DEVELOPMENT OF THE DATABASE OF THERMODYNAMIC FUNCTIONS OF AIR IN A WIDE RANGE OF TEMPERATURES AND PRESSURES FOR SOFTWARE PACKAGES OF HYPERSONIC FLOW SIMULATION

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Increasing requirements for the accuracy and quality of aerodynamic calculations lead to an increase in the number of cells in the grid, which, despite the continuous growing performance of processors, forces researchers to look for ways to reduce the number of arithmetic operations per element of the grid. With reference to the problem of modeling the thermodynamic properties of air, the above arguments suggest the use of approximation of table-given thermodynamic and thermophysical data by bicubic splines $S(p,t) = \sum_{k=0}^{3} \sum_{l=0}^{3} a_{k,l} p^k t^l$. In this case, the total volume of the coefficients of the bi-cubic spline approximating the given table is equal to the size of the table multiplied by 16, which, in principle, allows to keep in the operating memory of the processor spline coefficients constructed from large tables. The above approach is applied to modeling the following thermodynamic and thermophysical values of air as functions of pressure and temperature: density, enthalpy, entropy, specific heat at constant pressure, sound velocity, dynamic viscosity and thermal conductivity. As a starting material for modeling these values at temperatures from 200 to 12000 degrees Kelvin and pressures from 0.001 to 300 atmospheres tables from the books [1] and [2] were chosen.

On the basis of the obtained realization of thermodynamic and thermophysical quantities, a "user-defined real gas model" was created in programming language "C" for the ANSYS FLUENT 18.2 package, which was then validated on the problems of flow around a blunt body with a hypersonic flow of air, taking into account the available experimental data.

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1. Predvoditelev A.S. and others. Tablitsy termodinamicheskikh funktsiy vozdukha [Tables of thermodynamic functions of air]. Moscow, USSR Academy of Sciences Publ., 1957, 1962.
2. Vargaftik N.B. Spravochnik po teplofizicheskim svoistvam gazov i zhidkostey [Handbook of thermophysical properties of gases and liquids]. Moscow, "Science" Publ, 1972