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Summary. The activities of many outstanding domestic scientists and designers in the field of rocket and space technology were not limited only by the framework of an enterprise or a design office, where their scientific and engineering developments were carried out, but were also closely connected with education and teaching. The article describes the period of activity of a prominent scientist and designer of rocket and space technology, Vyacheslav Mikhailovich Kovtunenko, at the Dnipropetrovsk State University from 1953 to 1977. The article describes the key activities of the scientist at the University, and, in particular, at the department of aerohydromechanics (AHM). Also the article describes the team from the educational and research section of the Kovtunenko school, and the problems of his research. The representatives of the Kovtunenko ' school at the University were identified.

Keywords: V.M. Kovtunenko, Dnipropetrovsk State University, department of aerohydromechanics, aerodynamics, aircraft, space.

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ОСВІТНЬО-ДОСЛІДНИЦЬКА ЛАНКА НАУКОВО-КОНСТРУКТОРСЬКОЇ ШКОЛИ В.М. КОВТУНЕНКО

Анотація. Діяльність багатьох видатних вітчизняних вчених і конструкторів у галузі ракетно-космічної техніки не обмежувалася тільки рамками підприємства або конструкторського бюро, де здійснювалися їх наукові та конструкторські розробки, а й була тісно пов'язана з освітньою та викладацькою роботою. У статті розглянутий період діяльності видатного вченого і конструктора в галузі ракетно-космічної техніки В'ячеслава Михайловича Ковтуненка у Дніпропетровському державному університеті з 1953 по 1977 роки. Крім творчого колективу в КБ «Південне», вчений поступово сформував ще один творчий колектив на базі керованої ним кафедри. Така структурна складова науково-конструкторської школи В. М. Ковтуненка була визначена як її *освітньо-дослідницька ланка* та була створена в Дніпропетровському державному університеті (нині – Дніпровському національному університеті імені Олеся Гончара). В статті розкрито основні напрямки діяльності вченого в університеті, і, зокрема, на кафедрі аерогідромеханіки (АГМ). Розглянуто роль В'ячеслава Михайловича в розвитку та організації наукових досліджень і освіти в напрямках, пов'язаних з аеродинамікою ракетно-космічної техніки. Одним з його вагомих досягнень стало те, що він першим з вітчизняних вчених вирішив задачу про форму осесиметричного тіла мінімального опору при надзвукових швидкостях – затуплений конус в подальшому став класичною формою головних частин. В статті висвітлені деякі підходи та методи роботи вченого в університеті, цікаві особливості підготовки студентів і аспірантів. Важливим виявився також його практичний внесок в покращення наукових досліджень в університеті – це заснування комплексної фізико-технічної лабораторії (КФТЛ) і наукового корпусу №6. В. М. Ковтуненко створив в Дніпропетровському університеті колектив, в якому під його керівництвом було сформовано освітній і науковий напрям «Аеродинаміка літальних апаратів великих швидкостей». Цей колектив став важливою складовою науково-конструкторської школи видатного вченого і конструктора. В статті розглянута тематика досліджень колективу на кафедрі аерогідромеханіки, а також вперше визначені основні представники школи В. М. Ковтуненка в університеті та розказано про наукову діяльність деяких з них.

Ключові слова: В.М. Ковтуненко, Дніпропетровський державний університет, кафедра аерогідромеханіки, аеродинаміка, літальний апарат, космос.

To the 50th anniversary of the department of aerohydromechanics (AHM) at the Dnipropetrovsk University

Formulation of the problem. The understanding of the need to study research and design schools in the field of rocket and space technology is currently being shaped. Despite the complications of such studies by a number of factors, namely, the secrecy of the industry, a further decrease in the number of pioneers of rocket and space technology, the complexity of determining the composition of such a school, the relevance of their research is undoubted [6]. The author makes an attempt to study the educational and research unit of the school of one of the leaders in the field of domestic cosmonautics, V.M. Kovtunenko.

Analysis of recent research and publications. V.M. Kovtunenko's activities at the Dnipropetrovsk University was studied in the publications [2; 3; 4; 7]: however, this is not sufficient. One of the important sources for the research was the personal record of V.M. Kovtunenko, which covers the period of his work at Yangel Yuzhnoye Design Office, which is stored there [5]. In addition, the author used such sources as interviews and memories of the people

who worked with V.M. Kovtunenko at the Dnipropetrovsk University [1; 8]. In this study, the author also relied on her previous publications [6].

Highlighting previously unsolved parts of a common problem. Availability of the school of V.M. Kovtunenko at the Dnipropetrovsk University and its activities are presented in the article. For the first time, the educational and research unit of his school is defined and structured.

Objective of the article. The main purposes of the article are revealing the main areas of activity of V.M. Kovtunenko at the Dnipropetrovsk State University in 1953-1977, study of the contribution of the scientist to development and organization of education and scientific research at the University.

Basic information. Apart from the creative team at Yuzhnoye Design Office, Vyacheslav Kovtunenko gradually formed another creative team at the department he was in charge of. We define the structural component of the V.M. Kovtunenko – scientific design school as *educational and research unit*, established on the basis of the Dnipropetrovsk State University (now Oles' Honchar Dnipro National University), at which Kovtunenko began work in 1953 as a senior lecturer of the department 1 at the physics and technology faculty [7]. In the position of associate professor he had been working since 1955. In 1960, Kovtunenko was awarded the academic degree of doctor of technical sciences; in 1962 he was awarded the academic status of professor [5]. From 1963 to 1969 Kovtunenko headed the department of applied dynamics of gas and heat-mass exchange at the Dnipropetrovsk University, and from 1969 to 1977 he was head of the department of aerohydromechanics.

Kovtunenko was virtually the founder of the educational direction "aerodynamics of high-speed flying vehicles" at the Dnipropetrovsk University. He delivered the two main courses of lectures. Gas Dynamics, or Hydrogasdynamics (fundamentals of fluid and gas mechanics) – was the first part, an introductory course. Then came the applied part – Aerodynamics of Aircraft [1]. Kovtunenko was investigated the field of aerogasdynamics of high-speed aircraft and spacecraft heat and mass transfer, therefore a considerable part of his published works was devoted to aerodynamic calculation of space vehicles elements, study of satellite resistance in the upper atmosphere, solar activity, etc. [3].

One of his achievements was that he was the first domestic scientist to solve the problem of the shape of an axially symmetric body with minimal resistance at supersonic speeds – the blunt cone later became the classical shape of nose cones [4].

A team of like-minded people who worked at the department was gradually collected. Peculiar features of work of Kovtunenko, in the opinion of his disciple, Professor E.R. Abramovsky, who worked with him at the same department, were his methods of work with colleagues, teachers and reserchers. These methods were very democratic and at the same time clearly directed. For example, Kovtunenko did not lose time on minor things, being the research supervisor of a number of dissertation scholars, in preparing their dissertations. He clearly defined the main directions of their research, because he knew the unsolved problems. He trusted the person to whom this scientific problem was entrusted – to search for reference information, material, problem solving, etc. Kovtunenko differed from other research supervisors who read dissertations chapter-by-chapter to correct it for lack of time. He always defined the core – the main direction of research, what needed to be achieved, set a goal. **"Search for unsolved problems"** was his motto. And the students used to find interesting, from scientific and practical points of view, unsolved issues in various fields – for example, in wind turbine aerodynamics. Besides, Kovtunenko used to teach that one needed to be a widely educated and unselfish person. He used to say: "The most important thing is your work. You must do work and not think of how much you would get for it".

All the time Kovtunenko was directing future researchers, his colleagues, above all, *to rely on physical essence* of process or phenomenon. The engineering methods differ from the numerical methods so that "the numericals" usually take as-ready equations, in particular, differential equations, and, relying mainly on the mathematical apparatus, look for ways to solve these equations, and so on, but the engineering methods and the approximate methods should definitely be related to physical wrap pattern. Kovtunenko insisted: before solving the problem of flowing around a particular body, deal with the physical basis of this flow – where a jump occurs, where a rarefaction wave occurs, what impact does a friction have on the state of the boundary layer, where tear-off zones are located etc. This was the meaning of his main method of educating future researchers [1].

The second thing he demanded was mandatory *introduction into practice*. Kovtunenko considered that simply publishing of the work and believing that it is finished is not enough. Since he was at the same time the head of an important department at Yuzhnoye Design Office, deputy chief designer, his practical interest was that the work of his colleagues, applicants and graduate students should be surely implemented. Therefore, the results obtained at the University department were immediately transferred to the aerodynamics department and to other departments, specializing in – thermal physics, power systems etc.

In 1969, when the department of aerohydromechanics was separated from the department of applied dynamics of gas and heat-mass exchange and Kovtunenko headed the department of aerohydromechanics, all involved in the scientific research together with him, were transferred to a new department.

The main direction of the scientific research of the new department was development of the engineering methods for calculating aerodynamics of aircraft, which did not lose relevance even now. Under guidance of Kovtunenko the research work at the department went mainly in the direction of studying complex aerodynamics of long-range missile head parts, studying the main aerodynamic structure of the aircraft: its nose cone. Almost all of his disciples, including graduate students – N.N. Lychagin, L.E. Pitsyk, A.A. Kharitonov, I.S. Tonkoshkur, N.V. Polyakov, V.I. Timoshenko, V.R. Zhuravsky and others dealt with these issues.

Kovtunenko linked the research direction of the department mainly to aerodynamics issues, that matched the specialization of Yuzhnoye Design Office. At the same time, the research direction was also impressive for the wide coverage of

other issues: hydrodynamics of water-penetrating bodies; aerohydromechanics of hypersonic flows; aerodynamics and heat-mass exchange of conical planning bodies for study of the upper atmosphere; non-stationary aerodynamics; aerodynamics of superstructures and stagnant zones; jet hydrodynamics; industrial aerodynamics [4].

On the initiative of V. Kovtunenko in the 1960s, a complex physical-technical laboratory was created at the Dnipropetrovsk State University and dedicated premises were constructed for this laboratory (building 6). One of its parts was dedicated to rocket engines, the other part was the resource base of the departments of applied gas dynamics and aerohydromechanics. A subsonic aerodynamic tube T-5 was created there, and almost completely a supersonic tube was built (a copy of the T-114 tube of Central Aerohydrodynamic Institute). The subsonic aerodynamic tube T-5 was moved to the educational building 14 of the Dnipropetrovsk University, where it now serves the purpose of educating students [8].

In connection with the departure of Vyacheslav Mikhailovich in 1977 at Lavochkin NPO associate professor Oleg G. Goman was a head of the department of aerohydromechanics from 1978 to 1980, and Professor Evgeny R. Abramovsky occupied this position from 1980 to 1996. The department continued to work in the same direction, and scientific work was carried out with Lavochkin NPO on the relevant contractual topics also during the 7–10 years.

Under guidance of Kovtunenko, at least 8 dissertations were defended by members of the AHM department. Many of his disciples continue to work in various positions at the department of AHM and other departments of the Oles' Honchar Dnipro National University. Among the disciples of Kovtunenko at the Dnipro National University we can name the President of University, honored worker of science and technology of Ukraine, corresponding member of the National Academy of Sciences of Ukraine, Nikolay Polyakov; Professors Yevgeniy Abramovsky, Oleg Goman; associate professors Leonid Pitsyk, Fyodor Avrakhov, Nikolai Lychagin and others.

The scientific activity of Professor Abramovsky is associated with research in the field of aerodynamics of aircraft, wind turbines and environmental problems of air and water pollution near large cities. He published about 70 works, among them two monographs. "Wind turbine aerodynamics" (1987), one of his most important works, was the first monograph on this subject in the USSR and stimulated development of research in this direction. Over the years of work at the AHM department, Evgeny Abramovsky gave more than 20 training courses for students of mechanical and mathematical and physics and technology faculties: rocket technology, aerodynamics, fluid and gas mechanics, the theory of rarefied gases, wind power, economics, etc. His main works are "Aerodynamics of hypersonic devices" (1982), "Engineering methods of high-speed aerodynamics" (1985), "Aerodynamic characteristics of bodies in rarefied gas" (1986). Professor Abramovsky is an Honored Educationist of Ukraine [2].

From 2002 to 2010 Professor O.G. Goman was the head of the department of aerohydromechanics at the Dnipropetrovsk University. He taught before and teaches now students of the faculty of mechanics and mathematics a variety of general and dedicated courses on aero-hydrodynamic cycle, stability theory, oscillation theory, calculus of variations, optimal control problems etc. He is the author of over 130 publications and textbooks, co-author of several monographs. He was the managing editor of the "Bulletin of the Dnipropetrovsk University. Series Mechanics". He is engaged in research in the field of fluid mechanics of penetration of bodies in liquids, contact problems for isotropic and non-isotropic medium etc. His *main works* are "Numerical silulation of axisymmetric separated flows of incompressible fluid" (1993), "Problems of gravitational enrichment of titanic zircon sand" (1999) and others. Professor O.G. Goman is an Honored Worker of science and technology of Ukraine (2001).

The whole life and activity of Professor N. V. Polyakov is connected with Dnipropetrovsk University: junior researcher of the AHM department, associate professor, and professor of the differential equations department and then its head; since 1989 – dean of the faculty of mechanics and mathematics, in 1996 he was appointed a pro-rector for educational work. From November 1998 to the present time N.V. Polyakov is the President of the Oles' Gonchar Dnipro National University. Among his scientific achievements is development of methods for constructing analytical solutions of boundary problems in areas of complex geometric shape for the purpose of further use in conjunction with numerical methods for solving nonlinear problems of mechanics. His works are known both in Ukraine and abroad. N.V. Polyakov was awarded the Yangel prize of National Academy of Sciences of Ukraine (2005) for the cycle of works on hydraulic gas dynamics and flight dynamics of aircraft. Under his leadership 8 dissertations were prepared, his disciples successfully work at the National Research Institute of the National Academy of Sciences of Ukraine and at higher educational institutions. He made a significant contribution to training of staff with higher education. He does lot of work aimed at transforming and reforming the system of higher education, improving training of highly qualified personnel. Professor N.V. Polyakov is an Honored Worker of science and technology of Ukraine (1998). His *main works* are "Numerical-analytical methods for solving boundary value problems" (1991); "Rocket as an object of control: textbook" (2004); "Classical university: from the ideas of antiquity to the ideas of the Bologna process" (2007) and others.

The above is just a few touches to the "portrait" of a scientific and educational element of the V. Kovtunenko – scientific and design school, the block diagram of which, determined in the course of the study, is presented in fig. 1.

In 2010, the AHM department merged with the department of applied dynamics of gases and heat-mass exchange and is now called the department of aerohydromechanics and energy and mass transfer. After O.G. Goman, A.A. Kochubei headed the department since 2010, and L.I. Knish is its head since 2014.

Conclusions and offers. V.M. Kovtunenko created a team at the Dnipropetrovsk University, in which the educational and scientific direction "aerodynamics of high-speed flying vehicles" was formed under his leadership. This team has become an important component of the research and design school of the outstanding scientist and designer. A characteristic feature of V.M. Kovtunenko was the width

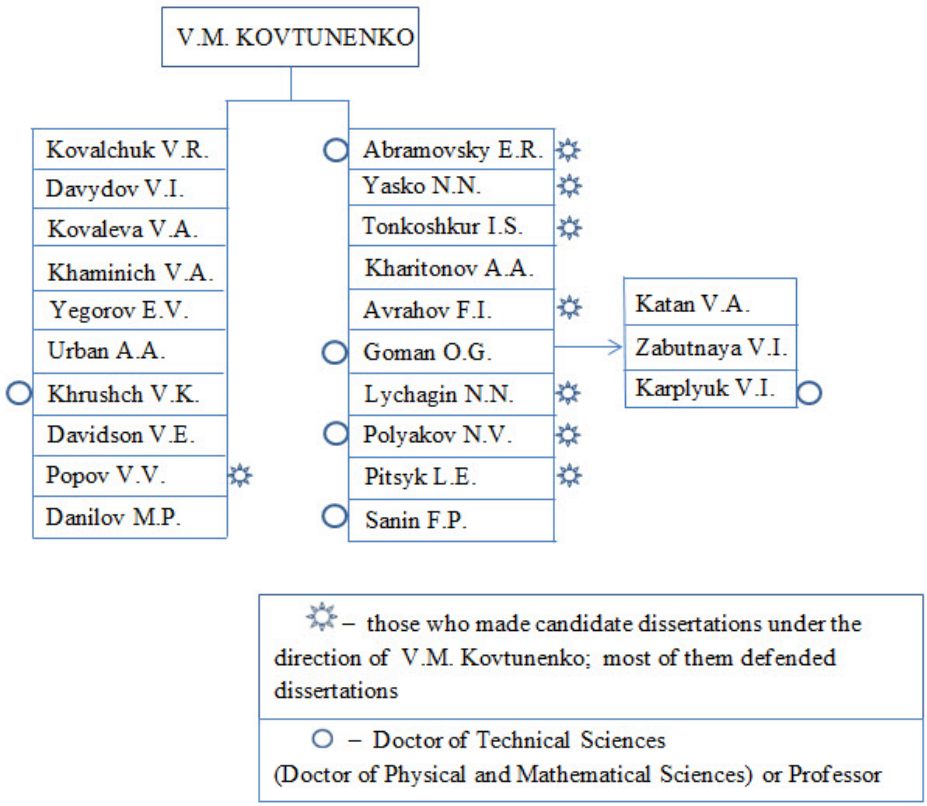

Fig. 1. Educational and research unit of the Kovtunenko school

Source: author development

of the range of his scientific interests. Vyacheslav Kovtunenko also brought to the AHM department a high level of exactingness and rigor to scientific production, and at the same time a style of exceptional benevolence and decency in mutual relations, which remains in the department even now [3].

The high level of research conducted at the department, and the fascinating manner of teaching by the disciples of Kovtunenko, by tradition, are passed on to next generations of teachers.

We can say that the educational and research unit of the Kovtunenko – scientific design school continues to evolve, changing the direction of research in accordance with the requirements of the time.

I also express special gratitude to the staff of the AHM department of Oles' Honchar Dnipro National University and to everyone who agreed to share his memories of V. Kovtunenko and his activities during his work at Dnipropetrovsk State University.

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