Taking into account the vorticity effect in the calculation of the specific heat flow in the laminar boundary layer on hemisphere impermeable surface in a supersonic air flow

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The analysis of the vorticity effect influence on the specific heat flux in the laminar boundary layer on an impermeable wall at the surface of the hemisphere in a supersonic air flow has been performed. Engineering method is proposed to account for the vorticity effect by correcting the specific heat flux.

REFERENCES

[1] Pugach M.A., Gorskiy V.V. *Inzhenerniy zhurnal: nauka i innovatsii – Engineering Journal: Science and Innovations,* 2013, iss. 7. Available at: http: //engjournal.ru/catalog/mathmode/aero/838.html

[2] Lunev V.V. *Mekhanika zhidkosti i gaza – Fluid Mechanics,* 1967, no. 1, pp. 127.

[3] Predvoditelev A.S., Stupochenko E.V., Pleshanov A.S. *Tablitsy termodinamicheskikh funktsiy vozdukha (dlya temperature ot 200 do 6000 K i davleniya ot 0,00001 do 100 atm.)* [Tables of Air Thermodynamic Functions (for Temperatures between 200 and 6000 K and Pressures from 0.00001 to 100 atm.). Moscow, Vychislitelnyi Tsentr AN SSSR Publ., 1962, 268 p.

[4] Hirschfelder J.O., Curtiss Ch.F., Bird R.B. *Molecular Theory of Gases and Liquids*. John Wiley & Sons, Inc., New York Chapman And Hall, Ltd., London 1954.

[5] Gorskiy V.V., Fedorov S.N. *Inzhenerno-Fizicheskii Zhurnal – Journal of Engineering Thermophysics*, 2007, vol. 80, no. 5, pp. 97–101.

[6] Sokolova I.A. Koeffitsienty perenosa i integraly stolknoveniy vozdukha i ego component [Transfer coefficients and collision integrals of air and its components]. In: *Fizicheskaya kinetika. Aerofizicheckie issledovaniya* [Physical kinetics. Aerophysical Research]. Novosibirsk, Proceedings of the Institute of Theoretical and Applied Mechanics SO AS USSR, no. 4, 1974, pp. 39–104.

[7] Capitelli M., Colonna G., Gorse C., D'Angola A. Transport properties of high temperature air in local thermodynamic equilibrium. *The European Physical Journal*, 2000, no. 11, pp. 279.

[8] Gorskiy V.V. *Zhurnal vychislitelnoy matematiki i vychislitelnoy fiziki RAN – Journal of Computational Mathematics and Computational Physics RAS*, 2007, vol. 47, no. 6, pp. 939–943.

[9] Gorskiy V.V., Sysenko V.A. *Zhurnal vychislitelnoy matematiki i matematicheskoi fiziki RAN – Journal of Computational Mathematics and Mathematical Physics RAS*, 2009, vol. 49, no. 7, pp. 1319.

[10] Gorskiy V.V., Zabarko D.A., Olenicheva A.A. *Teplofizika vysokikh temperatur RAN - High Temperature RAS*, 2012, vol. 50, no. 2, pp. 1.

[11] Samarskiy A.A. *Vvedenie v teoriyu raznostnykh skhem* [Introduction to the Theory of Difference Schemes].Moscow, Nauka Publ., 1971, 552 p.

[12] Paskonov V.M. Standartnaya programma dlya resheniya zadach pogranichnogo sloya. [The Standard Program for Solving the Boundary Layer Equations]. In: *Chislennye metody v gazovoy dinamike* [Numerical Techniques in Gas Dynamics]. Moscow, MGU Publ., 1963, iss. 1, pp. 110.

[13] Linnik Yu.V. *Metod naimenshikh kvadrdtov* [Least Square Method]. Moscow, Energiya Publ., 1976, 333 p.

[14] Aoki M. *Vvedenie v metody optimizatsii. Osnovy i prilozheniya nelineynogo programmirovaniya* [Introduction to Optimization Techniques. Fundamentals and Applications of Nonlinear Programming]. Moscow, Nauka Publ., 1977. [in Russian].

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