COMPUTATIONAL FLUID DYNAMICS: SUPERCOMPUTERS, PROGRAM TOOLS, YOUNG SCIENTISTS

Redchyts D.[1], Polevoy O.[1], Tarasov S.[1], Moiseienko S.[2],
Tuchyna U.[1], Chashyna I.[1], Tuchyna M.[3]

[1]*Institute of Transport Systems and Technologies of NASU (Ukraine)*

[2]*Kherson National Technical University (Ukraine)*

[3]*Institute of international relations Taras Shevchenko National University of Kyiv (Ukraine)*

To date computational fluid dynamics (CFD) is one of the components of the design process in aerospace industry, propulsion engineering, wind energy, due to the lower cost of numerical investigations are compared with the natural experiments. Major aim of CFD is reproduction real physical processes with the maximum degree of certainty. Due to this is possible better understanding the processes, make recommendations for aerodynamic shapes of designed device near to optimal. These calculations allow for detailed characteristics of the device well before its manufacture and deployment, significantly reducing the cost of expensive blowing in the wind tunnels, which are present in the standard design methods. Another problem are environmental problems - simulation of atmospheric phenomena, river hydrodynamics, distribution of pollution in urban and industrial areas.

Supercomputers to solve the CFD problems are installed and operated in the United States, Western Europe, Japan, China. Necessity to use such a powerful computer technology is caused to the fact that the vast majority flows occurring in practice are non-stationary, three-dimensional, turbulent. The practical application of computational fluid dynamics, for example, the choice of the optimal configuration of the device requires many parametric studies under realistic deadlines calculation unit (no more than 1-2 days). Today in Ukraine there are no supercomputers entering the TOP-500, the best Russian supercomputer ranked number 31 on the list.

Modern software packages aimed at solving problems in computational aerodynamics, can be divided into four groups.

The first group includes scientific software packages developed in major research centers in the U.S. and Western Europe (NASA, ONERA, DLR, NLR), as well as in corporations Boeing, Lockheed, etc. The tools have evolved over several decades and are designed primarily for applications aerospace industry. They involve the use of massively parallel supercomputers to get the results in real time. Unfortunately, these packages are the intellectual property of the developer and are usually available for a wide range of researchers.

The second group includes commercial CFD software such as ANSYS, STAR-CD, CFX, FLUENT, FLOW-3D, ACE-U, CFD++, etc. The objective purpose of commercial CFD software is to help designers associated with the tasks of computational fluid dynamics, but do not have real opportunities to develop their own CFD packages. From the point of view of the hardware used, the commercial packages are designed for use on personal computers or PC clusters. This, in turn, leads to decreased physical reliability of the results in favor of automating calculations and versatility of commercial packages.

The third group consists of CFD programs developed at universities and small research centers in almost all developed countries. Groups of employees are usually small (4-10 scientists, graduate students, programmers), computer equipment varied, depending on the level of funding an individual organization. It is here that there are new CFD ideas, new models of turbulence. Although these packages are inferior to the first and second group of the universality, research packets can compete successfully in dealing with individual, highly specialized tasks of computational fluid dynamics.

The fourth group includes software developed by the principle of "one researcher - one package." At present, this principle is extremely important for the development of young professionals and scientists. With self-development researcher develops computational aerodynamics basis, reveals the possibility of numerical methods and analyzes the physical features of these flows.

Creating a reliable CFD package requires the use of skilled programmers who own multiple programming languages. In Russia and Ukraine, there is a serious problem because the programmer in IT-profit organization earns several times more than the young scientist, even if he is PhD.

The authors of this paper have extensive experience in the development and application of computational fluid dynamics for wind power, high-speed ground transport, supersonic aircraft, turbine, control of flow separation using plasma actuators, heat and mass transfer in internal and external flows. Unfortunately, the actual calculations are limited to two-dimensional (plane and axisymmetric) flows, as well as several variants of three-dimensional flows. Power of personal computers or small clusters do not allow research flow around bodies of complex configuration (complete configuration of aircraft, ground transport), to apply modern methods of simulation turbulence (large scale turbulence, direct numerical simulation).

The authors have developed a specialized CFD package in which a compromise between the required computational resources and the quality of the results. On the one hand, provide a complete approach of computational fluid dynamics based on the Navier-Stokes equations, including several differential turbulence models, as well as multi-block approach for the flows in multiply connected domains. Designed CFD package allows us to solve the problem of dynamics and aerodynamics, including electrodynamics processes, electrochemistry, multiphase fluids, combustion processes and plasma kinetics. The results allowed us to formulate new technical ideas, get new understanding about the physics of flow separation and the ways of its control, to reproduce the real structure of the flow over a wide speed range from incompressible flow to supersonic.

CFD software developed by the authors is actually computing core software without the interactive shell. According to the above-proposed classification this package is relate to the fourth group. Establishment in Ukraine teams of young scientists associated with a number of objective difficulties.

Higher education institutions (universities) usually learned training of highly qualified CFD specialists. Analysis of the curricula of foreign universities shows that CFD is usually taught 2 years (3rd and 4th year). On graduation courses (MA) is individual training young professionals and scientists, often associated with the new solution of scientific problems. In Ukraine, experts in computational fluid dynamics do not get ready at all, and training on the mechanics of liquids and gases is the old fashioned way: on the basis of analytical and semi-empirical approaches, the basics of numerical methods are given in the framework of the model equations of

mathematical physics. As a result, Master Thesis's foreign graduates often exceed the level of candidate dissertation in the Ukraine.

After the collapse of the Soviet Union in 1991, the relationship between fundamental science and industry do not actually exist. The general crisis of the 90s led to the fact that the traditional consumers of high-end technologies (aerospace, engine building, shipbuilding) are forced to deal with short-term survival at the expense of the development of promising directions. Suffered as a science and education, and, objectively speaking, at the moment, scientists cannot fully provide for the needs of industry. A vicious cycle of "no orders from the industry - poor development of science," and vice versa, "obsolete technology - a weak competitiveness in foreign markets."

To date the level of funding for research and education leaves much to be desired. Young scientists and experts are still keen to go abroad or get a commercial structure in search of a normal material standard of living. The accelerated growth of science and education is essential to the development of new technologies, and concepts, training of young scientists.

Obviously, the disparate efforts cannot get out of the current crisis. Activity of coordination industries, Academy of Sciences, Ministry of Education is required at the highest level. The objective of the efforts, the appropriate level of organization and adequate funding are integral components.

A possible way out is to develop some target programs and create specialized groups, including young professionals to implement these programs. This would allow young researchers to find his place in science, benefiting the country.