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Thermodynamics Frontier Award 2024

The Thermodynamics Frontier Award (TheFA) is a yearly distinction for the best paper published in Archives of Thermodynamics (AoT) in the preceding calendar year, recognising work that pushes the frontiers of thermodynamics. The assessment criteria are originality, scientific significance, methodological quality, and impact on the field. As a rule, the AoT Editors nominate 8–10 papers, and the Award Donor, in cooperation with the Programme Council (advisory vote), selects the winner. In the 2024 edition, 12 papers were nominated:

1. Singh, J., & Lanjewar, A. (2024). Experimental investigation and performance prediction of SAH using different arc rib roughness geometries – A comparative study. *Archives of Thermodynamics*, 45(1), 33–44. doi: 10.24425/ather.2024.150436
2. Wajs, J., & Lukasik, J. (2024). Assessment of the impact of jet impingement technique on the energy efficiency of air-cooled BIPV/T roof tile. *Archives of Thermodynamics*, 45(2), 5–18. doi: 10.24425/ather.2024.150847
3. Sikora, M., Bohdal, T., Witczak, S., & Ligus, G. (2024). Flow maps in multiphase flows. *Archives of Thermodynamics*, 45(2), 19–28. doi: 10.24425/ather.2024.150848
4. Gurgul, S., & Fornalik-Wajs, E. (2024). Understanding of RANS-modelled impinging jet heat transfer through turbulence kinetic energy, momentum and energy budgets. *Archives of Thermodynamics*, 45(3), 13–30. doi: 10.24425/ather.2024.150451
5. Kaniowski, R.M. (2024). Pool boiling for water on surfaces with inclined microchannel. *Archives of Thermodynamics*, 45(2), 41–49. doi: 10.24425/ather.2024.150850
6. Rafałko, G., Mosdorf, R., Grzybowski, H., Dzienis, P., & Górski, G. (2024). Multiscale entropy applications for complexity analysis of two-phase flow. *Archives of Thermodynamics*, 45(2), 83−90. doi: 10.24425/ather.2024.150854
7. Bobrowski, J., & Gutkowski, A. (2024). Influence of wall temperature on condensation rate in duct flow of humid air: a comprehensive computational study. *Archives of Thermodynamics*, 45(3), 127–133. doi: 10.24425/ather.2024.151229
8. Sutjahja, I.M., Yusuf, A., Anggraini, Y., Ulhaq, S.D., Kurnia, D., & Wonorahardjo, S. (2024). Asymmetrical melting and solidification processes of phase change material and the challenges for thermal energy storage systems. *Archives of Thermodynamics*, 45(3), 135–147. doi: 10.24425/ather.2024.151224
9. Wang, Y., Ma, Z., Gu, Y., & Guo, Q. (2017). Multi-optimization of thermodynamic performance of an HT-PEM fuel cell based on MOPSO algorithm. *Archives of Thermodynamics*, 45(3), 197–208. doi: 10.24425/ather.2024.151231
10. Mamache, S., Mendil, F., & Bouda, F.N. (2024). Thermal instability of three-dimensional boundary layer stagnation point flow towards a rotating disc. *Archives of Thermodynamics*, 45(4), 61–72. doi: 10.24425/ather.2024.151997
11. Kuś, T., & Madejski, P. (2024). Numerical investigation of thermal-flow processes in the ejector-condenser for selected geometrical parameters. *Archives of Thermodynamics*, 45(4), 73–83. doi: 10.24425/ather.2024.151998
12. Kalina, J. (2024). Sizing large-scale industrial heat pump for heat recovery from treated municipal sewage in coal-fired district heating system. *Archives of Thermodynamics*, 45(4), 107–124. doi: 10.24425/ather.2024.152001

On 24 June 2025, a meeting of the Programme Council of AoT was held to select the laureate of TheFA for the year 2024. The meeting was attended by:

- Prof. Janusz Badur (Donor of TheFA 2024),
- Prof. Tadeusz Chmielniak,
- Prof. Piotr Furmański,
- Prof. Dariusz Kardaś (Chairman of the Council),
- Prof. Robert Kobyłecki.

Council members presented their views on 12 articles nominated by AoT Editors. The discussion covered both the scientific merit of each paper and their links to fundamental issues in thermodynamics. Finally, the Donor of the Award 2024, a renowned thermodynamicist – Professor Janusz Badur, presented his assessment of the most noteworthy articles. From among the nominated works, he decided to bestow his award on the paper:

> **Gurgul, S., & Fornalik-Wajs, E.** (2024). Understanding of RANS-modelled impinging jet heat transfer through turbulence kinetic energy, momentum and energy budgets. *Archives of Thermodynamics*, 45(3), 13–30. doi: 10.24425/ather.2024.150451

The Donor underlined that the awarded paper is deeply rooted in classical thermodynamics and that its subject—modelling turbulent heat transfer—rests on analysing temperature and velocity fluctuations. The work offers an alternative, novel approach to heat transfer in impinging-jet flows, and the selected application example helped to highlight key features of turbulent phenomena.

Short scientific biography of the Donor of TheFA 2024 – Professor Janusz Badur

Professor Janusz Badur (born 1952 in Iława, Warmia and Mazury Voivodeship, Poland) is a thermodynamicist who has been specialising for years in numerical modelling of combustion and phase transitions in the flow of working fluids through technical devices such as reactors, combustion chambers or turbines. Professionally, he is associated with the Institute of Fluid-Flow Machinery of the Polish Academy of Sciences in Gdańsk. He was also associated with such excellent technical universities as: Ruhr-Universität Bochum (1980–1993), Université de Poitiers (1994), Cape Town University (1996), Manchester University (1995), Technical University of Gdańsk (1996–2000, 2009–2015), Technical University of Koszalin (1999–2015), University of Warmia and Mazury (1998–2002), Kazimierz Wielki University of Bydgoszcz (2016–2022).

Prof. Badur's deepest professional interest and practical skills stem from his long and technically-oriented education – he learned the trade of a bricklayer at a vocational school in Prabuty (1965–1968) and the trade of a technician in Olsztyn (1968–1971).

He studied at Gdańsk Technical University (1971–1974) and Cracow Technical University (1974–1976). He worked part-time at numerous companies and offices, his longest stint being at the Gdańsk Industrial Construction Design Office (1976–1978).

His scientific ties lie primarily with the Institute of Fluid-Flow Machinery PAS, where he earned his doctorate in 1985 and habilitation in 1993. In 1993, as part of the Institute's transformation, Professor Zbigniew Bilicki entrusted him with the challenging task of building a department dedicated to modern methods of computational mechanics (CFD, CSD, FSI).

Thanks to the focused attention and talent of his staff and doctoral students, the Energy Conversion Department has developed computational programs based on mathematical models combining thermodynamics, fluid flow and solid deformation. These tools are continually developed and supplemented with elements resulting from practical needs.

In 1993–2013, the research team of the Energy Conversion Department, led by Professor Badur, participated in Alstom Power's large-scale program to modernise the Polish energy sector, which aimed at emission-free, highly efficient and cheap electric energy production. This was a major modernisation program for Polish power plants, which posed numerous challenges and scientific problems. Among them were the problems of numerical simulation of real, full-scale and unrecognised phenomena occurring in turbines and reactors. Many of these problems became the subjects of 54 doctoral theses supervised by Professor Badur.

Between 2013 and 2025, the research efforts of Professor Badur and his Energy Conversion Department focused on direct collaboration with the largest domestic power plants. A series of projects were carried out for power plants in: Bełchatów, Ostrołęka, Opole, Turów and Gorzów Wielkopolski. These projects yielded tangible financial benefits and improved the country's energy security.

Recently, Prof. Badur's main scientific specialisation, presented in over 90 publications, is the development of computational tools for the science called: fluid-solid interactions (FSI), where new models of boundary conditions for fluid-solid contact are necessary, since the basic phenomena are concentrated there.

In particular, the FSI formalism requires that many phenomena that either originate at the surface or are induced by the interface between two bodies, be reformulated or expressed completely differently. This applies especially to the surface boiling, cavitation, spontaneous condensation, catalytic combustion, wall turbulence, surface cracking, scaling, wear and friction, surface plasticity, and surface heat and mass transport. Due to this large accumulation of surface phenomena, numerical FSI methods must be of the "preserving structure" type, which is another major challenge in computational thermodynamics. Therefore, Professor Badur is developing the mathematical foundations of FSI within an approach called: "post-Hamiltonian thermodynamics."

Prof. Badur is also the author of a number of scientific monographs, among which the most famous is the 1160-pages work "The Evolution of the Concept of Energy" (2009). He revaluated and modernised the Carnot theory of heat exchange and the laws of thermodynamics established by Lazar Carnot and Sadi Carnot. In his monograph "Eternal Energy Conversion" (2017), he revaluated Aristotle's thermodynamics and examined its four renaissances. He showed that Aristotle's concept of teleology and his principle of least action could be a competing paradigm of thought compared to that of Clausius.

Similarly, in his monograph "Eternal Symmetry of Noether" (2019), drawing on historical research, he demonstrated the superiority of thermodynamic principles over the symmetries of gauge field theory.

Also, having a thermodynamic point of view on the problems of interaction of matter and fields, in the monograph "Eternal Relativity of Whitehead" (2022) he showed that excessive geometrisation of physics leads to models that violate the first law of thermodynamics, while algebraisation of physics, on the contrary, allows the elevation of the first and second laws of thermodynamics to the role of superior laws.

Janusz Badur, like Socrates, loves to talk and debate with young scientists. This is because he was fortunate enough to meet sages such as Anna Stefaniak, Janusz Chojnacki, Andrzej Walicki, Zbigniew Bilicki, Stanisław Sieniutycz, and others. From these science-minded individuals, he received much kindness and financial support. Therefore, the Thermodynamics Frontier Award (TheFA) is the best possible continuation of this approach.

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