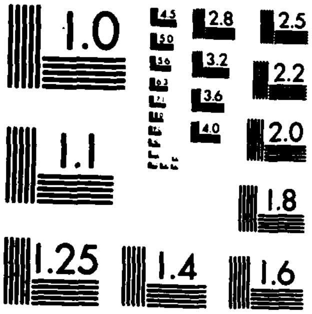
AD-A123 928   THE ROAD THROUGH SPACE(U) FOREIGN TECHNOLOGY DIV   1/1
WRIGHT-PATTERSON AFB OH   10 DEC 82 FTD-ID(RS)T-1034-82

UNCLASSIFIED   F/G 21/8.1   NL

END
DATE
FILMED
83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2

FTD-ID(RS)T-1034-82

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE ROAD THROUGH SPACE

Approved for public release;
distribution unlimited.

FTD -ID(RS)T-1034-82

EDITED TRANSLATION

FTD-ID(RS)T-1034-82 10 December 1982

MICROFICHE NR: FTD-82-C-001654

THE ROAD THROUGH SPACE

English pages: 11

Source: Hangkong Zhishi, Nr. 2, February 1982,
pp. 20-22

Country of origin: China
Translated by: LEO KANNER ASSOCIATES
F33657-81-D-0264
Requester: FTD/SDBS
Approved for public release; distribution unlimited.

Accession For
NTIS GRA&I ☒
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
Dist Avail and/or Special
A

PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

GRAPHICS DISCLAIMER

THE ROAD THROUGH SPACE

Golushko is a famous Soviet specialist in liquid propellant rockets. He has produced many kinds of rocket engines during his research career of almost sixty years. He is a person capable of tipping the balance because of the sensitive position he holds within the Soviet guided missile and spaceflight department. This article is told in Golushko's own words and describes the evolution of Soviet rocket dynamics.

I first learned about Tsiolkovsky in 1922 in a book written by Y. Perlman, entitled 'Interplanetary Travel'. However, at that time few of Tsiolkovsky's books were available in the libraries. I, therefore, decided to write to the author directly. I wrote him in September 1923 stating that I had been interested in a tentative space program for two years and asked help in obtaining copies of his books. I received a reply from the scholar the beginning of October and later that month I received two shipments of books from him.

Tsiolkovsky had already solved the theoretical problems regarding space travel. My task now was to put it into practice. Rocket engines thus became the object of my life's struggle.

Firstly, at middle school and later at university I accumulated some indespensable knowledge and did some design work. However, it wasn't until 1929 at Leningrad Gas Dynamics Laboratory that I first came into contact with experimental work. The first batch of three Soviet produced liquid propellant rockets used OPM-52 engines, delivered a thrust of 300 kg and were able to launch to an altitude of from 2-4 km. These rockets were manufactured by the Monetny Dvor (mint) machine shops and by the Pitrolovalosk Gas Dynamics Laboratory. The first two rockets, RLA-1 and RLA-2 were both unguided, whereas the third was guided. The latter was equipped with an instrument compartment housing two gyroscopes (taken from a naval torpedo). Commands from the gyros, via pneumatic servo-drives and mechanical pull rods, were directed to two pairs of aerodynamic rudders in the tail unit.

In autumn 1933 the Rocket Research Institute was officially founded. From then on the Gas Dynamics Laboratory and the National Jet Engine Research Institute joined with this organization. Work on rocket engines and rockets was at first conducted independently. This was because, at this time, each field had become quite complex and specialized and so it was no longer possible to keep them together.

At the time of opting for specialization, I chose to start with rocket technology - the production of rocket engines. I think that kinetic engineering is a fundamental of space navigation. Unless the problems relating to it cannot be solved, then space travel will be only a fantasy.

Fig.1. Types of combustion chamber walls: corrugated plate (left), ribbed (center), strengthened (right).
1. Exterior shell of combustion chamber
2. Inner cooling wall 3. Welding seam
4. Coolant channel 5. Gas

SPECIAL CHARACTERISTICS OF LIQUID PROPELLANT ROCKET ENGINES

The difference between liquid propellant rocket engines and other engines (including aircraft engines) lies in the extreme turbulence of its flow produced inside. Several hundred or as much as several thousand kg of fuel are burnt per second in modern rocket engine combustion chambers, which only have a capacity of a few litres. Under these conditions the level of complete combustion is near 1. Combustion chamber pressure goes as high as 200-300 ata, the stable-state gas temperature as high as 4400 degrees absolute temperature and the launching speed resulting from combustion reaches 4500m/sec. Therefore, the heat flow passing through the combustion chamber wall and the nozzle is extremely great. All these factors combine to make the engine unstable in its operation, since vibration occurs even in a very wide frequency range and thus causes a very big vibration overload. Measures must, therefore, be taken to prevent this from happening. The chemical corrosion of the fuel mixture, toxicity, low temperatures and heterogeneity all lead to complications in the operation of rocket engines, whereas, this is not the case for other types of engines. In the meantime, given these circumstances, the operation of extremely light rocket structures should be highly reliable, otherwise who would be willing to use them in the launching vehicle of a manned jet spaceship.

Many complicated technical problems in the production of liquid propellant rocket engines need to be resolved. The first of these is reliability, that is, in order to obtain a complete a combustion as possible a large amount of fuel propellant should be allowed into the small capacity combustion chamber. This also guarantees motor stability and, secondly, this is necessary so as to absolutely eliminate the possiblity of accidentally producing pressure vibrations in the combustion chamber. Furthermore, this guarantees the reliable cooling of the combustion chamber and nozzle, since combustion produces turbulent flow in the nozzle so as to prevent excessive loss.

If liquid propellant engines are compared with modern aircraft engines their structure appears simple. However, this is superficial, since there are complex problems which are hidden. These have been mentioned above. What I would like to further explain, however, is that the calculations involved in modern liquid propellant rocket engines are extremely complex and difficult. At present this problem can only be resolved by the use of huge digital and analog computers. Only by describing the engine as a control object can the equation group formed from a hundred linear and non-linear equations be established.

At present research has still not given us a clear understanding of the processes produced inside the liquid propellant rocket. Modern theory has yet to solve any of the problems associated with this type of rocket engine and also cannot make reliable pre-calculations concerning start-up stability. High frequency vibration combustion is particularly problematic in this respect. Research on engines is still inseparable from new engine production work and, therefore, complex laboratory and testing facilities are necessary.

WAYS OF IMPROVEMENT

In the 40's, some countries produced quite a few liquid propellant rocket engines. However, in both the Soviet Union and other countries, the design of the combustion chamber structure showed few prospects of continuously raising engine thrust, in particular, specific thrust. This is one aspect that has now been perfected, so that specific thrust is an important sign of efficiency.

By the end of the 40's, rocket engine designers had realized that if any substantive improvements were to be made in engine performance, then these could only be achieved by raising combustion chamber pressure and gas temperature. Furthermore, this would also result in an increase in heat flow caused by the cooling of the chamber wall. So that the chamber would not suffer damage through overheating, it was realized that it would have to be made thinner. However, calculations showed that it would not be able to withstand high pressure if this were the case. The only way out of this predicament was to search for a completely new design for rocket engine combustion chambers.

Research has finally been successful in this respect and a new design has been drawn up which employs a machine processed ribbed thermal wall and in which the upper part of the rib is joined to the cold outer shell (Fig.1.). In this way the coolant can effectively prevent the thermal wall from overheating, and, at the same time, because the channel load is very small, can withstand several hundred ata. Engine performance can thus be raised and improved.

When producing the inner wall of the combustion chamber, we began using high heat conduction heat proof bronze materials for the part which receives the most severe heat. Steel, titanium and other

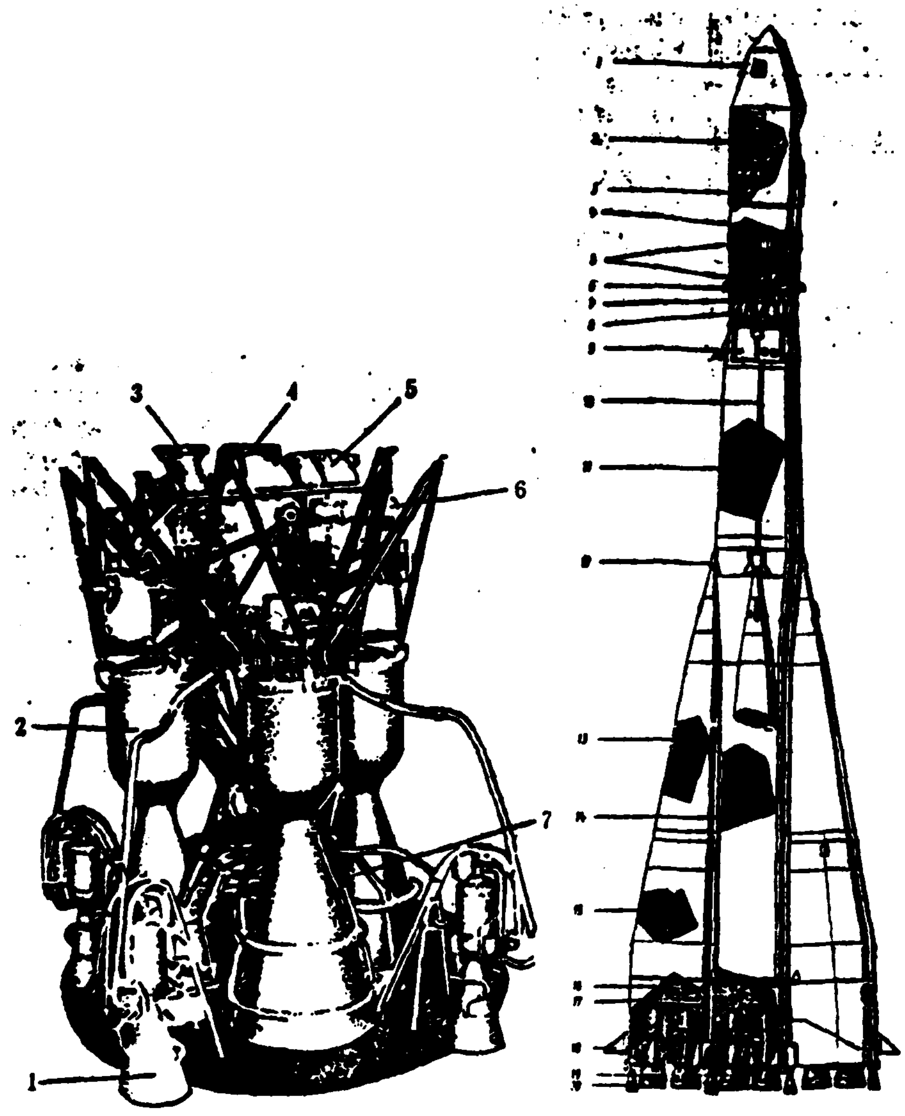


Fig.2. Vostok launch vehicle (right and its second-stage RD-108 engine (left).
Engine structure: 1. Attitude control motor
2. Main combustion chamber 3. Inlet connection of fuel pump 4. Inlet connection of oxidizer pump
5. Heat exchanger on turbine 6. Gas generator
7. Fuel manifold.

metals were used for the part which receives little heat. Between the inner and outer walls drill steel soldered corrugated sheet was used instead of cutting the machined ribs. The pressure produced by gas in the combustion chamber is supported by the outer cold steel shell.

The new combustion chamber can, therefore, work for a long time under high temperature and high pressure. It also has a suitable structural design and, furthermore, produced the possibility of using a high energy propellant for the engine.

In the following years, more improvements continued to be made to liquid propellant rocket engines. Improved models were used, such as the RD-107 engine in the first stage of the Vostok launch vehicle and the RD-108 engine in the second stage. Their structural design was successful and so far it is still used as a reliable means of launching manned spaceships and unmanned detectors.

Launch vehicles using RD-107 and RD-108 engines and their modified models have already been successful in launching several artificial earth and lunar satellites, moon, Venus and Mars probes, as well as the manned spaceships Vostok, Voskhod and Soyuz. The RD-119 used in the cosmos launch vehicle (Fig.3.) and the RD-214 engine are also still in use.

In order to raise the specific thrust of an engine, it is also necessary to raise the initial pressure in the combustion chamber. However, this is also subject to energy loss restrictions due to consumption in the turbopump unit.

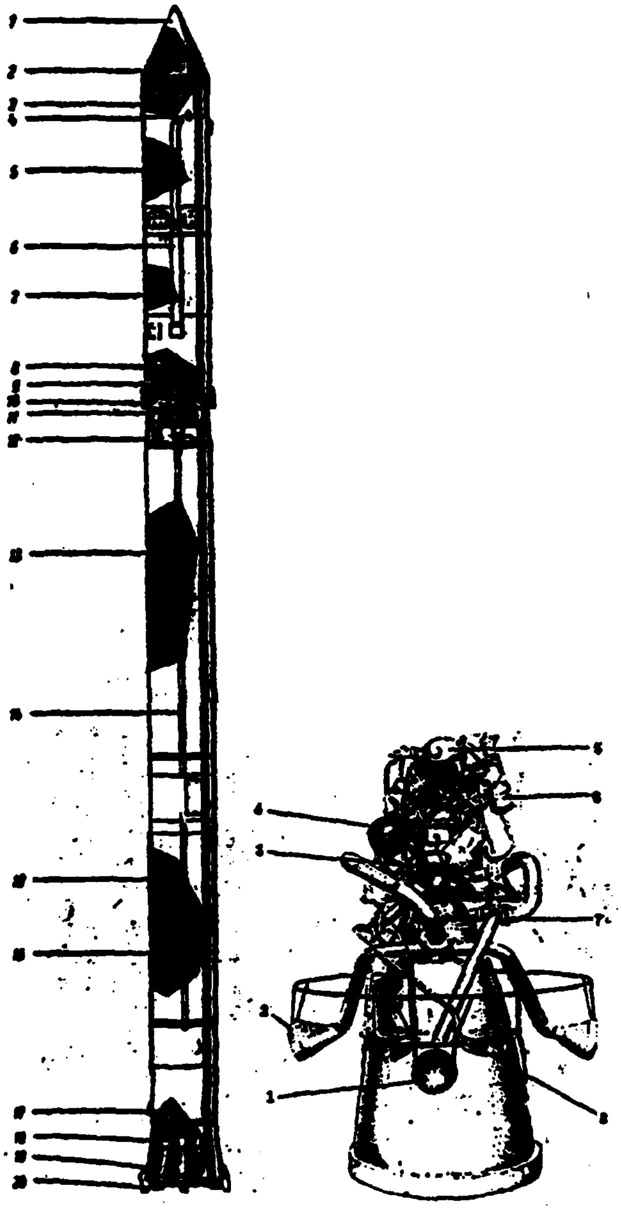


Fig.3. The 'Cosmos' launch vehicle (left) and its second-stage engine (right): 1,2. Pitch and yaw control nozzles 3. combustion chamber 4. bottle for compressed air 5. turbopump 6. gas generator 7. gas distributor 8. roll control nozzle.

The following explanation is to help those readers who do not understand certain aspects of combustion chamber operation. The function of the turbopump unit is to carry the rocket propellant to the combustion chamber. It consists of a pump and a gas turbine which is driven by the gas produced by the gas generator. The gas is then expelled again. Of course, in order to keep the turbopump working and to maintain gas consumption, it is inevitable that there will be some loss in specific thrust. If combustion chamber pressure is not greater than 75-90 ata, then specific thrust will be about 0.8 ~ 1.7%, which is permissible. If pressure is raised several times, however, then the loss will increase to an unacceptable extent.

A solution to this problem has nevertheless been found. In the plan for a new design of the liquid propellant rocket engine, the gas discharged is returned to the combustion chamber where it is burnt with a liquid propellant mixture of a rich oxidizer. In this way it causes the loss of the turbopump unit to be reduced to zero.

By causing the combustion chamber pressure to reach several hundred ata, an engine with very small dimensions and a very large thrust may be produced. An RD-253 engine for the Proton launch vehicle has already been produced based on this concept.

This engine differs from modern liquid fuel propelled rocket engines in several ways. Generally speaking, when considering ways of further improving the rocket engine, we have to think in terms of strengthening the combustion process, raising specific power and using a more efficient type of energy.

IMPORTANT TASKS ASSOCIATED WITH UNDERTAKING SPACEFLIGHTS

Usually, spaceship life-support and soft-landing systems employ solid fuel propelled engines. Electric rocket engines are used in space directional and orbital correction. Compared with liquid fuel propelled rocket engines, they can only be said to be supplementary, since liquid fuel propelled rocket engines are used in near-Earth orbits, planetary orbits and in-flying. In other words, liquid propellant engines are charged with the task of spaceflight.

The emergence and development of nuclear and electric rocket engines has not been able to change the use of liquid propellant engines in the take-off and recovery stages of rockets and spacecrafts. Apart from this, the latter have the added advantage of being able to avoid radiation pollution. A substitute for liquid propellant engines can only be produced when a high energy chemical fuel which is cleaner than nuclear fuel is invented.

The perfection of engine structure has greater significance in rocket technology than in aircraft technology. At present, in order to send a kg of useful load into near-Earth orbit, the weight of the launch vehicle on take-off has to be 25-50 kg. If the structure of the launch vehicle engine is imperfect in any respect, then quite a large part of its thrust cannot help but be consumed in its own take-off and acceleration. Therefore, to launch a useful load into space, the weight of the spaceship depends on the degree of perfection of the engine.

As for aircraft technology, the most demanding is the vertical take-off and landing aircraft. It can be inferred from foreign reports, that currently a turbojet engine has already been produced which satisfies vertical take-off demands, it has a comparative weight (the engine's structural weight compared with its produced thrust) which reaches 60-70 g for each kg of thrust.

In terms of producing rocket engines, an important point has been reached. The comparative weight of the Soviet produced large thrust rocket engines, already reached 7-10 g for each kg of thrust; this means the comparative engine weight is 100-150 times smaller than the thrust it produces. This kind of complex task can only be accomplished by attaining high objectives in terms of safety, reliability and performance in rocket engine work and also by using a new structure and new types of high strength light materials.

Zhou Yi Yun, Li Duan Chen editors.

LMED

-8