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# APPLICATION OF ANSYS TO SOLVE THE PROBLEM OF INDUSTRIAL HEAT ENGINEERING

*Abstract. With ANSYS actual problem of industrial heat engineering are solved: the combined problem of hydrodynamics and heat exchange in the flow around the NACA 23012 profile by in compressible subsonic turbulent flow when heating / cooling its surface.*
*Key words: software package, thermal calculation, temperature, non isothermal flow around the profile.*

**Introduction**. To determine the temperature and heat flux fields in the practically necessary problems of industrial heat engineering, a differential energy equation is solved, to which unambiguous conditions are added. If the studied process is simple, that is can be described by a linear equation, then the problem is solved by analytical methods. But in most practically necessary cases the studied processes are nonlinear, and it is necessary to apply numerical methods. The task is increasingly complicated if the studied processes involve the combined action of several factors, such as non-isothermal motion of a liquid or gas. In this case, a system of nonlinear differential equations of motion has to be added to the energy equation, which is very difficult to solve. The use of automated software package, such as ANSYS, can greatly facilitate such tasks by reducing time and costs.

**Analysis of recent research and publications.** Application of the ANSYS to solve the two-dimensional problem of inverse thermal conductivity presented in [10]. The authors emphasize that heat flow measurement is important in a number of industrial applications. Direct measurement heat flow is not an easy task, and sometimes even impossible; at the same time temperature measurement is much simpler and more viable in different areas of application. Estimation of heat flux using temperature measurement data requires solving the problems of reverse thermal conductivity with several unknown. The proposed solution is based on minimizing the sum of squares of errors between the calculated temperatures and the measured values relative to unknown heat fluxes in combination with Tikhonov regularization




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to overcome the incorrectness of the problem and achieve a stable calculation, is used to demonstration of the efficiency of the algorithm used in comparison with two numerical experiments developed using ANSYS.

The authors of [6-7] use the hydrodynamic module FLUENT of the ANSYS to solve a complex connected problem of hydrodynamics and heat exchange using alternative solar energy. In [7] a numerical study of the solar system of chimneys is presented – a new method of production electricity. In this case, solar radiation is used to increase the temperature and buoyancy of the air flowing through the system, in order to accelerating the speed of its flow. By converting thermal energy into kinetic energy of air movement, solar chimneys have a number of different applications, such as ventilation, passive solar heating and cooling of buildings, drying of solar energy and electricity production; they are often used as a system conversion of energy from solar to mechanical by means of the turbine established on a way of an air current which converts kinetic energy of an air stream into electricity. Numerical analysis is performed on a three-dimensional model of air flow, and control equations are given using the "k-epsilon" model turbulence. To verify the results obtained in [6], the problem of a solar chimney-pipe using the k-s model of turbulence in two-dimensional wording. The distribution of solar tube wall temperature profiles, velocity and air temperature fields is given.

The study [8] is devoted to determining the parameters of fluid flow taking into account heat transfer in a spiral microchannel, the design of which using numerical functions were obtained using Computational Fluid Dynamics (CFD) software ANSYS 14. Also for analysis and verification Minitab 17 software was also used, the comparison with the results of the calculation of which showed a good match for the values minimum pressure drop and intrinsic resistance of the spiral microchannel.

The problem of contamination of heat exchangers during heat utilization of industrial waste is considered in [13]: a numerical study of deposition processes and removal of ash in tubular beam heat exchangers for heat recovery of industrial waste using a comprehensive model of pollution, integrated with CFD structure and dynamic calculation grid in ANSYS FLUENT.

A comparison of analytical, experimental and numerical studies of different thermal systems in the field of mechanical engineering is given in [12]. Processes are investigated heat transfer, convection and radiative heat transfer in one-, two- and three-dimensional stationary and non-stationary systems by comparing analytical and experimental solutions with numerical ones using parametric analysis of finite elements of the ANSYS package.

In [5] a comparison of the results of numerical and experimental methods on the problem of local induction heating for steels hot stamping is carried out. Electromagnetic-temperature communication simulations were performed using ANSYS software. Simulation results were tested during experiments and showed a satisfactory match.

Thus, a review of recent studies shows that the use of automated software allows much more detail and it is less expensive to study the field of the required values for the process under consideration.

**The purpose of the study:** to verify and prove the feasibility of using software package ANSYS to solve practically necessary problem industrial heat engineering by comparing the obtained numerical results with the known data of other authors and by other methods.

**Presentation of the main material of the study.** At the first stage of research the procedure of verification of the ANSYS software package (FLUENT module), when solving the problem of finding the optimal mode of heating / cooling of the surfaces of the profile NACA-23012 on criteria of minimum aerodynamic drag and maximum lift when flowing it subsonic incompressible turbulent flow using a test problem of the same class on free convection in square cover was carried out.

The second stage of research is devoted to the verification of the ELCUT software package in solving the problem of determining the thermal field of induction heater with two-layer inwall for four pairs of inwall materials.

**Application of the ANSYS to solve the problem of optimizing the heating of the surface of the NACA-23012 profile during around its subsonic incompressible turbulent flow.**

In Fig. 1 the results of testing the algorithm on the known problem of free convection in a square cavity are given. The first column (Fig. 1, a, c, e) contains isotherms according to the obtained calculated values of the ANSYS, the second column (Fig. 1, b, d, f) – the results of [1]. Verification was carried out according to three values of the Grashof number: Gr = $10^3$ (Fig. 1, a, b), Gr = $10^4$ (Fig. 1, c, d), Gr = $10^5$ (Fig. 1, e, f).

Based on the satisfactory results of verification of the applied ANSYS algorithm, the problem of flow around aerodynamic profile NACA-23012 viscous incompressible fluid for Reynolds numbers belonging to the range from $10^4$ to $10^7$ for two formulations: in isothermal setting, as well as in the presence of heating / cooling of



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the profile surface is considered. The initial system of equations and boundary conditions of the problem of profile flow cited in [11].

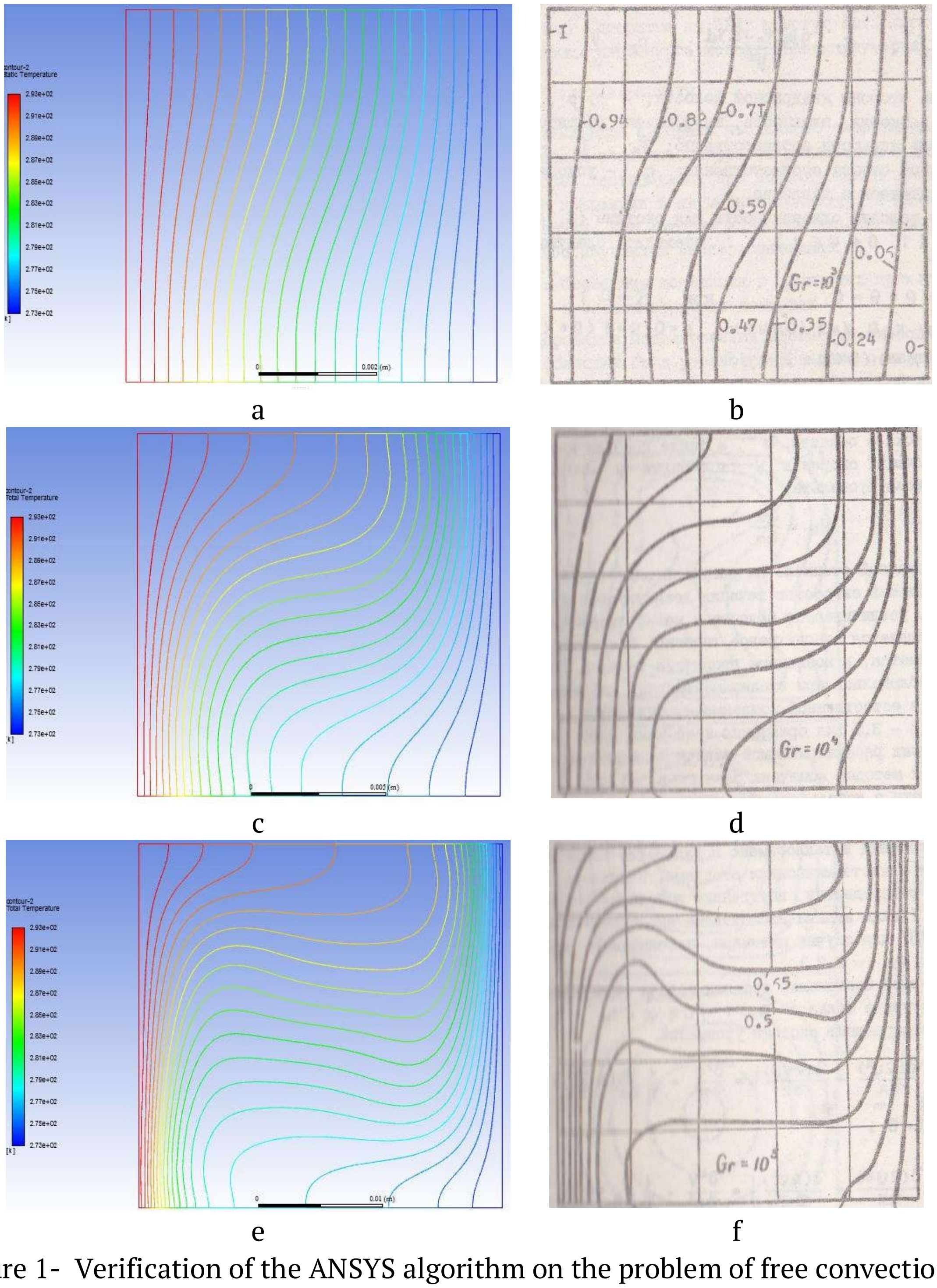


Figure 1- Verification of the ANSYS algorithm on the problem of free convection in a square cavity: a, b – Gr = $10^3$; c, d – Gr = $10^4$; e, f – Gr = $10^5$

To verify the applied algorithm, the value of the lift coefficient in the isothermal formulation [11] was compared with the corresponding the results of [9] at Re = $4.4{\cdot}10^5$.

The difference did not exceed 3.6%, which allows us to say about the adequacy of the algorithm used, in particular, and ANSYS, in general.

The influence on the lift and drag of the profile from the temperature difference of the upper and lower surfaces: it values were chosen equal to 30, 60 and 100 degrees.

Thus, the optimal aerodynamic characteristics (minimum drag and maximum lift) when flowing around the profile NACA-23012 viscous incompressible subsonic turbulent flow are realized by heating the lower surface of the profile and cooling the upper surface at maximum from the investigated temperature difference ΔT = 100 K; these results completely coincide with the theoretical conclusions of [4]. Flow pattern and pressure distribution over the surface of the profile in this case is illustrated in Fig. 2-3 and Fig. 4-5 respectively.

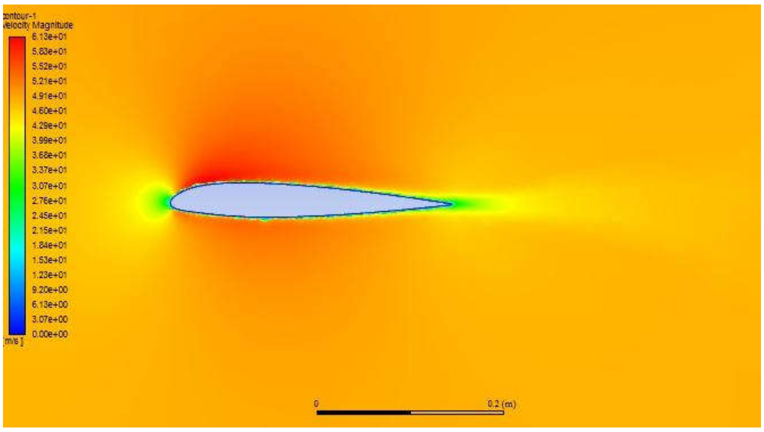


Figure 2 Velocity field for the profile flow problem with heating at ΔT = 100 K

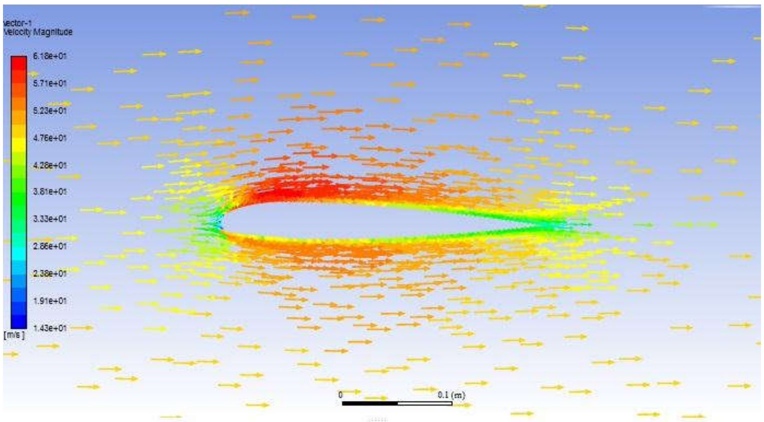


Figure 3. Vector speed diagram for the profile flow problem with heating at ΔT = 100 K


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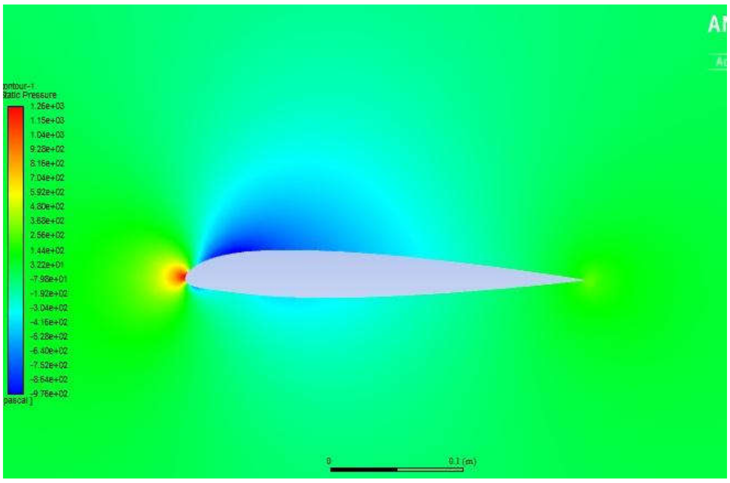

Figure 4. The pressure field for the profile flow problem with heating at ΔT = 100 K

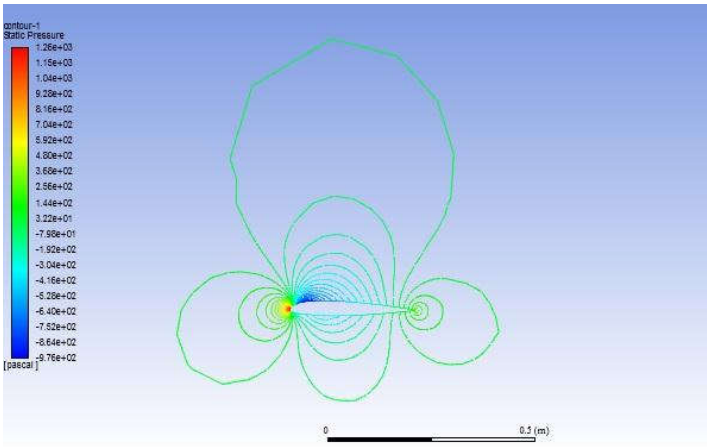

Figure 5 - Isobars for the profile flow problem with heating at ΔT = 100 K

The presented results were tested at the XXI, XXII International Conferences "Man and Space" [2-3].

**Conclusions**. In the course of performance of the set task the following types of works were carried out and conclusions were received:

1) the algorithm for calculating the fields of velocities and temperatures in the combined problem of hydrodynamics and heat transfer during flow non-isothermal viscous incompressible turbulent flow profile NACA-23012 taking into account the heating / cooling of its surfaces was created;

2) testing of the created algorithm is carried out:

– on the problem of free convection in a square cavity for three values of the Grashof number $Gr = 10^3, 10^4, 10^5$ in order to compare with the results of [1];

– on the isothermal problem of flow around the profile NACA-23012 in order to compare with the results of [9];

– on the non-isothermal problem of flow around the profile NACA-23012 in order to compare with the theoretical conclusions of [4];

3) the velocity and temperature fields in the combined problem of hydrodynamics and heat transfer during the flow of non-isothermal incompressible viscous turbulent flow profile NACA-23012 in order to find the optimal mode of heating / cooling of its surfaces according to the criteria of minimum aerodynamic drag and maximum lift using the ANSYS Workbench software package are calculated;

4) built:

– for the problem of free convection in the cavity – isotherms at $Gr = 10^3, 10^4, 10^5$;

– for the problem of profile flow – velocity, pressure and temperature fields, vector velocity diagrams, as well as pictures of isochors, isobars and isotherms at $Re = 10^4 \div 10^7$, $\Delta T = 30, 60, 100^0C$;

As a result of the conducted researches the maximum difference between the numerical solutions received at use of ANSYS software complex, and similar data of other works, did not exceed 3.6%. Thus, the expediency of using ANSYS to solve actually and practically necessary problem of industrial heat engineering.

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***Застосування програмного комплексу ANSYS до розв'язання задачі промислової теплотехніки***

*Розглядається розв'язок задачі промислової теплотехніки за допомогою програмного комплексу ANSYS. Сполучена задача гідродинаміки та теплообміну – про дозвукове турбулентне обтікання профілю NACA 23012 нестисливою в'язкою рідиною – розв'язана за допомогою пакету ANSYS Workbench. Для задачі проведена верифікація отриманих результатів шляхом порівняння їх з відомими даними аналогічних задач інших авторів або за іншими методиками.*

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