ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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INVESTIGATION AND IMPLEMENTATION OF THE FRACTAL PROPERTIES OF ELECTRIC LOAD ON CIVILIAN OBJECTS IN ORDER TO EFFICIENTLY PREDICT AND CONTROL ELECTRICAL CONSUMPTION (p. 6-12)

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We have investigated the process of constructing the charts of electrical load, as well as electricity consumption, of many-storied apartment houses in a city's neighborhood, taking into consideration the fractal structure and the existence of a long-term dependence, inherent to self-affine stochastic processes. The results from studying daily, weekly, monthly, yearly charts have shown the presence of fractal properties and the existence of short-term and long-term memory. This makes it possible, in order to efficiently predict and control power consumption, to apply a fractal analysis, which establishes the dependence of future values on retrospective information. Feature of the current study is determining a critical value for the Hurst exponent, approaching which leads to that the system loses stability and enters an unstable state under which the parameters are changing rapidly. The Hurst exponent can be transformed into fractal dimensionality, which is a measure for the complexity of a load chart. In the theory of fractal sets and fractal geometry, of significant importance are the self-similar and fractal sets. By using the specified properties of the fractal, this study has proven the existence of a fractal principle in the formation of the dynamics of electrical load on civilian targets using the example of power consumption by many-storied apartment houses within a city's neighborhood. The calculation of the Hurst exponent has made it possible to determine that the series is persistent and suitable for adequate prediction and efficient energy consumption management. The relevance of the current research is predetermined by the application of a fractal analysis to electricity consumption pattern particularly by civilian objects, since the scientific literature analyzes and predicts the processes that form electric load structure on energy systems, at industrial enterprises.

Keywords: fractal, self-affinity, persistence, Hurst exponent, trend resistance, forecast model.

References

1. Freder, J. (1988). Fractals. New York, 283. doi: https://doi.org/10.1007/978-1-4899-2124-6
2. Peters, E. (1994). Fractal Market Analysis: Applying Chaos Theory to Investment and Economics. Boston, 336.
3. Jian-Kai, L., Cattani, C., Wan-Qing, S. (2015). Power Load Prediction Based on Fractal Theory. Advances in Mathematical Physics, 2015, 1–6. doi: https://doi.org/10.1155/2015/827238
4. Lezhniuk, P. D., Shullie, Yu. A. (2015). Operatyvne prohnozuvannia elektrychnykh navantazhen system elektrospozhyvannia z vrakhuvanniam yikh fraktalnykh vlastyvostei. Vinnytsia: VNTU, 104.
5. Zhai, M.-Y. (2015). A new method for short-term load forecasting based on fractal interpretation and wavelet analysis. International Journal of Electrical Power & Energy Systems, 69, 241–245. doi: https://doi.org/10.1016/j.ijepes.2014.12.087
6. Bunn, D. W., Farmer, E. D. (1985). Comparative models for electrical load forecasting. New York: Jone & Sons, 200.
7. Chernenko, P., Martyniuk, O., Zaslavsky, A., Miroshnyk, V. (2018). Multifactor modeling and analysis of electrical load of the power system using the data of long-term prehistory. Tekhnichna Elektrodynamika, 1, 87–93. doi: https://doi.org/10.15407/techned2018.01.087
8. Box D., Jenkins G. Analysis of Time Series. Forecast and Management. New Jersey, 1977. 729 p.
9. Varetskyi, Yu. O., Karach, L. V. (2002). Operatyvno-dyspetcherske keruvannia elektroener-hetychnymy systemamy. Lviv: Lvivska politekhnika, 160.
10. Stakhiv, P., Kozak, Yu., Hoholyuk, O. (2014). Increasing of effectiveness of algorithms to create macromodels of electric power systems objects. Tekhnichna elektrodynamika, 5, 29–31.
11. Hovorov, P. P., Bakulevskyi, V. L. (2018). Improvement of Mathematical Model of Calculation and Power Loss Forecasting on the Basis of Neural Networks. Visnyk Vinnytskoho politekhnichnoho instytutu, 2, 14–19.
12. Prusty, B. R., Jena, D. (2018). An over-limit risk assessment of PV integrated power system using probabilistic load flow based on multi-time instant uncertainty modeling. Renewable Energy, 116, 367–383. doi: https://doi.org/10.1016/j.renene.2017.09.077
13. Wang, H., Ouyang, M., Wang, Z., Liang, R., Zhou, X. (2017). The power load's signal analysis and short-term prediction based on wavelet decomposition. Cluster Computing. doi: https://doi.org/10.1007/s10586-017-1316-3
14. Bondarchuk, A. S. (2015). Vnutrishnobudynkove elektropostachannia. Kyiv: Osvita Ukrainy, 480.

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ANALYSIS AND OPTIMIZATION OF THE REACTIVE POWER COMPENSATION MODES IN A POWER SUPPLY SYSTEM (p. 13-22)

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The paper reports the study of modes in a single-phase generalized power supply system in terms of improving energy indicators in the system by compensating for the reactive power. We considered three test versions of the power supply system with different ratios of complex load impedance and power lines. We show the drawbacks of the traditional method for calculating the parameters of the compensating device, which provide partial compensation of reactive power consumed only by the load. An analysis of the partial compensation mode indicates that with an increase in the reactivity of the transmission line, the energy indices, which can be obtained as a result of reactive power compensation, deteriorate. Using search engine optimization, it is shown that an increase in the capacity of the compensator is required for full compensation. The method of search engine optimization is implemented in the Mathcad software package using the given-find decision unit. For this purpose, we used the equations of the mathematical model of the power supply system based on component and topological equations. As additional conditions, we used relations that determine the reactive power of the supply source full compensation, as well as the conditions for the physical implementation of the compensating device structure. The optimization variables are the parameters of the mode under study and the parameters of the compensating device. Fragments of texts in the program with numerical solutions are presented, as well as comparative tables of analysis and optimization results of reactive power compensation modes in the studied power supply systems for all variants of their parameters. The quantitative estimates of additional capacity value are given, which is calculated based on the condition for the compensation of reactive power in the transmission line by it. Our study has shown that with an increase in the reactance of the transmission line, full compensation cannot be achieved with the use of shunt compensation and physical interpretation of this phenomenon. It implies that the voltage on the compensating shunt capacitor decreases faster than the reactive power of the transmission line compensated by it increases. It is shown that in the latter case, the full compensation of reactive power can still be achieved by using combined series-shunt compensation.

Keywords: power supply system, reactive power, compensation mode, power line, compensating device.

References

1. Hofmann, W., Schlabbach, J., Just, W. (2012). Reactive Power Compensation: A Practical Guide. John Wiley & Sons, 274. doi: https://doi.org/10.1002/9781119967286
2. Arrillaga, J., Watson, N. R., Chen, S. (2000). Power system quality assessment. John Wiley, 300.
3. Acha, E., Agelidis, V. G., Miller, T. J. E. (2002). Electronic Control in Electrical Systems. Newnes, 464. doi: https://doi.org/10.1016/b978-0-7506-5126-4.x5000-7
4. Kudrin, B. I. (2006). Elektrosnabzhenie promyshlennyh predpriyatiy. Lviv: Inzhiniring, 622.
5. Milykh, V. I., Pavlenko, T. P. (2016). Elektropostachannia promyslovykh pidpryiemstv. Kharkiv, 272.
6. Gerasimenko, A. A., Fedin, V. T. (2006). Peredacha i raspredelenie elektricheskoy energii. Rostov-na-Donu: Feniks, 720.
7. Nanda, P., Kumar Panigrahi, C., Dasgupta, A. (2017). Reactive power monitoring and compensation in a distribution network of modern power system. International Journal of Applied Engineering Research, 12 (22), 12395–12402.
8. Gayatri, M. T. L., Parimi, A. M., Pavan Kumar, A. V. (2018). A review of reactive power compensation techniques in microgrids. Renewable and Sustainable Energy Reviews, 81, 1030–1036. doi: https://doi.org/10.1016/j.rser.2017.08.006
9. Han, Y., Chen, L., Ma, H., Wang, Z. (2014). Optimization of reactive power compensation for distribution power system with small hydro power. 2014 International Conference on Power System Technology. doi: https://doi.org/10.1109/powercon.2014.6993939
10. Kopylov, I. P. (2004). Elektricheskie mashiny. Moscow: Vysshaya shkola, 607.
11. Yagup, V. G., Yagup, E. V. (2017). Primenenie optimizatsionnyh metodov dlya resheniya zadach uluchsheniya pokazateley elektricheskih sistem. Kharkiv: HNUGH im. A. N. Beketova, 170.
12. Yagup, V. G., Yagup, K. V. (2015). Synthesis of electric system in time domain by searching optimization method. Tekhnichna elektrodynamika, 2, 24–29.
13. Yagup, V. G., Yagup, K. V. (2016). Determination of reactive power compensation mode in four-wire three-phase electric power supply system using search engine optimization. Tekhnichna elektrodynamika, 1, 60–66.

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STUDYING THE MUTUAL INTERACTION OF HYDRAULIC CHARACTERISTICS OF WATER-DISTRIBUTING PIPELINES AND THEIR SPRAYING DEVICES IN THE COOLERS AT ENERGY UNITS (p. 23-29)

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This analytical study is based on the results from hydraulic tests of spray nozzles for the mixing (waterjet) steam condenser at a thermal power plant's turbo generator. The work was performed at the stage of launch operations at TPP. Such hydraulic tests were carried out by co-authors at the stage of launch operations at Razdan TPP (Armenia). The TPP is located in a mountainous region with a limited water supply; the plant's features include: dry cooling of circulating water in the radiator cooling towers; a steam condenser of mixing type.

The main tasks of hydraulic tests were: to determine the actual throughput capacity, to find a flow rate coefficient for the nozzles of

a steam condenser, as well as analyze their operation in a vacuum in the condenser.

This study considered the nozzles that have two openings with a diameter of 13 mm and 15 mm for spraying cooling water within the steam space of the condenser.

By exploring the hydraulic characteristics Q=f(H) of standard nozzles mounted at the end of a water-distributing pipeline, it was found that the diameter of the nozzle opening did not significantly affect the flow rate of water under the same water heads. Such a result is explained by that the pipeline's characteristic was obtained, rather than that of the spraying device.

The further hydraulic study into the nozzles was performed at a special laboratory bench.

The established factor of interrelation between the hydraulic characteristics of a water-distributing pipeline and the nozzles mounted onto it is important for performing similar studies.

The throughput capacity of the nozzles, considering the presence of a vacuum in the steam condenser of a turbo generator will be larger than that under atmospheric conditions. However, in a closed system of water circulation, the overall water flow rate of nozzles will equal the supply of cooling water from pumps into a given system. Therefore, the supply of cooling water to a condenser will not change dramatically, while the water flow rate of a single nozzle will be inversely proportional to their number.

In addition, we investigated a possibility to increase the feed of water to a condenser in order to improve energy performance. Our analysis reveals the impossibility of a substantial increase in the water supply to a condenser by increasing the diameters of spraying nozzles' openings. This does not substantially reduce the overall loss of water head and feed from circulating pumps to the steam cooling system in a turbine's condenser.

Keywords: spray device, water-distributing pipeline, water and stem cooler at a power plant, head and flow rate.

References

1. Posobie po proektirovaniyu gradiren (k SNiP 2.04.02-84 „Vodosnabzhenie, Na ruzhnye seti i sooruzheniya") (1989). Moscow: CITP Gosstroya SSSR.
2. Wei, Z., Xin-qian, B., Guo-qing, X. et. al. (2009). Study of the rules-based coordinated control of a condenser pressure system. Journal of Engineering for Thermal Energy and Power, 24 (2), 188–191.
3. Fedyaev, V. L., Morenko, I. V., Molov, V. I., Gaynullin, R. F. (2008). Vodoraspredelitel'nye sistemy bashennyh gradiren. Shkola-seminar molodyh uchenyh i specialistov akademika RAN V. E. Alemasova «Problemy teplomasoobmena i gidrodinamiki v energomashinostroenii»: Materialy dokladov. Kazan', 170–173.
4. Yufeng, G., Hua, Q., Daren, Y., Xiaomin, Z. (2008). Influences of Cooling Air Face Velocity and Temperature on Dynamic Characteristics of Direct Air-cooled System. CSEE Journal, 29, 22–27.
5. Husick, C. (2008). California's Otay Mesa selects Niagara Blower WSAC to keep its cool. Modern Power Systems, 28 (6), 45.
6. Liu, H., Zong, Q., Lv, H., Jin, J. (2017). Analytical equation for outflow along the flow in a perforated fluid distribution pipe. PLOS ONE, 12 (10), e0185842. doi: https://doi.org/10.1371/journal.pone.0185842
7. Lee, S., Moon, N., Lee, J. (2012). A study on the exit flow characteristics determined by the orifice configuration of multi-perforated tubes. Journal of Mechanical Science and Technology, 26 (9), 2751–2758. doi: https://doi.org/10.1007/s12206-012-0721-z
8. Hassan, J. M., Mohamed, T. A., Mohammed, W. S., Alawee, W. H. (2014). Modeling the Uniformity of Manifold with Various Configurations. Journal of Fluids, 2014, 1–8. doi: https://doi.org/10.1155/2014/325259
9. Cherniuk, V. V. (2008). Metod rozrakhunku napirnykh rozpodilchykh truboprovodiv. Prykladna hidromekhanika, 3, 65–76.
10. Chernyuk, V., Orel, V. (2009). Experimental Verification of a New Method of Calculation for Pressure Distributive Pipelines. Zeszyty Naukowy Politechniki Rzeszowskiej, 266, 27–34.
11. Idel'chik, I. E.; Shteynberg, M. O. (Ed.) (1992). Spravochnik po gidravlicheskim soprotivleniyam. Moscow: Mashinostroenie, 672.

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INFLUENCE OF THE FLOW STRUCTURE FORMATION ON HEAT TRANSFER PROCESSES IN TUBES WITH SPIRAL CORRUGATED INSERTS (p. 29-35)

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In order to enhance heat transfer processes in elements of power equipment with minimal energy consumption, the concept of partial structure formation of the heat transfer surface was developed. To determine the energy efficiency of partial structure formation of the heat transfer surface with transitional Reynolds numbers, the surface in the form of spiral corrugation is considered. Partial spiral corrugation due to a change in the flow structure makes it possible to increase the convective component of heat transfer with a moderate increase in friction loss in a transient flow regime. Based on direct numerical simulation of the three-dimensional non-stationary flow structure in the initial section of the tube with a spiral corrugated insert with the shock inlet and transition Reynolds number, the relationship between the structure of the disturbed non-isothermal flow and heat transfer rate on the tube surface is shown. The influence of temperature head on the growth rate of perturbations of the boundary layer in the tube, in the boundaries of which low-frequency oscillatory flow processes are formed, leading to an increase in convective heat transfer rate, is shown. The flow nature and changes in hydrodynamic and thermal parameters in the corrugated insert are investigated. The degree of influence of the spiral corrugated insert, not blocking the flow area of the tube, on the development of natural oscillations in the tube is determined. The influence of the pitch of spiral corrugation to the tube axis on the thermal and hydrodynamic processes in it is investigated. The resulting heat transfer enhancement (up to 20 %) with a simultaneous increase in friction loss (up to 7.5 %) correlates with the experimental results of other authors with similar corrugations in the given range of Reynolds numbers.

Keywords: partial corrugation, spiral corrugation, heat transfer in a tube, heat transfer enhancement, friction loss.

References

1. Mitrofanova, O. V. (2010). Gidrodinamika i teploobmen zakruchennyh potokov v kanalah yaderno-energeticheskih ustanovok. Moscow: FIZMATLIT, 288.
2. Oviedo-Tolentino, F., Romero-Méndez, R., Hernández-Guerrero, A., Girón-Palomares, B. (2008). Experimental study of fluid flow in the entrance of a sinusoidal channel. International Journal of Heat and Fluid Flow, 29 (5), 1233–1239. doi: https://doi.org/10.1016/j.ijheatfluidflow.2008.03.017
3. Guzmán, A. M., Cárdenas, M. J., Urzúa, F. A., Araya, P. E. (2009). Heat transfer enhancement by flow bifurcations in asymmetric wavy wall channels. International Journal of Heat and Mass Transfer, 52 (15-16), 3778–3789. doi: https://doi.org/10.1016/j.ijheatmasstransfer.2009.02.026

4. Stasiek, J., Collins, M. W., Ciofalo, M., Chew, P. E. (1996). Investigation of flow and heat transfer in corrugated passages – I. Experimental results. International Journal of Heat and Mass Transfer, 39 (1), 149–164. doi: https://doi.org/10.1016/s0017-9310(96)85013-7
5. Ciofalo, M., Stasiek, J., Collins, M. W. (1996). Investigation of flow and heat transfer in corrugated passages – II. Numerical simulations. International Journal of Heat and Mass Transfer, 39 (1), 165–192. doi: https://doi.org/10.1016/s0017-9310(96)85014-9
6. Vicente, P. G., García, A., Viedma, A. (2004). Experimental investigation on heat transfer and frictional characteristics of spirally corrugated tubes in turbulent flow at different Prandtl numbers. International Journal of Heat and Mass Transfer, 47 (4), 671–681. doi: https://doi.org/10.1016/j.ijheatmasstransfer.2003.08.005
7. Zimparov, V. D., Vulchanov, N. L., Delov, L. B. (1991). Heat transfer and friction characteristics of spirally corrugated tubes for power plant condensers – 1. Experimental investigation and performance evaluation. International Journal of Heat and Mass Transfer, 34 (9), 2187–2197. doi: https://doi.org/10.1016/0017-9310(91)90045-g
8. Vulchanov, M. L., Zimparov, V. D., Delov, L. B. (1991). Heat transfer and friction characteristics of spirally corrugated tubes for power plant condensers – 2. A mixing-length model for predicting fluid friction and heat transfer. International Journal of Heat and Mass Transfer, 34 (9), 2199–2206. doi: https://doi.org/10.1016/0017-9310(91)90046-h
9. Hærvig, J., Condra, T., Sørensen, K. (2015). Numerical Investigation of Single-phase Fully Developed Heat Transfer and Pressure Loss in Spirally Corrugated Tubes. Proceedings of the 56th Conference on Simulation and Modelling (SIMS 56). Linköping University, 391–397. doi: https://doi.org/10.3384/ecp15119391
10. Rivkin, S. L., Aleksandrov, A. A. (1984). Termodinamicheskie svoystva vody i vodyanogo para. Moscow: Energoatomizdat, 80.
11. Baskova, A., Voropayev, G. (2018). The structure of the vortex nonisothermal flow at the initial section of the pipe with transient Reynolds numbers. Hydrodynamics and acoustics, 1 (2), 117–131. doi: https://doi.org/10.15407/jha2018.02.117

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FLOW VISUALIZATION OF WATER JET PASSING THROUGH THE EMPTY SPACE OF CROSSFLOW TURBINE RUNNER (p. 36-42)

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Hydropower plants are a form of renewable energy resources, which comes from flowing water. The turbine is used to drive the generator then convert mechanical energy into electrical energy. The turbine wheel is located inside the turbine housing and the turbine wheel rotates the power shaft. One of the most used turbines is a cross-flow turbine. The pattern of water jet flowing throughout the empty space of the runner of the cross-flow turbine is influenced by the number of active runner blades pounded by water from the turbine nozzle. The difference in the flow patterns was believed having a relation to the performance differences of the three turbine models. The flow visualizations of water passing through the empty space of the cross-flow turbine runner were taken from the experimental study intended to investigate performance characteristics of three cross-flow turbine models designed on the same value of flow rates, runner diameters and rotational speeds; but each turbine model having different values of runner width as well as nozzle entry arc. Both of the nozzle and runner widths were designed as the function of the nozzle entry arc, therefore the shorter pair of runner-nozzle width the larger nozzle entry arc and vice versa. The flow visualizations of water passing on the turbine were studied using the empty space of the cross-flow turbine. The three models were tested on the same head and the same flow rate at the speed of 50, 100, 150, 250, 300 and 500 rpm. The photos of water flowing through the empty space in the turbine model runners were taken to find out the conditions of flow and the efficiency of the models was calculated to show the performance of the turbine. Images are taken within 10 cm and parallel to the turbine. The cross-flow turbine models were designed with 197 mm runner diameter of each and have the ratio of runner diameter to runner length of 1:2. One side of each turbine model end disk was made from transparent media named perspex facilitating the researcher to observe the water flow condition during flowing through inside the runner. The conditions of the flow of water passing through the empty space of turbine wheels were photographed using a Nikon camera equipped with a halłogen lamp having a power of 1000 watts to capture the difference of flow pattern among the three models of the turbine. The nozzle entry arcs used in this experimental study were 75°, 90° and 120°. In addition, the nozzle of each model has the same cross-sectional area and the roof of each was designed having roof curvature radius centered on the shaft axis. Such nozzle roof curvature was expected to be able to deliver water in the better direction as well as its flow condition as the water enters the turbine runner. The magnitude of the nozzle entry arc determines the number of active vanes pounded by the jet of water coming out of the nozzle, these conditions affect the pattern of water flow at the moment of passing through the empty space of the turbine wheel and then this flow pattern was believed to affect the performance characteristic of the cross-flow turbine. One side of each runner disk was made from Perspex, for the researcher to be able to observe the water flow condition during flowing through inside the runner.

Keywords: nozzle entry arc, flow condition, performance characteristic of cross-flow turbine.

References

1. Government Gazette Republic of Namibia. Available at: https://namiblii.org/system/files/gazette/2018/6670/%236670-Gov%20N163.pdf
2. England, J. F., Cohn, T. A., Faber, B. A., Stedinger, J. R., Thomas, W. O., Veilleux, A. G. et. al. (2018). Guidelines for determining flood flow frequency – Bulletin 17C. Techniques and Methods. doi: https://doi.org/10.3133/tm4b5
3. Thin Layer Chromatography (2019). Chemistry LibreTexts. Available at: https://chem.libretexts.org/Ancillary_Materials/Demos%2C_Techniques%2C_and_Experiments/General_Lab_Techniques/Thin_Layer_Chromatography
4. Childress, S. (2010). Walking on water. Journal of Fluid Mechanics, 644, 1. doi: https://doi.org/10.1017/s0022112009993107
5. Owusu-Boateng, G., Adjei, V. (2014). The potential utilization of grey water for irrigation: A case study on the Kwame Nkrumah University of Science and Technology, Kumasi Campus. Journal of Applied Research in Water and Wastewater, 1 (1), 31–37.
6. Wacławczyk, T., Koronowicz, T. (2008). Comparison of cicsam and hric high-resolution schemes for interface capturing. Journal of Theoretical and Applied Mechanics, 46 (2), 325–345.
7. Colonna, P., Harinck, J., Rebay, S., Guardone, A. (2008). Real-Gas Effects in Organic Rankine Cycle Turbine Nozzles. Journal

of Propulsion and Power, 24 (2), 282–294. doi: https://doi.org/10.2514/1.29718
8. Pasquale, D., Ghidoni, A., Rebay, S. (2013). Shape Optimization of an Organic Rankine Cycle Radial Turbine Nozzle. Journal of Engineering for Gas Turbines and Power, 135 (4), 042308. doi: https://doi.org/10.1115/1.4023118
9. Mazur, Z., Hernandez-Rossette, A., Garcia-Illescas, R., Luna-Ramirez, A. (2008). Failure analysis of a gas turbine nozzle. Engineering Failure Analysis, 15 (7), 913–921. doi: https://doi.org/10.1016/j.engfailanal.2007.10.009
10. Nuyttens, D., Baetens, K., De Schampheleire, M., Sonck, B. (2007). Effect of nozzle type, size and pressure on spray droplet characteristics. Biosystems Engineering, 97 (3), 333–345. doi: https://doi.org/10.1016/j.biosystemseng.2007.03.001
11. Hagena, O. F., Obert, W. (1972). Cluster Formation in Expanding Supersonic Jets: Effect of Pressure, Temperature, Nozzle Size, and Test Gas. The Journal of Chemical Physics, 56 (5), 1793–1802. doi: https://doi.org/10.1063/1.1677455
12. Chang, R., Nam, J., Sun, W. (2008). Effects of Dispensing Pressure and Nozzle Diameter on Cell Survival from Solid Freeform Fabrication–Based Direct Cell Writing. Tissue Engineering Part A, 14 (1), 41–48. doi: https://doi.org/10.1089/ten.a.2007.0004
13. Grisso, R., Hipkins, P., Askew, S. D., Hipkins, L., Mccall, D. (2013). Nozzles: Selection and sizing. College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University. Available at: https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/442/442-032/442-032_pdf.pdf
14. Kanoğlu, M. (2001). Cryogenic turbine efficiencies. Exergy, An International Journal, 1 (3), 202–208. doi: https://doi.org/10.1016/s1164-0235(01)00026-7
15. Poullikkas, A. (2005). An overview of current and future sustainable gas turbine technologies. Renewable and Sustainable Energy Reviews, 9 (5), 409–443. doi: https://doi.org/10.1016/j.rser.2004.05.009
16. Kacker, S. C., Okapuu, U. (1982). A Mean Line Prediction Method for Axial Flow Turbine Efficiency. Journal of Engineering for Power, 104 (1), 111. doi: https://doi.org/10.1115/1.3227240
17. Safarian, S., Aramoun, F. (2015). Energy and exergy assessments of modified Organic Rankine Cycles (ORCs). Energy Reports, 1, 1–7. doi: https://doi.org/10.1016/j.egyr.2014.10.003
18. Vennell, R. (2012). Realizing the potential of tidal currents and the efficiency of turbine farms in a channel. Renewable Energy, 47, 95–102. doi: https://doi.org/10.1016/j.renene.2012.03.036
19. Garrett, C., Cummins, P. (2007). The efficiency of a turbine in a tidal channel. Journal of Fluid Mechanics, 588. doi: https://doi.org/10.1017/s0022112007007781
20. Tiwari, A. K., Hasan, M. M., Islam, M. (2013). Effect of ambient temperature on the performance of a combined cycle power plant. Transactions of the Canadian Society for Mechanical Engineering, 37 (4), 1177–1188. doi: https://doi.org/10.1139/tcsme-2013-0099
21. Gorban', A. N., Gorlov, A. M., Silantyev, V. M. (2001). Limits of the Turbine Efficiency for Free Fluid Flow. Journal of Energy Resources Technology, 123 (4), 311. doi: https://doi.org/10.1115/1.1414137
22. Barthelmie, R. J., Jensen, L. E. (2010). Evaluation of wind farm efficiency and wind turbine wakes at the Nysted offshore wind farm. Wind Energy, 13 (6), 573–586. doi: https://doi.org/10.1002/we.408
23. Wind Turbine Blade Aerodynamics. Available at: http://kimerius.com/app/download/5784129509/Wind+turbine+blade+aerodynamics.pdf
24. Poursaeidi, E., Aieneravaie, M., Mohammadi, M. R. (2008). Failure analysis of a second stage blade in a gas turbine engine. Engineering Failure Analysis, 15 (8), 1111–1129. doi: https://doi.org/10.1016/j.engfailanal.2007.11.020
25. Mazur, Z., Garcia-Illescas, R., Aguirre-Romano, J., Perez-Rodriguez, N. (2008). Steam turbine blade failure analysis. Engineering Failure Analysis, 15 (1-2), 129–141. doi: https://doi.org/10.1016/j.engfailanal.2006.11.018
26. Stout, C., Islam, S., White, A., Arnott, S., Kollovozi, E., Shaw, M. et. al. (2017). Efficiency Improvement of Vertical Axis Wind Turbines with an Upstream Deflector. Energy Procedia, 118, 141–148. doi: https://doi.org/10.1016/j.egypro.2017.07.032
27. Sarkar, A., Behera, D. K. (2012). Wind Turbine Blade Efficiency and Power Calculation with Electrical Analogy. International Journal of Scientific and Research Publications, 2 (2).
28. Padture, N. P. (2002). Thermal Barrier Coatings for Gas-Turbine Engine Applications. Science, 296 (5566), 280–284. doi: https://doi.org/10.1126/science.1068609
29. Wang, C.-C., Chow, H.-M., Yang, L.-D., Lu, C.-T. (2009). Recast layer removal after electrical discharge machining via Taguchi analysis: A feasibility study. Journal of Materials Processing Technology, 209 (8), 4134–4140. doi: https://doi.org/10.1016/j.jmatprotec.2008.10.012
30. Liu, C., Jiang, D. (2014). Crack modeling of rotating blades with cracked hexahedral finite element method. Mechanical Systems and Signal Processing, 46 (2), 406–423. doi: https://doi.org/10.1016/j.ymssp.2014.01.007

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THERMODYNAMIC ANALYSIS OF THE SCHEMECYCLE DESIGN OF A HEATING-COOLINGMACHINEFOR AN INDIVIDUAL HOUSE (p. 43-49)

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The direction of the research is the thermodynamic analysis of the scheme-cycle designof a heating and cooling machine for an individual house powered by autonomous solar photovoltaic system of providing private consumers with the year-roundheating and cooling in conditions of dry tropical climate.

For the analysis, a single-stage compressor refrigerating machine was used, which operates in two modes: refrigeration forair conditioning and heat pump for heating, covering all rooms in the house. Change of the modes is made seasonally or during the day depending on the ambient temperature. The energy efficiency of the refrigerationcycle("energy" problem) associated with the properties of the working fluid, and cycle size("transport"problem) associated with the scheme-cycle design, equipment mass and investment costs,were determined. The study used the working fluids R404a, R134a, R410, R290, R600a, R32, which are neither prohibited nor expired. Calculations were performed separately for each mode. The results showed that the R290, R600a working fluids have a high ef-

ficiency in both modes, R404A, R410, R32 have the same energy efficiency, differing by no more than 10%, R134a is incompetitivein the heating mode. Among the cyclesizes, R32, R410 have the advantagewith the valueshalf the size of R290, R404A, R600a and R134a are not included in the alternative group. Based on the thermodynamic analysis and monitoring of the market of working fluids, only R32 can be recommended for real projects. A separate thermodynamic analysis of thescheme-cycle designs for CO_2 – the real prospect of refrigeration equipmentwas carried out.

Keywords: refrigerating machine, working fluid, thermodynamic analysis, energy efficiency, cycle size.

References

1. Razvitie mirovoy holodil'noy promyshlennosti. Available at: http://znakka4estva.ru/dokumenty/ekonomika/razvitie-mirovoy-holodilnoy-promyshlennosti/
2. Angrisani, G., Akisawa, A., Marrasso, E., Roselli, C., Sasso, M. (2016). Performance assessment of cogeneration and trigeneration systems for small scale applications. Energy Conversion and Management, 125, 194–208. doi: https://doi.org/10.1016/j.enconman.2016.03.092
3. Denysova, A., Alhemiri Saad, A., Morozyuk, L. (2018). Discussion of the possibility of creating trigeneration systems in the climate of the Middle East. Kholodylna tekhnika i tekhnolohiya, 54 (5), 36–43. doi: https://doi.org/10.15673/ret.v54i5.1249
4. Split/Multi-Split Type Air Conditioners. Available at: https://www.daikin.com/products/ac/lineup/split_multi_split/
5. York Rooftop Units Heatingand Air Conditioning. Available at: https://www.master.ca/en/professionnal/rooftop-units
6. Denysova, A., Morozyuk, L., Alhemiri Saad, A., Tsurkan, A. (2018). Schemes, design and technological features of trigeneration systems for the conditions of the Middle East. Bulletin of the National Technical University «KhPI». Series: Innovation researches in students' scientific work, 40, 10–16. doi: https://doi.org/10.20998/2220-4784.2018.40.02
7. Klyuev, P. G. Solnechnaya energetika: 2014. Available at: http://www.nanometer.ru/2010/08/23/12825909129704_216802.html
8. Bellos, E., Tzivanidis, C. (2017). Parametric analysis and optimization of a solar driven trigeneration system based on ORC and absorption heat pump. Journal of Cleaner Production, 161, 493–509. doi: https://doi.org/10.1016/j.jclepro.2017.05.159
9. Ghafoor, A., Munir, A. (2015). Worldwide overview of solar thermal cooling technologies. Renewable and Sustainable Energy Reviews, 43, 763–774. doi: https://doi.org/10.1016/j.rser.2014.11.073
10. Medved, D. (2011). Trigeneration units. Intensive Programme "Renewable Energy Sources", 47–50.
11. Monreal's'kiy protokol pro rechovini, scho ruynuyut' ozonoviy shar. Available at: https://zakon.rada.gov.ua/laws/show/995_215
12. Coulomb, D. (2013). The refrigerants future: the phase down of HFCsand its consequences. Nizkotemperaturnye i pischevye tekhnologii v XXI veke: materialy VI MNTK. Sankt-Peterburg. Sankt-Peterburg: NIU ITMO, IHiBT, 3–6.
13. Zapret hladagenta R134a v Evrope (2017). Available at: http://www.automaster.net.ua/artykuly/zapret-hladagenta-r134a-v-evrope,49721?wyslij=49721
14. Regulation (EU) No. 517/2014. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&from=EN
15. California approves original SNAP rules (2018). Cooling Post. Available at: https://www.coolingpost.com/world-news/california-approves-original-snap-rules/
16. Environmentally friendly and efficient propane heat pump (2018). Available at: https://phys.org/news/2018-09-environmentally-friendly-efficient-propane-burning.html
17. Opoku, R., Anane, S., Edwin, I. A., Adaramola, M. S., Seidu, R. (2016). Comparative techno-economic assessment of a converted DC refrigerator and a conventional AC refrigerator both powered by solar PV. International Journal of Refrigeration, 72, 1–11. doi: https://doi.org/10.1016/j.ijrefrig.2016.08.014
18. Infante Ferreira, C., Kim, D.-S. (2014). Techno-economic review of solar cooling technologies based on location-specific data. International Journal of Refrigeration, 39, 23–37. doi: https://doi.org/10.1016/j.ijrefrig.2013.09.033
19. Xu, Y., Li, M., Luo, X., Ma, X., Wang, Y., Li, G., Hassanien, R. H. E. (2018). Experimental investigation of solar photovoltaic operated ice thermal storage air-conditioning system. International Journal of Refrigeration, 86, 258–272. doi: https://doi.org/10.1016/j.ijrefrig.2017.11.035
20. Morozyuk, T. V. (2006). Teoriya holodil'nyh mashin i teplovyh nasosov. Odessa: Studiya «Negociant», 712.
21. Scroll Compressors. BITZER. Available at: https://www.bitzer.de/gb/en/scroll-compressors/?country=gb
22. Porshnevye kompressory. BITZER. Available at: https://www.bitzer.de/ru/ru/поршневые-компрессоры/

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GEOTHERMAL INVESTIGATION USES A DIPOLE-DIPOLE CONFIGURATION GEOELECTRIC METHODS WITH DELPHI PROGRAMMING (p. 50-56)

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The position of Indonesia which is located at the confluence of three plates (Eurasia, Indies Australia, and the Pacific) causes the formation of a series of volcanoes in some parts of the country and causes the formation of geothermal energy sources around the volcano. Geothermal energy is the energy of natural resources in the form of hot water or steam formed in a reservoir inside the earth through heating of subsurface water by igneous rocks (Team Pertamina, 2010). This geothermal energy can be used directly for drying agricultural production, tourism, and household needs or indirectly as a driver of electricity-generating turbines.

In this study focused in East Java, the author discusses geothermal potential by using geoelectric methods in the never-ending area of fire to contribute manifestation information as one of the answers to the community and government which is expected to provide an idea of how large geothermal potential is using the geoelectric method in the fire area has never been extinguished by Pamekasan Madura. the distance between the 5-meter electrode. The long-term goal of this research is to obtain petroleum fuel energy in the pamekasan area.

Geothermal research has been carried out on fire tours. This research uses the dipole-dipole configuration geoelectric method with the help of Delphi program. The results of this program are

suitable for time-efficient calculations for geoelectric data processing. This program is equipped with Wenner, Schlumberger, dipole-dipole and pole-pole configuration options so that we can choose the configuration we need. the results of this study are Line 1 stretching from North to South. The subsurface line 1 has a low resistivity of 72.3–98 Ωm. the resistivity value of this layer is a reservoir carrier with a depth of 12.8–78.8 meters below the soil surface. Line 2 stretches from east to west. The subsurface layer 2 has a low resistivity of 75.5–112 Ωm. the resistivity value of this layer is a reservoir carrier with a depth of 2.5–67.5 meters below the soil surface. Line 3 is a line that runs from east to west. The subsurface layer 3 has a low resistivity of 94.2–110 Ωm. the resistivity value of this layer is a reservoir carrier with a depth of 10.5–24.9 meters below ground level.

Keywords: Geothermal, Geoelectric, Dipole-dipole, Delphi Programming, Pamekasan Madura Indonesia.

References

1. Saini, B., Sharma, M. (2018). Thermal Energy Production From Closed Geothermal Reservoirs. International Journal of Trend in Scientific Research and Development, 2 (3), 961–965. Available at: https://www.ijtsrd.com/papers/ijtsrd11122.pdf
2. El-Kilani, R. J., Zaid, A. I. O. (2015). Geothermal energy in Palestine practical applications. 2015 Power Generation System and Renewable Energy Technologies (PGSRET). doi: https://doi.org/10.1109/pgsret.2015.7312223
3. El Haj Assad, M., Tawalbeh, M., Salameh, T., Al-Othman, A. (2018). Thermodynamic analysis of lithium bromide absorption chiller driven by geothermal energy. 2018 5th International Conference on Renewable Energy: Generation and Applications (ICREGA). doi: https://doi.org/10.1109/icrega.2018.8337607
4. Khan, K., Ahmed, M., Parvez, M. S., Hossain, M. M. (2015). Scope of geothermal potential of Bangladesh: A review. 2015 3rd International Conference on Green Energy and Technology (ICGET). doi: https://doi.org/10.1109/icget.2015.7315087
5. Bertani, R. (2012). Geothermal power generation in the world 2005–2010 update report. Geothermics, 41, 1–29. doi: https://doi.org/10.1016/j.geothermics.2011.10.001
6. Tousif, S. M. R., Taslim, S. M. B. (2011). Producing electricity from geothermal energy. 2011 10th International Conference on Environment and Electrical Engineering. doi: https://doi.org/10.1109/eeeic.2011.5874669
7. Maryanto, S. (2017). Geo Techno Park potential at Arjuno-Welirang Volcano hosted geothermal area, Batu, East Java, Indonesia (Multi geophysical approach). AIP Conference Proceedings, 1908. doi: https://doi.org/10.1063/1.5012712
8. Li, B., Li, F., Zhou, P., Hong, T., Liu, F. (2011). The geothermal resources assessment of Jinghong basin in Yunnan province. 2011 International Conference on Electrical and Control Engineering. doi: https://doi.org/10.1109/icececng.2011.6058199
9. Ichim, A., Teodoriu, C., Falcone, G. (2018). Estimation of Cement Thermal Properties through the Three-Phase Model with Application to Geothermal Wells. Energies, 11 (10), 2839. doi: https://doi.org/10.3390/en11102839
10. Rajver, D., Rman, N., Lapanje, A. (2016). The state of exploitation of geothermal energy and some interesting achievements in geothermal research and development in the world. Geologija, 59 (1), 99–114. doi: https://doi.org/10.5474/geologija.2016.007
11. Isnaniawardhani, V., Sukiyah, E., Sudradjat, A., Nanlohy, M. M. (2018). The geothermal potentials for electric development in Maluku Province. Jurnal Perspektif Pembiayaan dan Pembangunan Daerah, 5 (3), 129–140. doi: https://doi.org/10.22437/ppd.v5i3.4546
12. Yashin, A., Indrupskiy, I., Lobanova, O. (2018). Simulation of composition changes in reservoirs with large hydrocarbon columns and temperature gradient. Georesursy, 20 (4), 336–343. doi: https://doi.org/10.18599/grs.2018.4.336-343
13. Rajver, D., Lapanje, A., Rman, N. (2012). Possibilities for electricity production from geothermal energy in Slovenia in the next decade. Geologija, 55 (1), 117–140. doi: https://doi.org/10.5474/geologija.2012.009
14. Ali, M. N., Harmoko, U., Yuliyanto, G., Yulianto, T. (2018). Model of Temperature Distribution Geothermal Pesanggrahan Geothermal System, Central Java, Indonesia. International Journal of Recent Trends in Engineering and Research, 4 (11), 87–94. doi: https://doi.org/10.23883/ijrter.2018.4410.mccyh
15. Muravyev, A. (2018). Geothermal monitoring as a way to predict volcanic eruptions and estimate geothermal energy resources. Georesursy, 20 (4), 413–422. doi: https://doi.org/10.18599/grs.2018.4.413-422
16. Ji, W., Wang, J., Fang, X., Gu, S. (2012). Improvement and application of the Delphi method. Proceedings of the 10th World Congress on Intelligent Control and Automation. doi: https://doi.org/10.1109/wcica.2012.6359147
17. Mudge, J. C., Chandrasekhar, P., Heinson, G. S., Thiel, S. (2011). Evolving Inversion Methods in Geophysics with Cloud Computing – A Case Study of an eScience Collaboration. 2011 IEEE Seventh International Conference on eScience. doi: https://doi.org/10.1109/escience.2011.25
18. Muñoz, G., Ritter, O., Moeck, I. (2010). A target-oriented magnetotelluric inversion approach for characterizing the low enthalpy Groß Schönebeck geothermal reservoir. Geophysical Journal International, 183 (3), 1199–1215. doi: https://doi.org/10.1111/j.1365-246x.2010.04795.x
19. Seker, S. E. (2015). Computerized Argument Delphi Technique. IEEE Access, 3, 368–380. doi: https://doi.org/10.1109/access.2015.2424703
20. Geoelectric Monitoring : Current research and perspectives for the future (2011). Berichte Geol. B.-A, 93.
21. Chuan-tao, Y., Hong-fu, L., Xin-jun, Z. (2011). CSAMT investigations in the faulted basin geothermal field, Shanxi, China. 2011 International Symposium on Water Resource and Environmental Protection. doi: https://doi.org/10.1109/iswrep.2011.5893726
22. Mohamed, A. R. S., Susilo, A., Maryanto, S. (2013). Analysis of Zero Offset Vertical Seismic Profiling Data Processing To Evaluate the Oil and Gas Reservoir in Well 'X', Murzuk Basin, Soutwest Libya. International Refereed Journal of Engineering and Science, 2 (11), 19–29.
23. Heise, W., Caldwell, T. G., Bibby, H. M., Bannister, S. C. (2008). Three-dimensional modelling of magnetotelluric data from the Rotokawa geothermal field, Taupo Volcanic Zone, New Zealand. Geophysical Journal International, 173 (2), 740–750. doi: https://doi.org/10.1111/j.1365-246x.2008.03737.x
24. Maryanto, S., Dewi, C. N., Syahra, V., Rachmansyah, A., Foster, J., Nadhir, A., Santoso, D. R. (2017). Magnetotelluric-Geochemistry Investigations of Blawan Geothermal Field, East Java, Indonesia. Geosciences, 7 (2), 41. doi: https://doi.org/10.3390/geosciences7020041
25. Meller, C., Kontny, A., Kohl, T. (2014). Identification and characterization of hydrothermally altered zones in granite by combining synthetic clay content logs with magnetic mineralogical investigations of drilled rock cuttings. Geophysical Journal International, 199 (1), 465–479. doi: https://doi.org/10.1093/gji/ggu278

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ROLE OF SMALL ADDITION OF LIQUEFIED PETROLEUM GAS (LPG) ON LAMINAR BURNING VELOCITY OF HYDROUS ETHANOL (p. 56-62)

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Ethanol is an appropriate substitution for gasoline fuel in spark ignition engines. Ethanol has a high-octane number allowing to use it in the higher compression ratio of the engine. A better understanding of combustion characteristics of ethanol is needed before it is used widely in the spark ignition engine. One of the most important parameters of the replacement fuel is the burning velocity. Therefore, the purpose of the research is to investigate experimentally the effect of the small addition of liquefied petroleum gas (LPG) on the laminar burning velocity of hydrous ethanol. The combustion characteristic of the ethanol and LPG mixture was examined in a cylindrical combustion chamber with a diameter of 10.8 cm and a length of 17 cm. The flame had a spherically expanding shape. Fuel mixture was ignited by sparks inside the cylinder and the flame diameter was measured from the flame image captured by the high-speed camera. The research used two types of ethanol fuel such as anhydrous ethanol and hydrous ethanol containing 0.3 % of water. The percentage of LPG in the fuel mixture was varied from 0 % to 20 %. The results showed that the addition of 10 % LPG in ethanol increases laminar burning velocity. For anhydrous fuels, ethanol burning velocity is higher than for LPG and the highest burning velocity is in ethanol, to which 10 % LPG is added while the lowest is in LPG. Besides, the effect of water content in ethanol fuel causes a decrease in combustion speed significantly. But the addition of LPG up to 10 % makes hydrous ethanol relatively more robust to rising water content due to the combustion reaction is helped by a higher radical concentration in LPG. This is caused by two factors: the partial preheating zone resulted by the hydroxyl group (OH) of ethanol that supplied more heat energy and the high concentration of radicals in LPG that assists the combustion reaction.

Keywords: hydrous ethanol, liquefied petroleum gas, cylindrical chamber, laminar burning velocity.

References

1. Saxena, S., Schneider, S., Aceves, S., Dibble, R. (2012). Wet ethanol in HCCI engines with exhaust heat recovery to improve the energy balance of ethanol fuels. Applied Energy, 98, 448–457. doi: https://doi.org/10.1016/j.apenergy.2012.04.007
2. Li, G., Zhang, Z., You, F., Pan, Z., Zhang, X., Dong, J., Gao, X. (2013). A novel strategy for hydrous-ethanol utilization: Demonstration of a spark-ignition engine fueled with hydrogen-rich fuel from an onboard ethanol/steam reformer. International Journal of Hydrogen Energy, 38 (14), 5936–5948. doi: https://doi.org/10.1016/j.ijhydene.2013.03.008
3. Ramesh Kumar, C., Nagarajan, G. (2012). Performance and emission characteristics of a low heat rejection spark ignited engine fuelled with E20. Journal of Mechanical Science and Technology, 26 (4), 1241–1250. doi: https://doi.org/10.1007/s12206-012-0206-0
4. Sasongko, M. N., Wijayanti, W. (2017). Effect of ethanol addition on the performance and exhaust emissions of a spark ignition engine. Journaol f Mechanical Engineering and Sciences, 11 (2), 2734–2742. doi: https://doi.org/10.15282/jmes.11.2.2017.14.0248
5. Cracknell, R., Head, B., Remmert, S., Wu, Y., Prakash, A., Luebbers, M. (2013). Laminar burning velocity as a fuel characteristic: Impact on vehicle performance. Internal Combustion Engines: Performance, Fuel Economy and Emissions, 149–156. doi: https://doi.org/10.1533/9781782421849.4.149
6. Varea, E., Modica, V., Renou, B., Boukhalfa, A. M. (2013). Pressure effects on laminar burning velocities and Markstein lengths for Isooctane–Ethanol–Air mixtures. Proceedings of the Combustion Institute, 34 (1), 735–744. doi: https://doi.org/10.1016/j.proci.2012.06.072
7. Broustail, G., Seers, P., Halter, F., Moréac, G., Mounaim-Rousselle, C. (2011). Experimental determination of laminar burning velocity for butanol and ethanol iso-octane blends. Fuel, 90 (1), 1–6. doi: https://doi.org/10.1016/j.fuel.2010.09.021
8. Konnov, A. A., Meuwissen, R. J., de Goey, L. P. H. (2011). The temperature dependence of the laminar burning velocity of ethanol flames. Proceedings of the Combustion Institute, 33 (1), 1011–1019. doi: https://doi.org/10.1016/j.proci.2010.06.143
9. Costa, R. C., Sodré, J. R. (2010). Hydrous ethanol vs. gasoline-ethanol blend: Engine performance and emissions. Fuel, 89 (2), 287–293. doi: https://doi.org/10.1016/j.fuel.2009.06.017
10. Raja Samuel, A., Arasu Valan, A., Sornakumar, T. (2015). Effect of gasoline – ethanol blends on performance and emission characteristics of a single cylinder air cooled motor bike SI engine. Journal of Engineering Science and Technology, 10 (12), 1540–1552. Available at: http://jestec.taylors.edu.my/Vol%2010%20Issue%2012%20December%202015/Volume%20(10)%20Issue%20(12)%201540-1552.pdf
11. Breaux, B. B., Acharya, S. (2013). The effect of elevated water content on swirl-stabilized ethanol/air flames. Fuel, 105, 90–102. doi: https://doi.org/10.1016/j.fuel.2012.07.051
12. Bradley, D., Lawes, M., Liao, S., Saat, A. (2014). Laminar mass burning and entrainment velocities and flame instabilities of i-octane, ethanol and hydrous ethanol/air aerosols. Combustion and Flame, 161 (6), 1620–1632. doi: https://doi.org/10.1016/j.combustflame.2013.12.011
13. Liao, S. Y., Jiang, D. M., Huang, Z. H., Zeng, K., Cheng, Q. (2007). Determination of the laminar burning velocities for mixtures of ethanol and air at elevated temperatures. Applied Thermal Engineering, 27 (2-3), 374–380. doi: https://doi.org/10.1016/j.applthermaleng.2006.07.026
14. Suarta, I. M., Wardana, I. N. G., Hamidi, N., Wijayanti, W. (2016). The Role of Hydrogen Bonding on Laminar Burning Velocity of Hydrous and Anhydrous Ethanol Fuel with Small Addition of n-Heptane. Journal of Combustion, 2016, 1–8. doi: https://doi.org/10.1155/2016/9093428
15. Al-lwayzy Saddam, Yusaf, T. (2015). Combustion of Microalgae Oil and Ethanol Blended with Diesel Fuel. Energies, 8 (12), 13985–13995. doi: https://doi.org/10.3390/en81212409
16. Waluyo, B., Wardana, I. N. G., Yuliati, L., Sasongko, M. N. (2018). The role of molecule cluster on the azeotrope and boiling points of isooctane-ethanol blend. Fuel, 215, 178–186. doi: https://doi.org/10.1016/j.fuel.2017.10.103
17. Liao, S. Y., Jiang, D. M., Gao, J., Huang, Z. H., Cheng, Q. (2004). Measurements of Markstein numbers and laminar burning velocities for liquefied petroleum gas–air mixtures. Fuel, 83 (10), 1281–1288. doi: https://doi.org/10.1016/j.fuel.2003.12.013
18. Tian, G., Daniel, R., Li, H., Xu, H., Shuai, S., Richards, P. (2010). Laminar Burning Velocities of 2,5-Dimethylfuran Compared with Ethanol and Gasoline. Energy & Fuels, 24 (7), 3898–3905. doi: https://doi.org/10.1021/ef100452c
19. Razus, D., Oancea, D., Brinzea, V., Mitu, M., Munteanu, V. (2007). Experimental and computational study of flame propagation in propane-, n-butane- and liquefied petroleum gas-air mixtures. Third European Combustion Meeting. Chania.
20. Ebbing, D. D., Gammon, S. D. (2009). General Chemistry. New York: Houghton Mifflin, 1030.