ANALYTICAL AND EXPERIMENTAL STUDIES OF THE GRADUAL-ROTATIONAL FLOW OF FLUID IN A VORTEX HEAT GENERATOR

NIKOLSKY Valeriy[1], YARIS Vadim[1], ALIEKSANDROV Oleksandr[1], LOBODENKO Antonina[1] & VED Viktor[1]

[1]*Ukrainian State University of Chemical Technology, Dnipro, Ukraine*

Purpose. Obtain the results of the hydrodynamics of translational and rotational motion of the viscous fluid flow in the working space of a vortex heat generator of variable geometry through analytical and experimental studies and analytically set the critical speed and pressure.

Methodology. The studies were carried out by analysis of fluid cavitation methods and heating in different systems by performing analytical and experimental studies of the hydrodynamics of translational-rotational motion of a viscous fluid flow in the working space of a vortex heat generator of variable geometry to determine the required and critical velocities and pressures. According the national plan for the development of mining and power energy sectors in Ukraine and means the improving generation technologies and wastes utilization for supporting the cheap fuel and energetic issues for suitable development and decreasing the quantity of bulks in the surface.

Findings. The article presents the results of the performed analytical and experimental studies of the hydrodynamics of the translational-rotational motion of a viscous fluid flow in the working space of a vortex heat generator of variable geometry critical velocity and pressure are analytically determined.

A distinctive feature of the vortex heat generator is the use of a vortex device of a certain geometry as a fluid flow vortex. The high degree of torsion of a stream of the heat carrier provides the organization of eddy currents in a working tract of the vortex heat generator with increasing speed and decrease in pressure.

During the translational and rotational motion of the fluid through the pipe, there are two areas of motion: movement along the annular gap between the radius of the pipe and the radius of the vortex r_b, inside the annular gap. The fluid moves along the pipe with a velocity ω_x and rotates with a velocity ω_φ based on the preservation of the velocity moment.

A cylindrical cavity with radius r_b is formed on the axis of the pipe. It is filled with air because the tube is connected to the atmosphere.

The exact solution of the equation of translational-rotational motion of a fluid is a difficult-to-solve problem that can be solved with considerable simplification. The influence of the vortex generation device on the relationship of the above parameters is investigated.

In translational-rotational motion in a pipe of variable cross-section, as well as in the implementation of useful external work (for example, associated with the generation of heat based on cavitation effects), a continuous transition through the critical speed is possible. This helps to reduce the pressure, enhance the effect of

cavitation and increase the heat transfer process in the output device of the vortex heat generator, which determines the energy efficiency of its operation. In such way we improve the efficiency of the system work. It allows to insure motion process to reduce loses and to get the necessary economical effect.

The researches were conducted under authors own researches.

Key words: vortex device, fluid hydrodynamics, streamline, rotary motion, momentum, pressure, critical velocity

References

1. Nikolsky, V., Kuzyayev, I., Alieksandrov, O., Ved, V., Pugach, A., Yaris, V., Ptitsyn, S., & Lopatin, V. (2019). Analytical and experimental studies into the processes of hydrodynamics and heat exchange in the channels of disk pulse devices. Eastern-European Journal of Enterprise Technologies, 2019, 4/8 (100), 15-23. https://doi.org/10.15587/1729-4061.2019.174629

2. Nikolsky, V., Kuzyayev, I., Dychkovskyi, R., Alieksandrov, O., Yaris, V., Ptitsyn, S., Tikhaya, L., Howaniec, N., Bak, A.; Siudyga, T., Jura, B.; Cabana, E., Szymanek, A., & Smoliński, A. (2020) A Study of Heat Exchange Processes within the Channels of Disk Pulse Devices. *Energies*, 2020, *13*, 3492. https://www.mdpi.com/1996-1073/13/13/3492

3. Nikolsky, V.; Oliynyk, O.; Ved, V.; Svietkina, O.; Pugach, A.; Shvachka, A. Design and study of the energy-efficient unified apparatuses for energy-technological manufacturing. Eastern-European Journal of Enterprise Technologies, 2018, 3/8 (93), 59-65. https://doi.org/10.15587/1729-4061.2018.132572

4. Pivnyak, G,G, Dychkovskyi R.O, Falshtynskyi, V.S. and Cabana, Cáceres Edgar. (2017) Energy Efficiency and Economic Aspects of Mining Wastes Utilization within the Closed Cycle of Underground Gas Generator. Advanced Engineering Forum, (25), 1-10. https://doi.org/10.4028/www.scientific.net/AEF.25.1

5. 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. https://doi.org/10.15587/1729-4061.2017.111846

6. Falshtynskyi, V., Dychkovskyi, R., Lozynskyi, V., & Saik, P. (2015). Analytical, laboratory and bench test researches of underground coal gasification technology in National Mining University. New Developments in Mining Engineering 2015: Theoretical and Practical Solutions of Mineral Resources Mining, 97-106. https://doi.org/10.1201/b19901-19

7. Girin, O., Kuzyayev, I., Nikolsky, V., & Yaris, V. (2020). Discovering and Modelling the Wave-Like Shapes on the Surface of Metal Deposits, being Electrodeposited under the Force Impact. Novel and non-conventional materials and technologies for sustainability. Key Engineering Materials, (844), 135-145. https://doi.org/10.4028/www.scientific.net/KEM.844.135

8. Promtov, M.A., & Akulin, V.V. Mekhanizmy generirovaniya tepla v rotorno-impul'snom apparate. Vestnik TGTU, 11, 103-106.

9. Никольский, В.Е. (2015). Development and study of contact-modular heating system using immersion combustion units. Eastern-European Journal of Enterprise Technologies, 4(8(76)), 31. https://doi.org/10.15587/1729-4061.2015.47459

10. Report (1994). Development of a coal-fired combustion system for industrial process heating applications. Quarterly technical progress report, January--March 1994. https://doi.org/10.2172/10175382

11. Vukalovich M.P., & Novikov I.I. (1972). Termodinamika M.: Mashinostroyeniye, 672 p.

12. Ved, V., Nikolsky, V, Okhtina, O., & Kiselev, V. (2019). Research of gas content and interfacial area in the downflow pipes of a circulation apparatus with jet injection gas filling. Technology audit and production reserves, (4), 34-38.

13. Никольский, В.Е. (2015). Разработка и исследование отопительной контактно-модульной системы с применением аппаратов погружного горения. Восточно-Европейский журнал передовых технологий, 4 (8), 31-35.

14. Nikolsky, V., Oliynyk, O., Yaris, V., & Reshetnyak, I. (2017). Application of electromagnetic fields for intensification of heat and mass exchange in combined gas-liquid processes. Eastern-European Journal of Enterprise Technologies, 3(8 (87)), 33–39. https://doi.org/10.15587/1729-4061.2017.103868

15. Elperin, T., & Fominykh, A. (1995). Combined mass and heat transfer during nonisothermal absorption in gas-liquid slug flow. International Communications in Heat and Mass Transfer, 22(2), 285-294. https://doi.org/10.1016/0735-1933(95)00013-5

16. Karcher, C., & Kühndel, J. (2017). Convective heat transfer in engine coolers influenced by electromagnetic fields. Heat and Mass Transfer, 54(8), 2599-2605. https://doi.org/10.1007/s00231-017-2130-4

17. Dietrich, N., & Hebrard, G. (2018). Visualisation of gas-liquid mass transfer around a rising bubble in a quiescent liquid using an oxygen sensitive dye. Heat and Mass Transfer, 54(7), 2163-2171. https://doi.org/10.1007/s00231-018-2297-3

18. Alabovsky, A., Galperin, E., Salo, V., & Sulgik, N. (1992). An Application of Semi-Empirical Turbulence Theory to the Hydrodynamics and Heat Exchange in Gas-Liquid Foam. Design and Operation of Heat Exchangers, 407-419. https://doi.org/10.1007/978-3-642-84450-8_36

19. Mittermaier, M., & Ziegler, F. (2017). The impact of viscosity on the combined heat, mass and momentum transfer in laminar liquid falling films. Heat and Mass Transfer, 54(4), 1199-1215. https://doi.org/10.1007/s00231-017-2219-9

20. Kuzyaev, I. M. (2005). Intensification of Heat and Mass Transfer Processes in the Working Channel of Extrusion Machines during Processing of Newtonian Polymer Liquids. Heat Transfer Research, 36(5), 359-371. https://doi.org/10.1615/heattransres.v36.i5.30

21. Никольский, В. Е. (2015). Intensification of heat-mass exchange processes in the immersed burning apparatus by contacting phases oscillation. ScienceRise, 7(2 (12)), 38. https://doi.org/10.15587/2313-8416.2015.46987