measurement for the sintered mesh-wick evaporator in operating flat-plate heat pipes. International Journal of Heat and Mass Transfer, 53 (7-8), 1498–1506. doi: 10.1016/j.ijheatmasstransfer.2009.11.046
3. Wong, S.-C., Liou, J.-H., Chang, C.-W. (2010). Evaporation resistance measurement with visualization for sintered copper-powder evaporator in operating flat-plate heat pipes. International Journal of Heat and Mass Transfer, 53 (19-20), 3792–3798. doi: 10.1109/impact.2009.5382185
4. Wong, S.-C., Lin, Y.-C. (2011). Effect of copper surface wettability on the evaporation performance: Tests in a flat-plate heat pipe with visualization. International Journal of Heat and Mass Transfer, 54 (17-18), 3921–3926. doi: 10.1016/j.ijheatmasstransfer.2011.04.033
5. Wong, S.-C., Lin, Y.-C., Liou, J.-H. (2012). Visualization and evaporator resistance measurement in heat pipes charged with water, methanol or acetone. International Journal of Thermal Sciences, 52, 154–160. doi: 10.1016/j.ijthermalsci.2011.09.020
6. Weibel, J. A., Garimella, S. V. (2012). Visualization of vapor formation regimes during capillary-fed boiling in sintered-powder heat pipe wicks. International Journal of Heat and Mass Transfer, 55 (13-14), 3498–3510. doi: 10.1016/j.ijheatmasstransfer.2012.03.021
7. Wong, S.-C., Cheng, H.-S., Tu, C.-W. (2017). Visualization experiments on the performance of mesh-wick heat pipes with differing wick wettability. International Journal of Heat and Mass Transfer, 114, 1045–1053. doi: 10.1016/j.ijheatmasstransfer.2017.06.107
8. Wong, S.-C., Tseng, H.-H., Chen, S.-H. (2014). Visualization experiments on the condensation process in heat pipe wicks. International Journal of Heat and Mass Transfer, 68, 625–632. doi: 10.1016/j.ijheatmasstransfer.2013.09.069
9. Wong, S.-C., Kao, Y.-H. (2008). Visualization and performance measurement of operating mesh-wicked heat pipes. International Journal of Heat and Mass Transfer, 51 (17-18), 4249–4259. doi: 10.1016/j.ijheatmasstransfer.2008.01.022
10. Wang, P.-Y., Chen, X.-J., Liu, Z.-H., Liu, Y.-P. (2012). Application of nanofluid in an inclined mesh wicked heat pipes. Thermochimica Acta, 539, 100–108. doi: 10.1016/j.tca.2012.04.011
11. Senthilkumar, R., Vaidyanathan, S., Sivaraman, B. (2012). Effect of Inclination Angle in Heat Pipe Performance Using Copper Nanofluid. Procedia Engineering, 38, 3715–3721. doi: 10.1016/j.proeng.2012.06.427

DOI: 10.15587/1729-4061.2018.133643

IMPROVING THE ENERGY EFFICIENCY OF SOLAR SYSTEMS FOR OBTAINING WATER FROM ATMOSPHERIC AIR (p. 41-51)

Andrey Kholodkov
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0001-9412-8598

Eugeniy Osadchuk
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-8955-2041

Titlov Alexandr
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-1908-5713

Irina Boshkova
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0001-5989-9223

Nataliya Zhihareva
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-2643-6908

We considered problems of water scarcity elimination in arid regions of the planet and analyzed modern water producing systems. We showed the prospects of obtaining of water from atmospheric air directly while cooling it below the dew point using refrigeration units.

We proposed to use absorption-type cooling systems with a water-ammonia solution as a working liquid as cooling units in regions with an excess of solar energy. We noted that low energy characteristics of heat-using refrigeration cycle, with main problems associated with non-calculated losses of refrigerant (ammonia) during transportation through AWRU refluxer hamper a widespread use of absorption water-ammonia refrigerating units (AWRU) in systems for obtaining of water from atmospheric air. This contribution is particularly noticeable in operation of AWRU in a wide range of outdoor air temperatures.

We performed modeling of heat and mass exchange processes of a lifting section of an AWRU refluxer to find methods for elimination of ammonia transportation losses. At the heart of model representations were equations of heat and mass balances, and we took into account resistance of a diffusion process at radial movement of a vapor flow to a wall of a refluxer in modeling. A preliminary analysis of thermal resistance of reflux film showed its small contribution to the total resistance and we ignored it subsequently.

As a result of modeling, we found a significant (up to 36 °C) temperature difference between a flow inside a refluxer and its wall. Experimental studies of a serial AWRU confirmed the modeling results. The obtained results made possible to propose the original design of a heat-insulating casing of an AWRU refluxer with variable thermal resistance with a corresponding change in the outside air temperature. This gave possibility to increase energy efficiency from 18 to 36 % and productivity of systems for obtaining of water from atmospheric air.

Keywords: water producing systems, atmospheric air, dew point, solar absorption refrigeration units.

References

1. A new global partnership: eradicate poverty and transform economies through sustainable development. The Report of the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda. Available at: https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=893&menu=1561
2. Mezhdunarodnoe desyatiletie deystviy «Voda dlya zhizni», 2005–2015 gody. Mekhanizm «OON – vodnye resursy». Available at: http://www.un.org/ru/waterforlifedecade/background.shtml
3. Santilli, R. (2006). A new gaseous and combustible form of water. International Journal of Hydrogen Energy, 31 (9), 1113–1128. doi: 10.1016/j.ijhydene.2005.11.006
4. Dukhin, S. S., Mishchuk, N. A. (1993). Intensification of electrodialysis based on electroosmosis of the second kind. Journal

of Membrane Science, 79 (2-3), 199–210. doi: 10.1016/0376-7388(93)85116-e
5. Schmoldt, H., Strathmann, H., Kaschemekat, J. (1981). Desalination of sea water by an electrodialysis-reverse osmosis hybrid system. Desalination, 38, 567–582. doi: 10.1016/s0011-9164(00)86100-7
6. Selvey, C., Reiss, H. (1985). Ion transport in inhomogeneous ion exchange membranes. Journal of Membrane Science, 23 (1), 11–27. doi: 10.1016/s0376-7388(00)83131-2
7. Forbes, R. J. (1970). A short history of the art of distillation: from the beginnings up to the death of Cellier Blumenthal. BRILL, 405.
8. Perry, R. H. (Ed.) (1984). Perry's Chemical Engineers' Handbook. McGraw-Hill, 2240.
9. Al' Maytami Valid Abdulvahid Mohammed, Frumin, G. T. (2007). Napravleniya sovershenstvovaniya vodoobespecheniya v stranah araviyskogo poluostrova. Sovremennye problemy nauki i obrazovaniya, 6, 13–17.
10. Al' Maytami Valid Abdulvahid Mohammed, Frumin, G. T. (2008). Ekologicheski bezopasnye tekhnologii vodoobespecheniya v stranah araviyskogo poluostrova. Sovremennye problemy nauki i obrazovaniya, 3, 111–115.
11. Alekseev, V. V., Chekarev, K. V. (1996). Poluchenie presnoy vody iz vlazhnogo vozduha. Aridnye ekosistemy, 2 (2-3).
12. Perel'shteyn, B. H. (2008). Novye energeticheskie sistemy. Kazan': Izd-vo Kazan. gos. tekhn. un-ta, 244.
13. The European Solar Thermal Industry Federation (ESTIF). Available at: http://www.estif.org
14. Vasyliv, O. B., Kovalenko, O. O. (2009). Struktura ta shliakhy ratsionalnoho vykorystannia vody na kharchovykh pidpryiemstvakh. Naukovi pratsi ONAKhT, 35, 54–58.
15. Osadchuk, E. A., Titlov, A. S., Kuzakon', V. M., Shlapak, G. V. (2015). Development of schemes of pump and gasoline-pump absorption water-ammonia refrigeration machines to work in a system of water production from the air. Technology audit and production reserves, 3 (3 (23)), 30–37. doi: 10.15587/2312-8372.2015.44139
16. Titlov, O., Baidak, Yu., Khmelnyuk, M. (2015). Optimizing Nh3-H2o Absorption System To Produce Water From Ambient Air. Applied Science Reports, 10 (2). doi: 10.15192/pscp.asr.2015.10.2.9099
17. Titlov, O. S., Vasyliv, O. B., Kuzakon, V. M., Osadchuk, Ye. O. (2015). Pat. No. 104854 UA. Sposib oderzhannia vody z atmosfernoho povitria. MPK: F25B 15/10, E03B 3/28. No. 201507386; declareted: 23.07.2015; published: 25.02.2016, Bul. No. 4.
18. Titlov, O. S., Vasyliv, O. B., Osadchuk, Ye. O. (2015). Pat. No. 100195 UA. Sposib oderzhannia vody z atmosfernoho povitria. MPK: F25B 15/00, E03B 3/28. No. u201501512; declareted: 20.02.2015; published: 10.07.2015, Bul. No. 9.
19. Doroshenko, A. V., Kholpanov, L. P., Kvurt, Y. P. (2009). Alternative Refrigerating, Heat-Pumping and Air-Conditioning Systems on the Basis of the Open Absorption Cycle and Solar Energy. Nova Science Publishers, 210.
20. Absorption Cooling Basics. Available at: https://www.energy.gov/
21. Morozyuk, L. I. (2014). Teploispol'zuyushchie holodil'nye mashiny – puti razvitiya i sovershenstvovaniya // Kholodylna tekhnika ta tekhnolohiya, 5, 23–29. doi 10.15673/0453-8307.5/2014.28695
22. Norcold Inc. Refrigerators. Available at: http://www.norcold.com
23. Titlov, A. S. (2006). Nauchno-tekhnicheskie osnovy energosberezheniya pri proektirovanii holodil'nyh apparatov s absorbcionno-diffuzionnymi holodil'nymi mashinami. Naukovi pratsi Odeskoiyi natsionalnoiyi akademiyi kharchovykh tekhnolohiy, 29, 194–200.
24. Rodríguez-Muñoz, J. L., Belman-Flores, J. M. (2014). Review of diffusion-absorption refrigeration technologies. Renewable and Sustainable Energy Reviews, 30, 145–153. doi: 10.1016/j.rser.2013.09.019
25. Kholodkov, A., Titlov, A. (2017). Modeling of thermal modes of the reflux condenser of the absorption refrigeration unit. EUREKA: Physics and Engineering, 3, 31–40. doi: 10.21303/2461-4262.2017.00358
26. Babakin, B. S., Vygodin, V. A. (2005). Bytovye holodil'niki i morozil'niki. Ryazan': Uzorech'e, 860.
27. Mirmov, I. N. (2011). Ispol'zovanie solnechnoy energii i vtorichnyh istochnikov teploty dlya polucheniya holoda. Holodil'naya tekhnika, 9, 44–49.
28. El-Shaarawi, M. A. I., Said, S. A. M., Siddiqui, M. U. (2014). Comparative analysis between constant pressure and constant temperature absorption processes for an intermittent solar refrigerator. International Journal of Refrigeration, 41, 103–112. doi: 10.1016/j.ijrefrig.2013.12.019
29. Yildiz, A., Ersöz, M. A., Gözmen, B. (2014). Effect of insulation on the energy and exergy performances in Diffusion Absorption Refrigeration (DAR) systems. International Journal of Refrigeration, 44, 161–167. doi: 10.1016/j.ijrefrig.2014.04.021
30. Wang, Q., Gong, L., Wang, J. P., Sun, T. F., Cui, K., Chen, G. M. (2011). A numerical investigation of a diffusion absorption refrigerator operating with the binary refrigerant for low temperature applications. Applied Thermal Engineering, 31 (10), 1763–1769. doi: 10.1016/j.applthermaleng.2011.02.021
31. Hassan, H. Z., Mohamad, A. A. (2012). A review on solar cold production through absorption technology. Renewable and Sustainable Energy Reviews, 16 (7), 5331–5348. doi: 10.1016/j.rser.2012.04.049
32. Acuña, A., Velázquez, N., Cerezo, J. (2013). Energy analysis of a diffusion absorption cooling system using lithium nitrate, sodium thiocyanate and water as absorbent substances and ammonia as the refrigerant. Applied Thermal Engineering, 51 (1-2), 1273–1281. doi: 10.1016/j.applthermaleng.2012.10.046
33. Long, Z., Luo, Y., Li, H., Bu, X., Ma, W. (2013). Performance analysis of a diffusion absorption refrigeration cycle working with TFE–TEGDME mixture. Energy and Buildings, 58, 86–92. doi: 10.1016/j.enbuild.2012.12.003
34. Sathyabhama, A., Ashok, B. (2008). Thermodynamic simulation of ammonia-water absorption refrigeration system. Thermal Science, 12 (3), 45–53. doi: 10.2298/tsci0803045s
35. Sözen, A., Menlik, T., Özbaş, E. (2012). The effect of ejector on the performance of diffusion absorption refrigeration systems: An experimental study. Applied Thermal Engineering, 33-34, 44–53. doi: 10.1016/j.applthermaleng.2011.09.009
36. Bogdanov, S. N. et. al. (1999). Svoystva veshchestv. Holodil'naya tekhnika: spravochnik. Sankt-Peterburg: SPbGAHPT, 320.
37. Osadchuk, E. A., Kirillov, V. H. (2017). Matematicheskoe modelirovanie rabochih rezhimov deflegmatora absorbcionnogo vodo-ammiachnogo holodil'nogo agregata v sistemah polucheniya vody iz atmosfernogo vozduha s ispol'zovaniem solnechnoy energii. Kholodylnaia tekhnika ta tekhnolohiya, 53 (1). doi: 10.15673/ret.v53i1.534
38. Titlov, A. S. (2011). Energosberegayushchee upravlenie rezhimami bytovyh absorbcionnyh holodil'nyh priborov (AHP). Chast' 1. Avtomatyzatsiya tekhnolohichnykh i biznes protsesiv, 5-6, 38–44. doi: 10.15673/2312-3125.5-6/2011.35022
39. Vasyliv, O. B., Titlov, A. S., Holodkov, A. O. (2017). Modelirovanie teplovyh rezhimov pod'emnogo uchastka deflegmatora bytovogo

absorbcionnogo holodil'nogo agregata. Kholodylna tekhnika ta tekhnolohiya, 53 (1). doi: 10.15673/ret.v53i1.535

40. Holodkov, A. O., Titlov, A. S., Titlova, O. A. (2017). Modelirovanie teplovyh rezhimov deflegmatora bytovogo absorbcionnogo holodil'nogo agregata. Kholodylna tekhnika ta tekhnolohiya, 53 (4). doi: 10.15673/ret.v53i4.703
41. Kreyt, F., Blek, U. (1983). Osnovy teploperedachi. Moscow: Mir, 512.
42. Shervud, T., Pigford, R., Uilki, Ch. (1982). Massoperedacha. Moscow: Himiya, 696.
43. Dul'nev, G. N. (1984). Teplo- i massoobmen v radioelektronnoy apparature. Moscow, 247.
44. Osadchuk, E. A., Titlov, A. S. (2011). Analiticheskie zavisimosti dlya rascheta termodinamicheskih parametrov i teplofizicheskih svoystv vodoammiachnogo rastvora. Naukovi pratsi ONAKhT, 39, 178–182.
45. DSTU 3023-95 (HOST 30204-95, ISO 5155-83, ISO 7371-85, ISO 8187-91). Prylady kholodylni pobutovi. Ekspluatatsiyni kharakterystyky ta metody vyprobuvan (1996). Kyiv: Derzhstandart Ukrainy, 22.
46. Titlova, O. A., Titlov, A. S. (2011). Analiz vliyaniya teplovoy moshchnosti, podvodimoy v generatore absorbcionnogo holodil'nogo agregata, na rezhimy raboty i energeticheskuyu effektivnost' absorbcionnogo holodil'nogo pribora. Naukovi pratsi ONAKhT, 39, 148–154.
47. Titlova, O. A., Hobin, V. A. (2014). Energoeffektivnoe upravlenie absorbcionnymi holodil'nikami. Kherson: Grin' D.S., 216.
48. Doroshenko, A. V., Gorin, A. N., Glauberman, M. A. (2008). Solnechnaya energetika (Teoriya, razrabotka, praktika). Doneck: Nord-Press, 374.

DOI: 10.15587/1729-4061.2018.133655

THE INNVESTIGATION OF THE PROCESS STREAMS INTEGRATION IN THE MULTIEFFECT EVAPORATION PLANT FOR THE CONCENTRATION OF SORGHUM SYRUP (p. 52-58)

Tatiana Babak
National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-2944-5110

Olga Golubkina
National Technical University „Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4515-8533

Yevgeniya Ponomarenko
National Technical University „Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-9878-6093

Ludmila Solovey
National Technical University „Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-5308-6782

Gennadii Khavin
Join-stock Company "Sodrugestvo-T", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-4340-7615

The study on the integration of heat streams of the evaporation station for sorghum syrup concentrating is presented. The relevance of the research is is why the research, aimed at reducing the consumption of external energy and enhancing operating efficiency, is relevant and has practical value.

The main purpose of the work is to create a scientifically substantiated design with enhanced economic indicators of operation, ensuring saving in consumption of hot utility (steam) and cooling water.

The problem was solved using the pinch-analysis. Heat streams, requiring heating and cooling, were identified, and the alternative project based on the selection of the value of minimum temperature difference $\Delta T_{min.}$, was created. This value was calculated and substantiated based on the data on thermal streams. The stream of condensate of return steam, the heat excess of which had not been used so far, was added to the system. For the alternative project, the layout of heat exchange equipment was proposed, calculation of plate heat exchangers was performed. The designed network of heat exchangers made it possible to decrease the annual steam consumption by 18 %.

Cost-effectiveness analysis was conducted by comparing the indicators for two of the projects of the syrup preheating department for the evaporation station. The proposed alternative project saves power consumption of cooling water by 35.9 kW, of heating vapor steam – by 60.5 kW. At the interest rate of profit tax of 18 %, implementation of the alternative project will pay off in 4 months. As a result, net annual gain of an enterprise is planned to increase by 16 %, at virtually the same payback period of the projects. Application of the methods of heat streams integration made it possible to develop an effective project of sorghum syrup preheating before evaporation and ensure saving of external utilities.

Keywords: energy recovery, pinch-analysis, evaporation plant, plate heat exchangers, sorghum syrup concentration.

References

1. Westphalen, D. L., Wolf Maciel, M. R. (2000). Optimization of bleed streams in evaporation systems based on pinch analysis: new approach. European Symposium on Computer Aided Process Engineering-10, 997–1002. doi: 10.1016/s1570-7946(00)80168-6
2. Perin-Levasseur, Z., Palese, V., Marechal, F. (2008). Energy integration study of a multi-effect evaporator. PRES08: 11th Conference Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction. Praha.
3. Higa, M., Freitas, A. J., Bannwart, A. C., Zemp, R. J. (2009). Thermal integration of multiple effect evaporator in sugar plant. Applied Thermal Engineering, 29 (2-3), 515–522. doi: 10.1016/j.applthermaleng.2008.03.009
4. Kemp, I. C. (2007). Pinch Analysis and Process Integration. A User Guide on Process Integration for the Efficient Use of Energy. Butterworth-Heinemann, 416. doi: 10.1016/b978-0-7506-8260-2.x5001-9
5. Smit, R., Klemesh, Y., Tovazhnyanskiy, L. L., Kapustenko, P. A., Ul'ev, L. M. (2000). Osnovy integracii teplovyh processov. Kharkiv: NTU «KhPI», 458.
6. Barambu, N. U. A., El-Nafaty, U. A., Saeed, I. A. (2017). Energy Integration of Sugar Production Plant Using Pinch Analysis: A Case Study of Savanah Sugar Company Yola. Advances in Applied Science Research, 8 (2), 20–29.
7. Tovazhnyanski, L. L., Kapustenko, P. A., Ulyev, L. M., Boldyryev, S. A. (2002). Heat Integration Improvement for Eastern European Countries Sugar-Plant. Proceedings of 15th International Congress of Chemical and Process Engineering, CHISA'2002. Prague, 251.

8. Tovazhnyanskiy, L. L., Kapustenko, P. A., Ul'ev, L. M., Boldyrev, S. A. (2002). Teplovaya integraciya i energosberezhenie v saharnoy promyshlennosti. Vestnik NTU «KhPI», 1 (9), 95–105.
9. Arsen'eva, O. P., Babak, T. G., Demirskiy, A. V., Havin, G. L. (2011). Modernizaciya sistemy posledovatel'no ustanovlennyh podogrevateley saharnogo soka. Nauchnye trudy ONAHT, 2 (39), 151–155.
10. Demirskiy, A. V., Tovazhnyanskiy, L. L., Arsen'eva, O. P., Havin, G. L., Kapustenko, P. A. (2013). Analiz raboty sistemy podogrevateley saharnogo soka s uchetom zagryazneniy teploobmennoy poverhnosti. Integrirovannye tekhnologii i energosberezhenie, 2, 14–18.
11. Babak, T. G., Golubkina, O. A., Korol', D. S., Ponomarenko, E. D. (2017). Povyshenie energoeffektivnosti raboty stancii uparivaniya saharnogo siropa. Vestnik NTU «KhPI», 18 (1240), 46–52.
12. Lambert, C., Laulan, B., Decloux, M., Romdhana, H., Courtois, F. (2018). Simulation of a sugar beet factory using a chemical engineering software (ProSimPlus ®) to perform Pinch and exergy analysis. Journal of Food Engineering, 225, 1–11. doi: 10.1016/j.jfoodeng.2018.01.004
13. Eggleston, G., Cole, M., Andrzejewski, B. (2013). New Commercially Viable Processing Technologies for the Production of Sugar Feedstocks from Sweet Sorghum (Sorghum bicolor L. Moench) for Manufacture of Biofuels and Bioproducts. Sugar Tech, 15 (3), 232–249. doi: 10.1007/s12355-013-0229-6
14. Tovazhnyanskiy, L. L., Kapustenko, P. A., Havin, G. L., Arsen'eva, O. P.; Havin, G. L. (Ed.) (2007). Plastinchatye teploobmenniki v teplosnabzhenii. Kharkiv: NTU «KhPI», 448.
15. Arsenyeva, O. P., Tovazhnyanski, L. L., Kapustenko, P. A., Khavin, G. L. (2009). Mathematical Modeling and optimal Design of Plate-and-Frame Heat Exchangers. Chemical Engineering Transactions, 18, 791–796. doi: 10.3303/cet0918162

DOI: 10.15587/1729-4061.2018.132572

DESIGN AND STUDY OF THE ENERGYEFFICIENT UNIFIED APPARATUSES FOR ENERGY-TECHNOLOGICAL MANUFACTURING (p. 59-65)

Nikolsky Valeriy
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0001-6069-169X

Olga Oliynyk
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0003-2666-3825

Viktor Ved
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-2391-6463

Olena Svietkina
National TU Dnipro Polytechnic, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0003-0857-8037

Andrii Pugach
Dnipro State Agrarian and Economic University, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-5586-424X

Alexander Shvachka
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0003-1076-6950

The improved industrial sample of the rotor-pulse heat generator (RPH), integrated into the thermal heating systems of industrial buildings, was produced. Rotor-pulse generators do not occupy significant positions in the market of heating equipment because of the lack of reliable data on effectiveness of the use of such equipment in the thermal heating systems of industrial facilities.

The design of the developed cavitation chamber was changed, parameters of the channels, located between the rotor and the stator, were determined. It was found that the optimal width of the gap between the rotor and the stator channels at maximum efficiency of 0.7 was 8–10 mm. When integrating the cavitation chamber of the RPH into the thermal system, the design of the heat exchanger "pipe-in-pipe" was changed into the plate one.

Bench tests of energy efficiency of the thermal system operation were conducted. Indicators of energy efficiency of the system with the improved RPH were determined, the analysis was performed by comparing with analogues, described in the literature. It was proved that improvement of the thermal system allowed obtaining the improved indicators of energy efficiency. Bench testing showed that efficiency of the improved thermal system is by ≈17 % higher than efficiency of thermal systems based on the multi-stage RPH.

The automatic system of monitoring and control of the thermal system with the use of vibration-frequency sensors for assessment of cavitation process effectiveness was developed. The conducted commissioning works made it possible to determine the possibility of applying the developed automatic system with appropriate software for monitoring and control of the thermal system operation.

The obtained data of comparative analysis allow recommending the developed rotor-pulse heat generator as a credible alternative to the used thermal devices in thermal heating systems of industrial buildings.

Keywords: rotor-pulse apparatus, cavitation heat generator, efficiency, vibration method of control, control system.

References

1. Byun, J., Park, S., Kang, B., Hong, I., Park, S. (2013). Design and implementation of an intelligent energy saving system based on standby power reduction for a future zero-energy home environment. IEEE Transactions on Consumer Electronics, 59 (3), 507–514. doi: 10.1109/tce.2013.6626231
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: 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, 900. doi: 10.1201/9781315374567
4. Self, S. J., Reddy, B. V., Rosen, M. A. (2013). Geothermal heat pump systems: Status review and comparison with other heating options. Applied Energy, 101, 341–348. doi: 10.1016/j.apenergy.2012.01.048
5. Mahapatra, K., Gustavsson, L. (2008). An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden. Energy Policy, 36 (2), 577–590. doi: 10.1016/j.enpol.2007.10.006
6. Miozzi, M., Lalli, F., Romano, G. P. (2010). Experimental investigation of a free-surface turbulent jet with Coanda effect. Experiments in Fluids, 49 (1), 341–353. doi: 10.1007/s00348-010-0885-1
7. Nikolsky, V. E., Lobodenko, A. V. (2016). Razrabotka i issledovanie cel'nometallicheskoy kamery sgoraniya dlya apparatov pogruzhnogo goreniya. Intehrovani tekhnolohii ta enerhozberezhennia, 1, 69–65.
8. Nikolsky, V. (2015). Development and study of contact-modular heating system using immersion combustion units. Eastern-Eu-

ropean Journal of Enterprise Technologies, 4 (8 (76)), 31–35. doi: 10.15587/1729-4061.2015.47459

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: 10.15587/1729-4061.2017.111846
10. Bahramara, S., Moghaddam, M. P., Haghifam, M. R. (2016). Optimal planning of hybrid renewable energy systems using HOMER: A review. Renewable and Sustainable Energy Reviews, 62, 609–620. doi: 10.1016/j.rser.2016.05.039
11. Strantzali, E., Aravossis, K. (2016). Decision making in renewable energy investments: A review. Renewable and Sustainable Energy Reviews, 55, 885–898. doi: 10.1016/j.rser.2015.11.021
12. Connolly, D., Lund, H., Mathiesen, B. V. (2016). Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union. Renewable and Sustainable Energy Reviews, 60, 1634–1653. doi: 10.1016/j.rser.2016.02.025
13. Chua, K. J., Chou, S. K., Yang, W. M. (2010). Advances in heat pump systems: A review. Applied Energy, 87 (12), 3611–3624. doi: 10.1016/j.apenergy.2010.06.014
14. Li, Y., Fu, L., Zhang, S., Zhao, X. (2011). A new type of district heating system based on distributed absorption heat pumps. Energy, 36 (7), 4570–4576. doi: 10.1016/j.energy.2011.03.019
15. Ziębik, A., Gładysz, P. (2012). Optimal coefficient of the share of cogeneration in district heating systems. Energy, 45 (1), 220–227. doi: 10.1016/j.energy.2012.02.071
16. Petkovšek, M., Mlakar, M., Levstek, M., Stražar, M., Širok, B., Dular, M. (2015). A novel rotation generator of hydrodynamic cavitation for waste-activated sludge disintegration. Ultrasonics Sonochemistry, 26, 408–414. doi: 10.1016/j.ultsonch.2015.01.006
17. Ved, V., Nikolsky, V., Oliynyk, O., Lipeev, A. (2017). Examining a cavitation heat generator and the control method over the efficiency of its operation. Eastern-European Journal of Enterprise Technologies, 4 (8 (88)), 22–28. doi: 10.15587/1729-4061.2017.108580
18. Shevchenko, A. B. (2011). Vihrevye teplogeneratory termery: problemy i perspektivy. Stroitel'stvo. Materialovedenie. Mashinostroenie. Seriya: Sozdanie vysokotekhnologicheskih ekokompleksov v Ukraine na osnove koncepcii sbalansirovannogo (ustoychivogo) razvitiya, 60, 192–207.
19. Rooze, J., Rebrov, E. V., Schouten, J. C., Keurentjes, J. T. F. (2013). Dissolved gas and ultrasonic cavitation – A review. Ultrasonics Sonochemistry, 20 (1), 1–11. doi: 10.1016/j.ultsonch.2012.04.013
20. Takagi, R., Yoshizawa, S., Umemura, S. (2010). Enhancement of Localized Heating by Ultrasonically Induced Cavitation in High Intensity Focused Ultrasound Treatment. Japanese Journal of Applied Physics, 49 (7), 07HF21. doi: 10.1143/jjap.49.07hf21
21. Spirin, N. A., Lavrov, V. V., Zaynullin, L. A., Bondin, A. R., Burykin, A. A. (2015). Metody planirovaniya i obrabotki rezul'tatov inzhenernogo eksperimenta. Ekaterinburg: OOO «UINC», 290.
22. Promtov, M. A. (2001). Pul'sacionnye apparaty rotornogo tipa: teoriya i praktika. Moscow, 260.
23. Oliynyk, O., Taranenko, Y., Shvachka, A., Chorna, O. (2017). Development of autooscillating system of vibration frequency sensors with mechanical resonator. Eastern-European Journal of Enterprise Technologies, 1 (2 (85)), 56–60. doi: 10.15587/1729-4061.2017.93335
24. Oliynyk, O. Yu., Taranenko, Yu. K. (2017). Model Furie-filtratsiyi vykhidnykh analohovykh syhnaliv chastotnykh datchykiv. Tekhnolohyia pryborostroenyia, 2, 21–24.

DOI: 10.15587/1729-4061.2018.133673

DEVELOPMENT OF THERMAL INSTALLATION ON THE BASIS OF THE CASCADE HEAT PUMP FOR ENSURING ALL THERMAL AND REFRIGERATING NEEDS OF THE CONSUMER (p. 66-72)

Vladimir Parshukov
Limited Liability Company Scientific and Production Enterprise "Donskie tehnologii", Novocherkassk, Rostov Region, Russian Federation
ORCID: http://orcid.org/0000-0001-6700-4784

Nikolay Efimov
Limited Liability Company Scientific and Production Enterprise "Donskie tehnologii", Novocherkassk, Rostov Region, Russian Federation
ORCID: http://orcid.org/0000-0002-5010-6773

Vladimir Papin
Don State Technical University, Rostov-on-Don, Russian Federation
ORCID: http://orcid.org/0000-0002-3277-9413

Roman Bezuglov
Don State Technical University, Gagarin sq., 1, Rostov-on-Don, Russian Federation
ORCID: http://orcid.org/0000-0001-7142-5207

Aleksei Ovechkin
Don State Technical University, Gagarin sq., 1, Rostov-on-Don, Russian Federation
ORCID: http://orcid.org/0000-0001-7756-7089

This article describes the developed and manufactured multifunctional heat point, which allows to supply heat and refrigeration energy to consumers. For effective operation, the heat point contains an automated control system that allows to direct heat flows in an optimal way. Development of this thermal point began because in Russia there are no complex researches on creation of systems of power supply on the basis of heat pumps now. There are some works which actually copy the western technologies. At the same time, features of climatic zones are not considered that is extremely important for the development of similar power stations. That is, earlier nobody created a product which equally well works in the conditions of the Southern regions and Far North. Thermal and hydraulic calculations of thermal point were executed. Coefficients of performance and resistance of the contours of the heat pumping plant were the results of these calculations. These calculations showed that the transformation coefficient on all contours is in the range from

3.352 to 4.884. Now starting tests of the thermal point which showed a regularity of the chosen design decisions and operability of the installation are carried out.

The received results will be useful at projection of similar systems as the main characteristics of cascade heatpumping plants are received by a calculated path.

The concrete received results of a research are as follows:

– the multipurpose thermal point allowing to carry out heating – 25 kW, hot water supply – 5 kW, conditioning – 16 kW, ventilation of 25 kW is developed;

– key indicators of thermal effectiveness of the power station, such as transformation coefficient, thermal rating etc are defined;

– capacity of compact accumulators of warmth is determined. Heating with the temperature of 35 oC, within 12 hours of nighttime requires the boiler tank of 2500 l whereas the accumulator on change phase of 300–500 l;

– on the basis of the analysis of available renewable and secondary energy sources the structure of heat fluxes of the standard consumer with sources of excess warmth and points of its consumption is developed.

Keywords: heat pump, thermal point, air conditioning system, heating system, renewable energy sources, solar energy.

References

1. Yang, S.-H., Son, J.-E., Lee, S.-D., Cho, S.-I., Ashtiani-Araghi, A., Rhee, J.-Y. (2016). Surplus thermal energy model of greenhouses and coefficient analysis for effective utilization. Spanish Journal of Agricultural Research, 14 (1), e0202. doi: 10.5424/sjar/2016141-7517
2. Hossain, M. F. (2016). In situ geothermal energy technology: an approach for building cleaner and greener environment. Journal of Ecological Engineering, 17 (1), 49–55. doi: 10.12911/22998993/61189
3. Fernández, F., Folgueras, M., Suárez, I. (2017). Study and Optimization of Design Parameters in Water Loop Heat Pump Systems for Office Buildings in the Iberian Peninsula. Energies, 10 (12), 1958. doi: 10.3390/en10121958
4. Wang, F., Fan, X.-W., Chen, J., Lian, Z.-W. (2014). Energy and exergy analysis of heat pump using R744/R32 refrigerant mixture. Thermal Science, 18 (5), 1649–1654. doi: 10.2298/tsci1405649w
5. Ovidiu, N., Marcel, R., Codruţa, B., Marius, C. (2013). Ground Source Heat Pump in Heating System with Electronics Monitoring. Journal of Electrical and Electronics Engineering, 6 (2), 21–24.
6. Parshukov, V. I., Efimov, N. N., Papin, V. V., Bezuglov, R. V., Lagutin, A. Y., Kopitsa, V. V. (2018). Studying possibilities of seasonal cold for application in multifunctional heat supply units. ARPN Journal of Engineering and Applied Sciences, 13 (7), 2623–2631.
7. Ahn, B.-L., Park, J.-W., Yoo, S., Kim, J., Leigh, S.-B., Jang, C.-Y. (2015). Savings in Cooling Energy with a Thermal Management System for LED Lighting in Office Buildings. Energies, 8 (7), 6658–6671. doi: 10.3390/en8076658
8. Kovalev, O. P. (2007). Features of the use of heat pumps in heating systems. Proceedings of the Far Eastern State Technical Fisheries University, 35–42.
9. Volkov, V. N., Kozina, L. N., Dzyuban, A. M. (2015). Current use of heat pumps for heating buildings. NGIEI Journal Bulletin, 6 (49).
10. Efimov, N. N., Papin, V. V., Bezuglov, R. V. (2016). Micro Energy Complex Based on Wet-SteamTurbine. Procedia Engineering, 150, 324–329. doi: 10.1016/j.proeng.2016.07.022

DOI: 10.15587/1729-4061.2018.133659

CFD MODELLING OF PARTICLE SIZE EFFECT ON STOKER COALFIRED BOILERS COMBUSTION (p. 73-78)

Moch. Agus Choiron
University of Brawijaya Malang, Malang, Indonesia
ORCID: http://orcid.org/0000-0002-4052-4832

In the previous study, CFD simulation had been developed to predict combustion characteristic on the Fluidized Bed Boiler and Pulverized Boiler. The high demand on coal used for stoker-fired boilers in Indonesia the power plants provide challenge due to low thermal efficiency problem. In this study, CFD simulation is observed to predict the temperature distribution, heat of reaction, CO and CO_2 mass fraction on the stoker-fired boiler. Boiler geometry is modelled as the combustion chamber until the area before economizer. The selection of boundary conditions is set according to the governing equations available in the ANSYS Fluent software. Parameter design of coal which are particle size and properties of coal is determined to investigate the effect of the observed values. Four models are set to provide a combination of particle size and properties of coal. The solution strategy is developed to reduce instability of the simulation process. Coal combustion modelling includes several physical processes that could result in numerical stability issue when all processes are solved at once. The three stages were used to run the solution of the model. Plot of temperature distribution, heat of reaction, CO_2 and CO mass fraction is generated. The maximum temperature in the 1st to 4th model is 1440.95, 1473.85, 1347.72 and 1617.17 [K]. The amount of CO produced from each model tends to increase; respectively from the 1^{st} to 4^{th} model is 2.314E-07, 5.878E-07, 5.678E-07 and 7.904E-07. Based on the simulation results, it can be seen that the particle size of coal affects the combustion characteristic in the Stoker Coal-Fire Boiler.

Keywords: Stoker boiler, temperature distribution, heat of reaction, CO and CO_2 mass fraction.

References

1. Dong, N., Baruya, P. (2015). Coal and Gas Competition in Power Generation in Asia. IEA Clean Coal Centre, 106. Available at: https://www.usea.org/sites/default/files/022015_Coal%20and%20gas%20competition%20in%20power%20generation%20in%20Asia_ccc246.pdf
2. Rompalski, P., Róg, L. (2016). Effect of the temperature of different combustion zones in the boiler grate on changes in physical and chemical parameters of bituminous coal and slags. Journal of Sustainable Mining, 15 (2), 73–83. doi: 10.1016/j.jsm.2016.07.002
3. Zhang, X., Ghamari, M., Ratner, A. (2013). Numerical modeling of co-firing a light density biomass, oat (Avena sativa) hulls, and chunk coal in fluidized bed boiler. Biomass and Bioenergy, 56, 239–246. doi: 10.1016/j.biombioe.2013.05.006
4. Bartoňová, L. (2015). Unburned carbon from coal combustion ash: An overview. Fuel Processing Technology, 134, 136–158. doi: 10.1016/j.fuproc.2015.01.028
5. Kobyłecki, R. (2011). Unburned carbon in the circulating fluidised bed boiler fly ash. Chemical and Process Engineering, 32 (4). doi: 10.2478/v10176-011-0020-8
6. Makino, H., Matsuda, H. (Eds.) Improvement of Pulverized Coal Combustion Technology for Power Generation. Central Research Institute of Electric Power Industry. Available at: https://criepi.denken.or.jp/en/energy/research/pdf/Improvement.pdf
7. Statistik MINERBA 2017. Ministry of Energy and Mineral Resource of the Republic Indonesia.
8. Wang, Q., Yin, W., Yang, H., Lu, J., Zhao, B. (2015). Numerical study on the effect of fine coal accumulation in a coal beneficiation fluidized bed. Powder Technology, 283, 570–578. doi: 10.1016/j.fuproc.2014.02.015
9. Zhenfu, L., Qingru, C. (2001). Effect of fine coal accumulation on dense phase fluidized bed performance. International Journal of Mineral Processing, 63 (4), 217–224. doi: 10.1016/s0301-7516(01)00050-3

10. Pronobis, M., Kalisz, S., Polok, M. (2013). The impact of coal characteristics on the fouling of stoker-fired boiler convection surfaces. Fuel, 112, 473–482. doi: 10.1016/j.fuel.2013.05.044
11. Depman, A. J. III. (2014). Stoker Boiler CFD Modeling Improvements Through Alternative Heat Exchanger Modeling. University of Iowa, 97. Available at: https://ir.uiowa.edu/cgi/viewcontent.cgi?article=5125&context=etd
12. Zhou, H., Jensen, A., Glarborg, P., Jensen, P., Kavaliauskas, A. (2005). Numerical modeling of straw combustion in a fixed bed. Fuel, 84 (4), 389–403. doi: 10.1016/j.fuel.2004.09.020
13. Van der Lans, R. (2000). Modelling and experiments of straw combustion in a grate furnace. Biomass and Bioenergy, 19 (3), 199–208. doi: 10.1016/s0961-9534(00)00033-7
14. Dong, W., Blasiak, W. (2001). CFD modeling of ecotube system in coal and waste grate combustion. Energy Conversion and Management, 42 (15-17), 1887–1896. doi: 10.1016/s0196-8904(01)00048-6
15. Ford, N. W. J., Cooke, M. J., Sage, P. W. (1993). Modelling of fixed bed combustion. Fuel Processing Technology, 36 (1-3), 55–63. doi: 10.1016/0378-3820(93)90010-2
16. Yu, D., Xu, M., Sui, J., Liu, X., Yu, Y., Cao, Q. (2005). Effect of coal particle size on the proximate composition and combustion properties. Thermochimica Acta, 439 (1-2), 103–109. doi: 10.1016/j.tca.2005.09.005
17. Tutorial ANSYS FLUENT: Coal Combustion with Eddy Break Up (EBU) Model (2012). ANSYS, Inc.