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Rocket Complex with Orbiter and with Liquid Propellant Engines on high concentrated Hydrogen Peroxide

Oleksandr S. Levenko[1], Oleg L. Pauk[2], Vladimir I. Prisyzhniy[3]
4 floor 25-27 Nagirna Str., Kyiv, Ukraine, 04107, Air-Space Agency "Magellan"

Abstract
The author gives a review of criteria for the establishment of active orbital spacecraft, taking into account the analysis of aspects of the application of the propulsion system running on hydrogen peroxide and the possibility of his return to the Earth surface. As a result, proposed the concept of creating a modern type of spacecraft - maneuvering in orbit returning unmanned orbiter in the embodiment of the satellite remote sensing (SRS). In a paper reflects the results of optimizing the design of the Launch Vehicle (LV). Article examines the preceding schematic design elements of space rocket complex. In particular, the elements of LV, Orbiter, and their propulsion systems. Carried initial calculations aerodynamic parameters of Orbiter on the descent and maneuvering in low orbit.

Keywords: *Rocket Space Complex, Launch Vehicle, Liquid Propellant Rocket Engine; Return Orbital Apparatus, Orbital Unmanned SpaceCraft.*

Introduction

With all the variety of research, practical results Astronautics currently insignificant. Gone are the grandiose projects of achievement at any cost (the first satellite, the first man on the Moon, first space station, the first Shuttle, etc.). Prospects for the development of astronautics are uncertain.

This can be attributed to various reasons. With so many ideas and projects virtually the international community focused on Launch Vehicle (created on the basis of the achievements of military engineering) and Satellites [4, 6]. The few exceptions (experimental Boeing X-37B, interplanetary spacecraft, original craft for space tourism, space electric rocket engine, etc.) do not change the overall situation.

It can be stated that almost all rocket spacecraft use either two-component liquid rocket engines (LRE) with a limited set of oxidizer and fuel, or solid rocket engines, differ little from each other.

The Space Rocket Complex with unmanned orbiter as a remote sensing satellite

The research is based on the optimization of the author's previously proposed low-budget version of Rocket and Space Complex (RSC) with a small-sized LV and Unmanned SpaceCraft (USC) [7, 9, 11]. This option is presented in the 50th International Paris - Le Bourget Air Show, June 17-20, 2013. Option for LV RSC without turbopump unit is shown in Fig. 1.

In this embodiment, the hydrogen peroxide can be used without its prior full expansion in the gas generator, which greatly simplifies the design, manufacture and reduces its cost. Option previously presented at the meeting in "Kazkosmos", Astana, 08-09 September 2013.

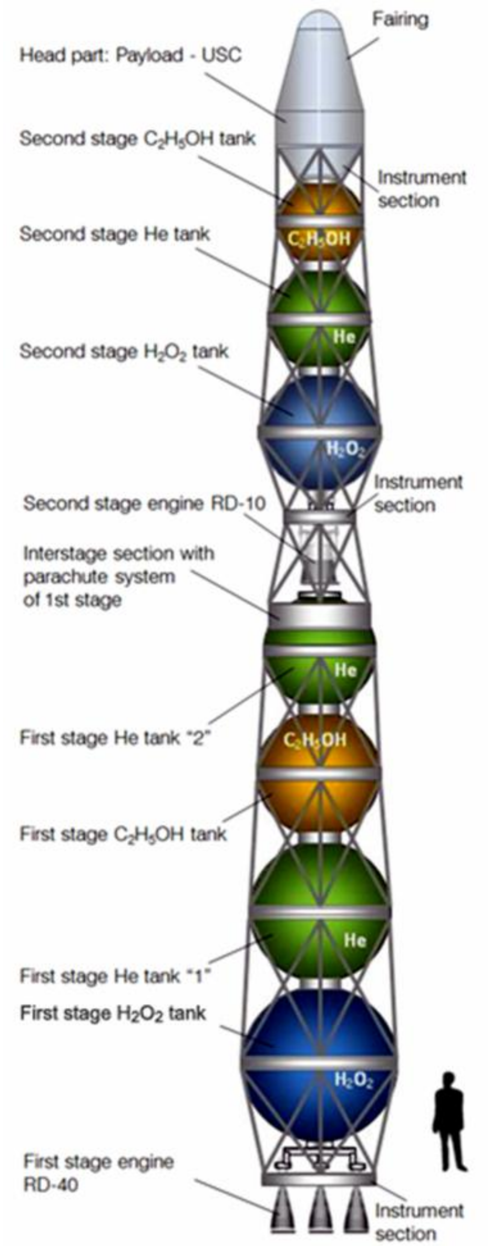

Fig. 1: Structural outline LV-1.2P

Designed layout drawings USC for studies presented in Fig. 2-4. In the schemes, an embodiment of the orbiter capable of performing the function of remote sensing satellite.

1. Oleksandr S. Levenko, General Designer of Space Complexes, email:alexander.levenko@gmail.com
2. Oleg L. Pauk, Designer of Space Complexes, email:paykoleg@ukr.net
3. Vladimir I. Prisyzhniy, General Director, t/f +380444893002, +380444893400, email:vip.17071957@gmail.com

Orbiter design provides rigidly fixed propulsion rocket engine combustor RD-05, and two steering rocket engine chamber LRE-10N-H, each with their oscillation in the same vertical plane.

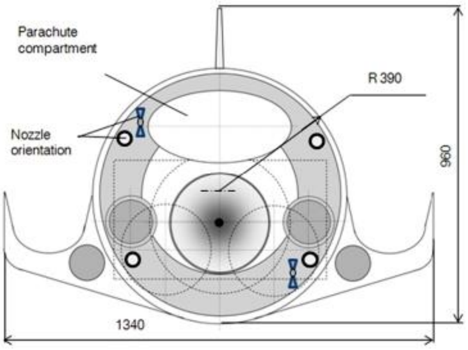

Fig. 2: Orbiter USC view from the stern

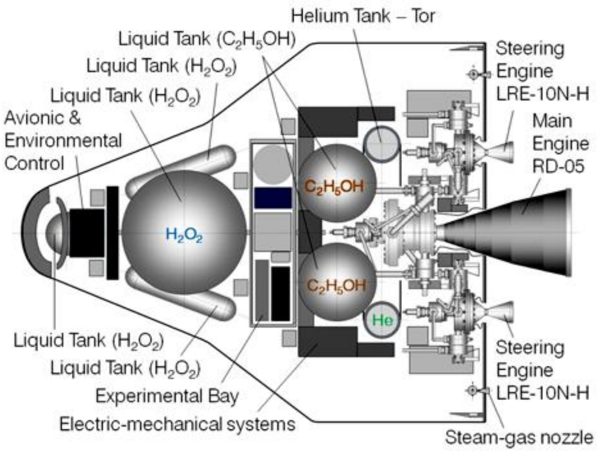

Fig. 3: The orbiter as satellite remote sensing. Top view

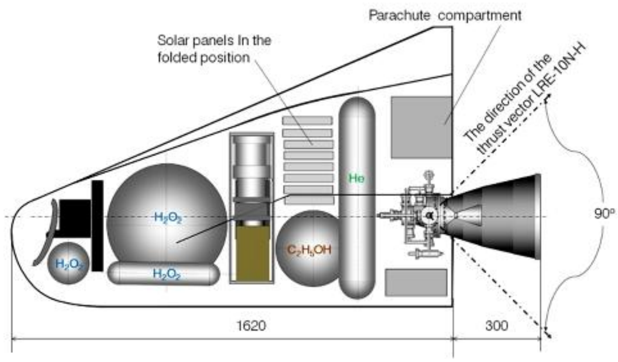

Fig. 4: Orbiter USC. Side view. Changing the direction of the thrust vector steering LRE

LRE chamber steering swing in one plane (in the same or opposite directions). Changing the direction of the thrust vector LRE-10N-H provides maneuvering USC in space on the Aviation. Fuel supply in the LRE-10N-H is provided through the hollow axis of oscillation. In this embodiment, the lowest torque.

Option of the launch vehicle with the tanks of high pressure and USC

Complexes LV 1.1P and LV 1.2P basedat the same booster and payload are distinguished. The first stage of LV lands by parachute.

Fuel tanks LV are made of carbon fiber for high operating pressure. Pressure cylinders is provided with compressed helium (gas pressure of 320-360 kg_f/cm^2 LV design reinforced tubular of aluminum alloy. No need to design and manufacture turbo pump assemblies.

Parameters LV with USC shown in Table 1.

Table 1: Preliminary design parameters LV + USC

Function	Orbital Launch Vehicle + USC	
Author of the project	Alexander S. Levenko	
Country	Ukraine	
	Launch Vehicle	
Model	LV 1.1P	LV 1.2P
Height	24 m	
Diameter, max	3 m	
Mass (start)	31,112 kg	31,516 kg
Stages	2	
Payload to LEO	300 kg (satellite)	504 kg (USC)
Status	Project	
Launch sites	Small-Size LV	ASP Black Sea
	Stage 1	
Engine, LRE	1 RD-40	
Thrust	40,000 kg (sea level)	
Specific impulse	291.62 seconds (sea level)	
Burn time	-	147,6 seconds
Fuel	100_{-2}% H_2O_2 / $100_{-0,1}$% C_2H_5OH	
Fuel supply	pressure helium gas	
	Stage 2	
Engine, LRE	1 RD-10	
Thrust	10,819 kg (vacuum)	
Specific impulse	338.44 seconds (vacuum)	
Burn time	-	141,2 seconds
Fuel	100_{-2}% H_2O_2 / $100_{-0,1}$% C_2H_5OH	
Fuel supply	pressure helium gas	
Orbiter, Unmanned SpaceCraft - USC		
Engine, LRE	1 RD-05 (main engine)	
Thrust	504 kg (vacuum)	
Specific impulse	338.285 seconds (vacuum)	
Burn time (exit to the orbit of 200 km)	65.6 seconds (interruption, the total time to orbit 241 seconds)	
Fuel	100_{-2}% H_2O_2 / $100_{-0,1}$% C_2H_5OH	
Fuel supply	pressure helium gas	
	Steering LRE USC – 2 LRE-10N-H	
Thrust 1 LRE	1.02 kg (vacuum)	
Specific impulse	322.271 seconds (vacuum)	

LV consists of three main elements:

- of one type of spherical tanks for fuel components and helium;
- combustion chamber of the liquid rocket engine of the same type [5, 7, 8] (the LV first stage is used cluster LRE, the second - single chamber; LRE orbiter USC is used single chamber); LRE is used for the manufacture of conventional equipment engineering plant;
- fittings and automatic equipment (valves, regulators purchased on the world market equipment).

Industrial building required for the assembly of equipment and laboratory management system for "cold" engine tests.

Submission of propellants through the cavity in the axes swing cameras LRE. Gas and liquid tanks cavity components separated by a flexible membrane.

A gel cavity and discharge cavity air pressure in the tanks with helium are separated by a flexible membrane.

Liquid Propellant rocket Engine. In an ideal used LRE ecological fuel: ethyl alcohol and hydrogen peroxide contained in the bodies of living beings [10].

First, both of these components are used with a concentration of ≈ 100% [2, 3, 5, 12].

This is allows maximizing the energy of the chemical reaction of hydrogen peroxide vapors + ethanol. The temperature in the LRE combustion chambers almost 1000 ºK lower than in pairs "LOX + kerosene".

Fuel components are not used in cryogenic and normal climatic conditions [1].

Increasing the pressure in the combustion chamber rocket engine to 150-250 kg_f/cm^2 achieves the velocity of the gas from the nozzle at a pair of "LOX + kerosene".

Material combustor steel. Nozzle material "carbon + carbon".

Research model aerodynamic corps USC

Within the limits of given clause the opportunity of creation of the case proceeding from the technical project and functionalities of the USC is analyzed.

Also it is carried out primary (roughly speaking, in "zero approach") aerodynamic calculation by means of the automated systems (program complex SolidWorks) with use of a finite element method (FEM).

SolidWorks – system of the automated designing (CAD), the engineering analysis and preparation of manufacture of products of any complexity and purpose. It represents the tool environment intended for automation of designing of complex products in mechanical engineering and in other areas of the industry.

In a concrete case the analysis of three-dimensional model of the case of the USC is carried out in program addition SolidWorks Flow Simulation. Experience of works in given CAD specifies, that the error in calculations makes the order of 15-20 % that is comprehensible at the initial stages of designing and a choice of optimum design decisions

Choice concept aerodynamic case. The huge experience which has been saved up by mankind in creation of space means, allows to do the certain conclusions concerning the further development of these means. The basic tendency of space techniques influencing development in modern conditions is economic rationality, i.e. the minimal cost of creation and operation of techniques is high-grade carrying out the functions.

And also minimizing electronic components, that, basically, reduces weight of useful loading and does space vehicles by more functional.

Proceeding from it, the increasing urgency is got by inexpensive reusable space systems of an lightweight class. Their cheapness can will conclude in technological decisions or design - optimum there is a complex of these decisions.

For a basis of development which is considered within the limits of the given edition, the concept of "the bearing case" lowered device with hypersonic aerodynamic quality equal to one is taken. It allows the Orbiter in weight about 500 kg. To carry out at a stage of descent lateral maneuver up to 12000 km. from a ballistic line of flight and to lower the sizes of area of landing up to 0,5x0,5 km. The orbital apparatus executed under the scheme "bearing case" has the extended asymmetrical form and is an intermediate variant between winged orbital devices. The Orbiter lands on the bottom with use of a parachute system.

The aerodynamic case proceeding from following tasks which are shown to the given element pays off:

- protection of internal volume against aerodynamic and thermal loadings;
- ability of the case in current of 2 minutes to resist to a temperature stream 76830 kW/m^2;
- the Opportunity of realization of lateral (horizontal) maneuver with the purpose of a correcting area of a landing of the USC;
- adaptability to manufacture in manufacture;
- the Minimal cost of development and manufacture.

Centering of the USC. For convenience of work, on the basis of a preliminary weight report of Orbiter is made the centering sheet (see Table 2).

Table 2: Centerline statement USC

№	Name	Gi, kg_f	Xi, m	Gi·Xi, kg_f·m
1	Payload compartment	38	0,88176	33,50688
2	Balloon-tank with hydrogen peroxide	64	0,56904	36,41856
3	Tank cooling system with hydrogen peroxide (2 pcs.)	48	0,54853	26,32944
4	Balloon-tank consumable cooling system with hydrogen peroxide	5	0,21019	1,05095
5	Balloon-tank with ethanol (2 pcs.)	18	1,10732	19,93176
6	torus-helium tank with helium	30	1,26829	38,0487
7	RD-0.5	70	1,40979	98,6853
8	LRV-10N-H x 2	48	1,53282	73,57536
9	Electromechanical steering gear (2 pcs.)	12	1,47643	17,71716
10	Board control system with batteries and on-board computer	7	0,31784	2,22488
11	Power supply system with batteries	7	1,48668	10,40676
12	Course locator	26	0,23517	6,11442
13	Side-looking radar equipment	20	0,32805	6,561
14	Gas feed nozzle orientation (4 pcs.)	4	1,63048	6,52192
15	The side gas nozzle orientation (4 pcs.)	4	0,789481	3,157924
16	Power rack	10	0,963782	9,63782
17	Temperature control system of the inner compartment a flexible sheath	16	0,994541	15,912656
18	System of solar panels with power equipment unit	8	1,086818	8,694544
9	Extension system of aerodynamic case	14	0,768975	10,76565
20	Parachute system	23	1,507191	34,665393
21	Aerodynamic case	50	1,045806	52,2903

Due saving computer resources made some simplifications three-dimensional model that is valid, taking into account the initial assessment of the characteristics of the device. As a result, three-dimensional modeling in SolidWorks to get 3-D model of the aerodynamic body.

Analysis of aerodynamic parameters of the finite element method in the environment of SolidWorks Flow Simulation.

The analysis is carried out in a design case with maximum aerothermal load and maximum speed pressure.

Use the following parameters requested CAD:

- altitude – 40 km;
- flight velocity – 3000 m/s;
- the temperature of the standard atmosphere at an altitude of 40 km is equal to – 22.75 °C, pressure – 287 Pa.

It is assumed that the speed of a USC before entering the dense layers of the atmosphere is reduced by braking blunt bow of the hull and the use of hypersonic braking unit (HBU) [9], discharged from hull before applying USC normal landing parachute system (HBU performed in a special high-temperature parachute material "carbon + carbon").

The following results:

- force of longitudinal resistance = 19.368 kg_f;
- force of vertical resistance (elevating force) = 0.851 kg_f.

In this case the nose of the apparatus is heated up to 2758 ° C. Even in the conditions of use of CCC to improve reliability requires additional measures to reduce the body temperature. Preliminary study design USC involves the use of forced cooling bow apparatus with recycling of the resulting vapor gas.

Perhaps the use of hydrogen peroxide flight supplies and helium for the organization of the protective film from the “cold” gas on the surface of aerodynamic case USC.

Note that outer casing USC not directly connected with the indoor units – the principle of “thermal bridges” in the form of internal thermal insulation assemblies from the outer casing. Infographics results of the calculations are presented in Fig. 5 and 6.

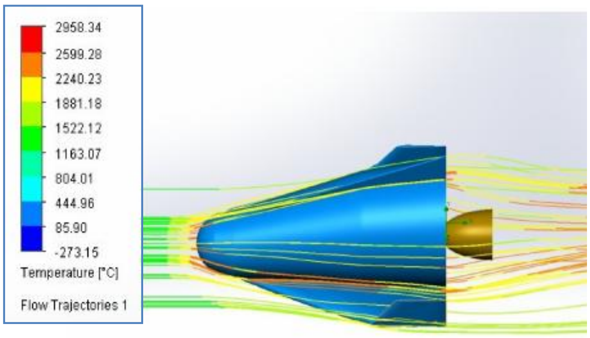

Fig. 5: Wrap the model hull USC gas stream

The results allow continuing research to produce the most effective aerodynamic hull lines USC and to ensure reliable operation of the machine in all operating conditions.

Among the objectives of the following studies:

- optimization of the parameters in the form of aerodynamic bearing housing;
- layout of internal components and refinement USC center of mass system;
- determination of the center of pressure apparatus at various maneuvers in the atmosphere;
- evaluation of the maximum permissible parameters of maneuver in the atmosphere (pitch, yaw and roll);
- clarification of requirements for HBU;
- study of the effectiveness of the forced cooling of the nasal part of the body;
- assessment of the organization on the surface of hull under the detached shock wave laminar flow of protective gas flow;
- evaluation of the position control USC in outer space with the shifted gas nozzle aerodynamic body orientation;
- evaluation of the effectiveness of the use of atmospheric gas nozzle orientation USC;
- to assess the possibility of controlled retractable needle in a wind bow of the hull at short USC controlled flight in the dense layers of the atmosphere with cosmic speeds.

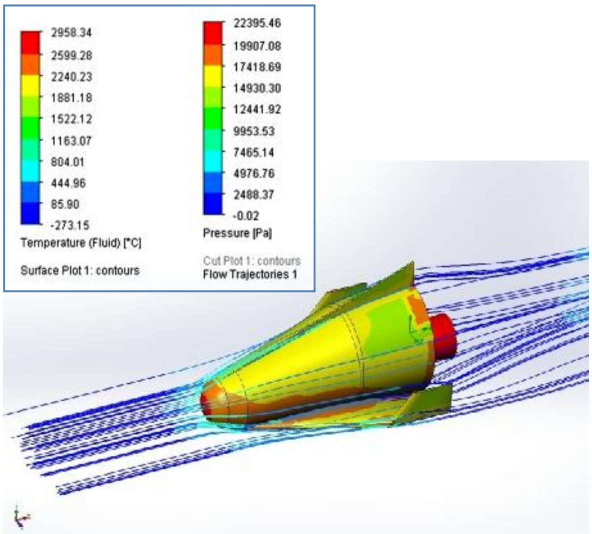

Fig. 6: The aerodynamic heating model hull USC

Evaluation of the results obtained. Carrying aerodynamic case can be effectively used in the design of USC. In view of the relatively small size of the apparatus, and correspondingly low coefficients of the effective surface heat dissipation, USC requires additional techniques of the thermal load.

Project authors assumed for this purpose to use additional ablative coating on graphite (which carries heat from the evaporating surface of the device and which can be restored on the surface of hull to re-flight USC) and the porous structure of the aerodynamic hull, the body is filled by a coolant. Possible to use braking propulsion, obtained by cooling-utilizing the nasal hull steam and gas, for an additional braking device.

In the future, these processes are subject to detailed research.

Conclusion

Presented Space Rocket Complex with USC allows overcomes some of the shortcomings of existing projects returning orbiters:

- high reliability trouble-free return to Earth in terms of aerodynamic heating is provided by solid carbon fiber hull structure unrelated to the indoor units and not having the outer surface of any elements that create local wind resistance; heat removal in the front part of the machine design reduces heat when properly secured aerodynamic characteristics;

- design Rocket Space Complex and USC of small and relatively inexpensive, does not require, including a specially equipped spaceport to start Launch Vehicle and the first stage of landing using a parachute system, the orbiter lands using a parachute system;

- space flight speed in "diving" orbiter into the dense layers of the atmosphere can be maintained using a retractable wind needle position, it provides flight control;

- the maximum possible in the Earth orbiter removal from the plane, combined with atmospheric jet MS using liquid cooling, cooling the frontal part of the cabinet, with its transition into the gas phase.

This complex of Ukrainian specialists can create in cooperation with foreign colleagues and businessmen in the context of the commercialization of space research and engagement of private initiative in the framework of global trends.

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