

Ludwig Prandtl, the world-famous founder of Aviation Science

Ukrainian scientists and engineers are to know word history of their science and personalities in it in order to make authorities of their own history part of the whole one. The personality of German fluid mechanics scientists Ludwig Prandtl and his scientific school are rather unknown in the former Soviet Union countries. His heritage and scientific methodology influenced this science are discussed in this short paper.

Ukraine, and its capital Kyiv particularly, are rather unknown but notable places in the history of world aviation. First airship in Russian empire was created by engineer Fedor Anders here. Igor Sikorsky started his designing of aircrafts before his emigration to USA. Prof. Mikola Delone founded “Kyiv aeronautic society” in 1909 here that brought together a number of aviation volunteers as well as first practical pilots, particularly famous Pyotr Nesterov. It is less known that a special “AviaCity” was organized near Kherson in 1916 leaded by Prof. from Sankt Petersburg Alexander Van-der-Vliet [1]. Finally, prominent Ukrainian aircraft designer Oleg Antonov worked in our city and created world-famous aircraft company. We need to rediscover again the domestic history of aviation. However, we also need to stress its continuous links with the world history and its personalities. That is why this article is devoted to one of Fathers of world aviation, aerodynamics and aeronautics Ludwig Prandtl (1875–1953).

The name of this German is well known to scientists of the former Soviet Union. We learned it from many textbooks. His name is also commemorated in thermophysics in such terms as “Prandtl-Pitot Tube”, “Prandtl Number”, in high-speed aerodynamics in the term “Prandtl-Mayer Flow”, in turbulence theory in the term “Prandtl Hypotheses” and many others. Especially famous is his “Boundary-Layer Theory” born in 1904. We knew his name but not his history or his scientific heritage.

We meet more other separate names in handbooks on Fluid Mechanics, Aerodynamics and Hydraulics but few our scientists know that they were his students. One of such names is Nikuradze, which might be guessed to have something to do with our former Soviet Republic Georgia and whose research from 1933 is often cited in studies on tube resistance. Another famous name is Theodor Karman, founder of US aeronautics and astronautics. So let penetrate into the late history to enquire its experience relevant to our days full of changes and challenges.

The former Soviet scientists know very little about the personality of L. Prandtl and his scientific school because of the “iron curtain” in the past. However, his achievements and those of his school in aerodynamics and, more generally, in Fluid Mechanics had a huge influence on the SU and Ukrainian aviation and technical science in general. In particular, Stephan Timoshenko, the founder of Institute of Mechanics of Ukrainian National Science Academy, hold him as his second “Doctor Father” [2]. This historical overview associates many of known

names with L. Prandtl scientific school and is based on recently published books [3-5] and other materials almost unknown in Eastern countries.

Ludwig Prandtl graduated from Munich technical university in 1894. His first scientific work on plasticity was written there, but as early as in 1904 he was invited by the prominent mathematician Felix Klein to Göttingen Georg-August-Universität where he fruitfully worked until his death in 1953. His work was inspired by flights of the first aircrafts that almost simultaneously happened in the US, France, Germany, Russia and (as we know now) in Ukraine. He built one of the first wind tubes (1907); later on, an aerodynamic tube (low speed, 1915). He was the author of one of the three theories of lift force mechanisms over wings (besides other Russian and English theories). He founded the world's first scientific center for aerodynamics, the Kaiser-Wilhelm Institute (KWI), where students Theodore von Kármán, P.R.H. Blasius, W. Tollmien, H. Schlichting, J. Ackeret, M. Munk, J. Nikuradse and many others grew up into brilliant world-known scientists. The success of German aviation in the Second World War was due to this KWI. Secondly, the post-war success of the American aviation and astronautics was due to Th. Kármán. His "Boundary Layer Theory" (BLT, 1904) was the groundbreaking achievement of his period in aerodynamics. In addition to these, a number of methodological issues associated with L. Prandtl, even philosophical and methodological ones, are to be discussed in the presentation. Below are the most important points that relate to our current situation.

1. Prof. F. Klein was severely criticized for his intention to change traditional direction of Göttingen university to fundamental sciences based on modern mathematics and physics instead of "practical sciences", alike it happens in Ukraine now. What should we infer from that historical experience? Nowadays one can often hear joke of recent German scientists: "There is the most dense population of Nobel Laureates in Göttingen now!"

2. All the Prandtl's articles and books were published under his name exclusively. This was also the manner of his aforementioned students to publish their articles. Such scientific ethics was also present in Russian scientific tradition before and shortly after the revolution of 1917. It is completely neglected nowadays, however. That is why we often hear about plagiarism scandals. A tradition appeared when administrators appropriate results and achievements of their subordinated scientists.

3. What are the relations between theory and practice in aerodynamics and fluid mechanics? What is the link between mathematics and experiments in Prandtl's heritage? Prandtl's case is very illustrative.

He held the first report on his BLT at the 3rd International Mathematical Congress (1904). Indeed, his leading idea was the comparison between terms of unsolvable Navier-Stokes equations, neglecting some of them and thus reducing them to solvable ones. However, there was too much physics for mathematicians to understand Prandtl's work that time. The BLT remained a successful engineering tool only for a long time as it happened with operational calculus of Oliver Heaviside. Phenomenon of boundary layer got complete mathematical acceptance

only at the end of the XX century, despite the fact that numerous reliable and practical solutions had been found before this time.

4. Ludwig Prandtl worked in Göttingen university side-by-side with the prominent mathematician David Hilbert. That was the time when “Nicolas Bourbaki”, the group of French mathematicians, tried to perform mathematics into a logically rigorous system. Discovery of BLT was done completely mathematically by L. Prandtl, and he might be thought so to accept such a methodology. In contrast, Prandtl delivered a course of lectures that he entitled “Useful Mathematics”. Did he not respect mathematics?

The role of mathematics and its significance in creation of the physical models and their experimental verification is a constant problem of scientific methodology and philosophy, and is discussed in [7] for the Prandtl case.

5. Ludwig Prandtl, his KWI and the Nazis’ 3rd Reich is a painful theme for the Germans. This was also a problem for the former Soviet science to acknowledge the role of Prandtl and his school for the aviation science. However, there is an opinion in Germany that he opposed the persecution of Jewish scientists. But why do we cite classical experiments by J. Nikuradze of 1932-1933, and none of his later works? Why we know so little about the life of the later? There seems to be a conspiracy of silence between Prandtl’s students, because Nikuradze, a refugee from Bolshevik’s Georgia, collaborated with Nazis along with his brother A. Nikuradze.

With regard to Prandtl himself, a question arises if scientists have the right to stay outside social and society issues. The latter issue is important for today’s Ukraine with association to resent aggression to our Crimea and Donbass.

Ludwig Prandtl is well known in Ukraine as an expert in fluid mechanics and the author of boundary layer theory (BLT). As mentioned over, in Ukrainian aviation there were several schools both in the early years (I. Sykorsky and others) and later on (O. Antonov) that aimed at theoretical approach to airplane performance. Kyiv aerodynamics school was founded by A. Mkhitarian, Professor of NAU. There were other aerodynamics schools in Ukraine both in universities and in the National Academy of Sciences: in Kharkov, associated with names of Naum Akhiezer and Ivan Tarapov; in Dnipro university (surved to Yuzhny Machine-Building Plant named after A.M. Makarov); and Donetsk university (where Ivan Povkh, the corresponding member of UNAS, brought all the best from Sankt Petersburg’ Fluid Mechanics school). Many scientists proclaimed themselves as indirect Prandtl’s students. For example, two professors of Kyiv’ Institute of Hydromechanics UNAS, namely Prof. I. Nikitin and Prof. L. Kozlov [6]. The Prandtl’s thinking methodology to “look for appropriate solvable simplification of the problem to be solved” turned out to be fully approved by scientists of the former SU. The new computer-based Fluid Dynamics (CFD) challenges and sometimes brakes these traditional approaches. However, classical works and methods of Ludwig Prandtl remain essential for us. More information contains in the article [6] and will also be given in the conference presentation.

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