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Chapter 6

Academician Valentin Glushko—Outstanding Russian Scientist and Designer of Rocket Engineering. To 110 Anniversary of Birthday*

Vladimir Sudakov†

Abstract

Valentin Glushko was a founder of Russian (Soviet) rocket space engineering, pioneer and creator of domestic rocket-and-space technology. He designed the world's first electrothermal rocket engine (1928–1933), the first Soviet liquid-propellant rocket engine—ORM (1930–1931), a family of RLA rockets operating with liquid propellant components (1932–1933), powerful liquid propellant engines installed on first missiles and rockets and on practically all domestic space rockets launched up to present time. Glushko's engines put into space orbit the first Earth satellite as well as subsequent spacecraft with Yuri Gagarin and other cosmonauts onboard. Those engines also supported flights to the Moon and other planets. According to his ideas and under his leadership, the unique reusable rocket space system Energia-Buran was designed, developed, and successfully launched, the base module of *Mir* long-life orbital station was created, and so forth. V. Glushko, as chief and general designer of rocket engines and rocket systems, made renowned activities in practical cosmonautics, also he made valuable

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personal contributions to world science. His long-standing works, fundamental references for thermal constants, thermal dynamics, and thermal physical properties of various substances (1956–1982, 40 books total), were highly acknowledged all over the world. His reference books were translated abroad, and many scientists and engineers currently use them as handbooks. For several decades, V. Glushko performed active work as head of the Scientific Council at the Presidium of Academy of Sciences of the Union of Soviet Socialist Republics (USSR) for "liquid propellant" issues. He also enlisted to these works numerous scientific and educational institutions of the whole country. He was an active member of International Academy of Astronautics (IAA) and a chairman or member of many scientific councils. He was editor-in-chief of three editions of "Cosmonautics" encyclopedia (1968, 1970, 1985) in our country.

Valentin Glushko was twice Hero of Socialist Labour (1956, 1961), winner of Lenin (1957) and State awards (1967, 1984). He was awarded with five Orders of Lenin and other State orders and medals including Gold Medal 2, named after K. Tsiolkovsky of the Academy of Sciences of the USSR (1958). He was an honorary citizen of the cities of Kazan, Kaluga, Baikonur, Odessa, Primorsk, Khimky, and Elista, member of the Parliament of USSR, a member of the Central Committee of the Communist Party of the Soviet Union (1976–1989).

Figure 6–1: Valentin Glushko.

I.

Valentin Glushko was born on 2 September 1908. He took a great interest in cosmonautics at the early age of 12, and he decided "to devote himself to it completely" at that time. In 1922–1924, he observed stars in the sky at the 1st State Observatory in Odessa. Since 1923, young Glushko had been in corre-

spondence with K. Tsiolkovsky for many years. Starting in 1922, he began to collect information for two books. One of the books, *Problems of Planets Exploitation*, was finished in 1924 when the author was 16 years old. This book was not published at that time. Our company—NPO Energomash—published the manuscript of this book in 1998 and received very positive responses from many Russian scientists.

In 1925, V. Glushko entered Leningrad State University in the department of physics and mathematics. He was fascinated by the university world, but his student life was very hard: he existed in half-starved conditions and he had to earn his living constantly.

In 1928, while working on his diploma, he took a great interest in the idea of creating an electrothermal rocket engine (ERD); his application for ERD was acknowledged as an invention. These ideas of Glushko were proposed to Gas Dynamic Laboratory (GDL) in Leningrad, and he started his work at GDL on 15 May 1929 as team chief and then became department chief.

Figure 6–2: 1930.

At this laboratory, he developed and tested the first ERD in the world, the first domestic liquid-propellant rocket engines family: ORM, ORM-1 ... ORM-52 and developed his first rockets RLA-1, RLA-2 and RLA-3 for vertical lift-off up to 2–4 km. In 1933, at GDL, he developed engines ORM-50 (150 kgf thrust) and ORM-52 (300 kgf thrust), which passed official acceptance tests.

Since 1934, V. Glushko with his team worked for the newly established RNII (first State Propulsion Research Institute in the world) in Moscow. He focused with engines for rockets and continued working on nitric-acid liquid-propellant rocket engines of ORM series. Here Glushko developed the reusable engine ORM-65 for S. Korolev's rocket glider RP-318 and winged rocket 212.

This engine was the best engine of that time in terms of reliability and other parameters.

On 23 March 1938, V. Glushko was arrested for sabotage based on false accusation. He was under arrest in Lubyanka and then in Butyrskaya prison until 15 August 1939. Court verdict—eight years imprisonment in the camp. Later, being a prisoner, he worked on creation of aircraft rocket engines in Kazan. In 1941, he became chief designer of Experimental Design Bureau (OKB) controlled by NKVD. For fewer than three years—up to the middle of 1944—he managed development of RD-1 rocket engine with thrust of 300 kgf, with the help of a staff consisting mostly of prisoners.

S. Korolev (prisoner also) was directed to Glushko's OKB as a leading engineer—team chief—responsible for installation of RD-1 engine in aircraft design. This OKB (since 1944—OKB-SD) had developed two-, three-, and four-chamber engines with thrust up to 1,200 kgf for different airplanes. In 1944—RD-1 engine and in 1945—RD-1KhZ and RD-2 engines passed official state fire tests. The reports on these tests were approved by I. Stalin. In summer 1944, for achievements in their activities, V. Glushko, S. Korolev, and a number of other OKB employees (35 persons) were released with removal of their convictions. More than 400 flight tests of airplanes with Glushko's engines had been conducted, but such airplanes never had participated in World War II.

II.

After World War II, V. Glushko at rank of colonel-engineer, S. Korolev, and a number of other OKB specialists visited Germany on a mission to acquire knowledge about rocket hardware. V. Glushko, being chief of the engine department of the Central Administration of Authorized Committee in Germany, took part in studying A-4 (V-2) German ballistic rocket engine hardware. An OKB-SD team of leading specialists worked in Germany under his management. They returned to the Soviet Union only in January 1947. During that period, the tremendous work on studying and reconstruction of the engine for the A-4 rocket was performed, and 407 fire tests were conducted. V. Glushko reported results of that work to General L. Gaidukov, chairman of the Special Government Commission in Germany, and D. Ustinov, chairman of Government Commission, Minister of Arms. In reports, Glushko also described the concept of organization for rocket engine production in the Soviet Union together with a statement of work performed.

On 29 September 1946, the Soviet government issued instructions to move V. Glushko's OKB-SD from Kazan to plant 456, located in Khimky (near Mos-

cow), to be reoriented for production of rocket engines. V. Glushko's OKB received a new name, OKB-456.

Figure 6–3: 1945.

Great experience in LPRE development, gained at GDL, RNII and OKB-SD, helped V. Glushko to reproduce quickly the engine of the German A-4 rocket and to conduct, in 1948, the first fire tests of the powerful RD-100 engine, which was made of domestic materials and by Russian workers. The Soviet army received the R-1 rocket with RD-100 engine.

During reproduction of the RD-100 engine, V. Glushko took steps to modify completely the baseline configuration. So, the RD-101 engine, with thrust of 37 tf, for the R-2 rocket and the RD-103 engine, with thrust of 44 tf, for the R-5 and R-5M rockets with a nuclear warhead were developed.

However, further progress on rocket propulsion needed other new design solutions. Thus, for significant improvement of LPRE performance, it was required to increase pressure and temperature in the combustion chamber, or to use more effective propellant components. A new solution was found: a thin welded/brazed structure of load-carrying jacket and ribbed fire wall was designed. The chamber was lighter and operable at high temperature (even more than 4,000° C) and high pressure. Such design and technology started to be used widely in all next designs of OKB-456 and other OKBs of Russia, and it initially related to oxygen-kerosene RD-107 and RD-108 engines developed in OKB-456 for first and second stages of the R-7 rocket. Artificial satellites were launched by these engines. There were not only artificial Earth satellites, but Moon and Sun artificial satellites, automatic stations for flights to the Moon and Vostok, Voskhod and Soyuz manned spacecrafts. There were many enthusiastic comments on these engines. The first one was Yuri Gagarin's comment. And, even US President John Kennedy wrote about the engine in his message to Congress on 25 May 1961: "We became the witnesses of the fact that the Soviet Union made the

first space achievements due to that they had powerful rocket engines. That secured the leading role to Soviet Union."

Such expert opinion about the main reason for Soviet superiority over the United States in space exploration, expressed all over the world, was a high international appraisal of V. Glushko's activity. RD-107 and RD-108 engines created more than 60 years ago, are being constantly upgraded and widely used for national and international cosmonautics.

Figure 6–4: 1963.

An extremely large amount of work relating to creation of storable propellant engines for military missiles had been performed during the Cold War period. New powerful engines, using nitric-acid, nitrogen tetroxide with kerosene or with unsymmetrical dimethylhydrazine (UDMH), for missiles, which can be kept in filled condition on the launch pad for a long time, were created under V. Glushko's management. R-12, R-14, R-16, and R-36 earth-based and silo-based missiles with these engines installed, established a reliable defensive shield for our country.

At the beginning of the 1960s, V. Glushko's OKB began mastering and implementing a staged combustion scheme of powerful LPRE with after-burning preburner gas. For the first time on powerful LPRE, this scheme was used in the RD-253 engine for the first stage of the Proton launch vehicle (LV). Such engines have been operating perfectly for more than 50 years. Since 1965 until now, the RD-253 and his next modifications remains as the world's most powerful single-chamber LPRE operating with storable propellant. Since that time, a staged combustion scheme (with oxygen-rich preburner gas after-burning) has been used in all OKB-456 (renamed now as NPO Energomash) designs, providing the highest operating parameters of new engines.

III.

In May 1974, NPO Energia was established, and V. Glushko was assigned as its Director and General Designer. By Glushko's suggestion, the activities began on creation of a universal reusable space complex (RSC) Energia-Buran. V. Glushko suggested creating the RD-170 oxygen-kerosene engine with unique performance and vacuum thrust of more than 800 tf for the first stage of a superheavy launch vehicle. Hard work requiring all efforts was successfully fulfilled: the first RD-171 flight engine was tested on a Zenit LV in April 1985 and, then, RD-170 engines were successfully operated during two flights of an Energia LV on 15 May 1987 and of the Energia-Buran RSC on 15 November 1988. The impressive landing of the Buran orbital spacecraft in automatic mode was on television and evoked admiration of people all over the world. This most exceptional flight was the apotheosis of Glushko's activity as general designer of new space rocket systems. One of the perspective problems to be solved with the help of the Energia LV, which put into Earth orbit payloads of more than 100 t, would be creation of a permanently inhabited base on the Moon, and there were a number of other important tasks for this unique vehicle.

Concurrently with the RD-170 engine, the RD-120 engine—an 85-ton oxygen-kerosene engine with a high Isp of 350 sec—was created for the Zenit LV second stage.

An LPRE of the new generation was developed, taking into consideration the following new requirements: a great margin of service life with a number of starts; the capability of engine reuse. At the same time, many design and technological approaches were found that are currently considered to be national wealth for the Russian aerospace industry. The significance of V. Glushko's ideas on development of a new, modern LPRE is invaluable!

During the same period when V. Glushko was NPO Energia General Designer, he managed activities on development of the Soyuz manned spacecraft and its modifications, Soyuz T and Soyuz TM, as well as the cargo spacecraft Progress, improvement of orbital stations Salyut, building of the base module of the long-life orbital station Mir, and realization of manned flight programs, including international ones; V. Glushko went deep into issues and introduced many useful ideas to solve these problems and issues of LV external aerodynamics and many others. All that helped to increase reliability of basic development that ensures successful flight tests and normal flights.

Figure 6–5: 1987.

V. Glushko survived the flight of RSC Energia-Buran by less than two months. He died on 10 January 1989, when he was 80 years old, and he was buried at Novodevichye Cemetery in Moscow. His creation—universal reusable space complex Energia-Buran—was not launched after the death of its general designer.

IV.

The importance of V. Glushko's role in development of rocketry and cosmonautics in our country or, more exactly, in development of world space science and engineering can hardly be overestimated. In each historical period, V. Glushko put before himself and his personnel the most complicated problems that had not yet been resolved anywhere in the world. As a result of his creative work and efforts, sometimes on the edge of impossible, he achieved outstanding results.

V. Glushko's style of management—to work hard without any leniency, with maximum efforts, enthusiasm, and self-devotion. He had a talent to inspire his personnel to solve any tasks that seemed unrealistic to be resolved. He managed to combine democracy with tough discipline. While making a decision, he created the atmosphere of real equality, and everyone could defend his idea. He made decisions himself, and they were often unexpected by his colleagues. When a decision was made, he was exceptionally strict to provide its realization; he

paid great attention to every aspect of a problem, selection of the shortest way for realization of an idea, and he was merciless to ill-informed employees and those who did not tell the truth. These traits of his personality became apparent at critical moments. It could be noted without exaggeration, and many people witnessed that just his intelligence, will, and energy assured a change in the process of extremely hard development of RD-170/171 engines for the first stage of Energia and Zenit.

V. Glushko gave much attention to activities concerning investigation of rocket propellant characteristics and new, more effective propellants. He was head of the Scientific Council on liquid-propellant rocket issues at the Presidium of the Academy of Sciences of the USSR for several years, and he enlisted many scientific and educational institutions for solution of these problems. As a result of these investigations in particular, storable propellants were implemented that became "flight propellants" for combat missiles for many years. He stressed advanced research of various highly effective propellants, including such "exotic" propellants as fluorine and compounds of boron and beryllium as well. V. Glushko always thought that operating with these components would open new opportunities for long-distance spaceflights in the future, providing that requirements of safety engineering were observed. He always took great interest in problems of gas dynamics and thermodynamics. His long-standing activities on reference book publications (40 books in total) during 1956–1982 relating to thermodynamic constants, thermal and thermal physical properties of substances illustrate this. These publications were translated and are widely used abroad.

All his life, V. Glushko tried to dedicate some of his time to scientific, teaching, and educational activities. In the 1930s, he was lecturing on rocket engines and propellants at the Air Force Academy named after N. E. Zhuckovsky. (First part of his lectures, 224 pages, was published in 1936; second part was lost in 1938.)

In 1945, V. Glushko was appointed head of a newly organized sub-faculty of the rocket engines department at Kazan Aviation Institute. The teaching staff included his colleagues D. Sevruk, G. Zhiritsky, S. Korolev, and others. From 1947 until 1954, he lectured on principles of reactive liquid-propellant engine design for the High Engineering College under Moscow High Technical School named after N. Bauman. His lectures were always laconic, impressive, and they were always a success.

V. Glushko paid much attention to exhibition activity. In the middle of the 1960s, he received authorization to display LPRE mockups in Soviet Union National Economic Achievements Exhibition (VDNKh) and International exhibitions abroad. NPO Energomash follows this tradition and our expositions are

center of attention at various international aerospace exhibitions. Owing to V. Glushko's activities, NPO Energomash began at the end of the 1940s to form exposition of its Demonstration Room that displays the history of rocket propulsion.

In the 1960s–1980s, V. Glushko published a number of books on propulsion technology, rocket production and cosmonautics, among those first of all we would like to note *Development of Rocket Production and Cosmonautics in USSR*. This book was published in three editions. V. Glushko, as editor-in-chief, took much creative effort to edit three editions of "Cosmonautics" encyclopedia. It was a perfect example of his wonderful, amazing, and comprehensive erudition.

V. Glushko generously shared his knowledge with his colleagues, representatives of other enterprises, who dealt with similar problems. In the 1940s, when he was in Kazan, he told V. Bolhovitinov and A. Isaev about his LPRE findings and demonstrated to them test benches, production, and analysis procedures. His idea of LPRE creation inspired A. M. Isaev. After this visit, A. M. Isaev became a rocket engine specialist, and he established his own excellent design bureau. At the beginning of the 1950s, a number of LPREs of Glushko's design were handed to Dnepropetrovsk for serial production. V. Glushko sent a group of his main specialists there to organize the serial production. Among the experts who entered the group were N. S. Shnyakin (at first he was SDB chief designer at plant, and then he was M. K. Yangel's deputy) and I. I. Ivanov, who became leader of the established Design Bureau of Rocket Engines at M. K. Yangel's OKB. V. Glushko and his experts rendered great methodical assistance to the engine design bureaus of S. A. Kosberg (then A. D. Konopatov) and N. D. Kuznetsov.

We must particularly emphasize V. Glushko's important role in creation of highly qualified personnel of our company, a team of engineers and designers as well as his deputies and chiefs of leading departments. Such outstanding scientists and designers as G. S. Zhiritsky, V. A. Vitka, G. N. List, V. L. Shabransky, V. P. Radovsky, N. A. Zheltukhin, A. D. Veber, M. P. Gnesin, A. D. Daron, A. P. Pavlov, S. P. Agafonov, and many others, creatively working with Glushko and his disciples, has well ensured the position of NPO Energomash at International Market in spite of difficult economic conditions.

The RD-170 engine, the most powerful LPRE in the world, was highly appreciated in all countries, including the United States of America. Based on the RD-170 engine, the new RD-180 engine was developed at NPO Energomash, named after academician V. P. Glushko under order of the Lockheed Martin company. This engine won in a US competition for rocket engines for the Atlas

III LV. On 24 May 2000, the Atlas LV (AC-201), powered by the RD-180 engine, was successfully launched for the first time. Now, we have 87 successful flights of US launch vehicles (Atlas and Antares) with our engines.

It is difficult to overstate V. Glushko's role in the development of national rocketry and cosmonautics and achievements in this field. That was the goal and sense of his life from his youth. From 1947 until 1988, more than 50 most reliable and most powerful LPREs and their modifications operating with cryogenic and storable propellants were created according to his ideas and under his leadership in the Energomash Design Bureau for different missiles and space rockets.

Former president and general designer of RSC Energia, named after S. Korolev, academician Y. Semenov said about him: "He was a great scientist, he contributed a lot to the rocket-space engineering and he was an indisputable authority in this field. Frankly speaking he was a figure of equal standing to Sergey Pavlovich Korolev."

V. Glushko was not only very talented, but he also had a gift for art and music, and he was of pleasing appearance as well. He always looked much younger than his age, and N. S. Khrushchev had mentioned about it at meeting of OKB-456 workers in Khimky on 23 April 1958. V. Glushko always dressed in good taste and elegance, and his employees tried to follow his example. As a person of responsibility, V. Glushko always kept his word and was deeply respected for it.

V. Glushko's views and actions were always based on what was good for business and, if he believed he was right, he pursued his ideas even if he had to conflict with his direct management. Speaking in today's language, he was a stern and hard chief.

In August 1994, the name of Valentin Petrovich Glushko as a pioneer and founder of rocket propulsion was perpetuated by decision of XXIId General Assembly of the International Astronomic Council: a crater on the visible side of the Moon was named after him. The name of V. Glushko is among the names of world great explorers, such as N. Bor, G. Galileo, D. Dalton, A. Einstein on the map of the Moon.

A big crater of 43 km in diameter, domineering during full Moon within west hemisphere of Moon, was named after V. Glushko. This is not an ordinary crater. The light beams coming from the crater spread on the surface of the Moon Storm Ocean in different directions through approximately 1000 km, and the crater can be observed from Earth using powerful enough binoculars.

The information given above is evidence of V. Glushko's recognition as the greatest explorer of the 20th century and first magnitude star all over the world.

Figure 6–6.

All awards and ranks that a human gets in his lifetime pass away with him, but memory of him stays with descendants, in his works and books, in his engine and rocket designs. V. Glushko made possible human breakthrough into space. And memory about our compatriot, patriot of Motherland, pioneer and creator of rocket engineering will live forever.