III International Conference

CONDENSED MATTER & LOW TEMPERATURE PHYSICS

ABSTRACTS BOOK

5th - 11th June 2023

47 Nauky Ave | Kharkiv, Ukraine

B. Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine

III International Advanced Study Conference
Condensed Matter and Low Temperature Physics

CM&LTP 2023

5 - 11 June 2023 | Kharkiv, Ukraine

BOOK OF ABSTRACTS

Kharkiv 2023

Research on entropy generation in complex flow structures in the artificial network of the circulatory system

L.V. Batyuk[1], N.N. Kizilova[2]

[1]Kharkiv National Medical University, 4 Nauky Ave., Kharkiv, 61022, Ukraine
e-mail: lili.batyuk@gmail.com
[2]V.N. Karazin Kharkiv National University, 61022, Kharkiv, Svobody sq., 4,
e-mail: n.kizilova@gmail.com

The paper investigates the degree of irreversibility or thermodynamic non-ideality in a tree-shaped network of an artificially simulated circulatory system with a constant heat flow of the wall. The tree-like network of the circulatory system is a dichotomous and homothetic structure. For simulations, we use entropy generation as a means of quantifying the work lost due to irreversibility in tree-like flow networks on blood vessels [1]. Based on this thermodynamic approach, we compare the transport of power-law and Newtonian fluids in networks of an artificial circulatory system designed according to the Hess-Murray law, and we also investigate the characteristics of circulatory systems with variable wall permeability and the effect of blocked vessels at different levels of bifurcation. The found equations relate the shear stress in the liquid, the rate of shear deformation, with the concentration of microcells, the index of the consistency of the liquid, and the index of the behavior of microparticles in the liquid [2]. The work examines variations in the homothetic ratio of the length and diameters of the separation of the network of blood vessels, as well as variations in the permeability of the walls of the structure, the existence of blocked structures in the network, fluid characteristics, and the effect of friction and heat on entropy generation. Analytical expressions for the amount of entropy generation are obtained in terms of heat transfer rates, Reynolds number, tube wall properties, and the location and number of blocked structures. The influence of parameters such as fluid behavior index, Nusselt number, homothety coefficients for length and diameters, as well as the permeability of artificial network walls is evaluated [3]. From the results obtained in the study, the following conclusions were drawn, namely, the ratio of entropy created on two successive structures (parent and daughter) does not depend on the characteristics of the liquid, if the bifurcation is designed for maximum access to the heat flow; the entropy ratio can be equal to unity or be higher than unity if only the wall of daughter structures is permeable; entropy generation in tree networks varies from maximum to minimum. In the flow network of an artificially simulated circulatory system, entropy generation decreases with increasing Nusselt number; higher Reynolds numbers cause entropy generation to increase with fluid behavior index, but lower Reynolds numbers cause the opposite effect on the thermal dependence of entropy change.

[1] A. F. Miguel, International Journal of Heat and Mass Transfer. 92, 349-359 (2016).
[2] L. Batyuk, N. Kizilova, Journal Bulletin of the Taras Shevchenko National University of Kyiv. Series: Physical and Mathematical Sciences. 2, 37–41 (2022) [Visnik Kiïvs'kogo Nacional'nogo Universitetu imeni Tarasa Shevchenka. Seriya: Fiziko-Matematichni Nauki. 2, 37-41 (2022)].
[3] A. Khalin, L. Batyuk, N. Kizilova, Biomechanics in Medicine, Sport and Biology. A. Hadamus, S. Piszczatowsk, M. Syczewska, M. Blazkiewicz (Eds). Springer Ser. Lecture Notes in Networks and Systems. 328, 1-16 (2022).