HYDROCARBON POLYMERS FILLED BY METAL HYDRIDES AS FUEL AND STRUCTURE MATERIALS FOR SPACE TRANSPORT SYSTEM

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Such well-known events as stopping of the “Space Shuttle” program, closing of the NASP and “Buran” programs etc. give the reason to think about the design and operation crisis in the field of reusable space transport systems based on the traditional principles.

At the beginning of the XX century Ukrainian pioneer of cosmonautics Alexander Shargey (Yury Kondratyuk) proposed as minimum two ideas, which can be used as the base of perspective space transport systems [1]. At first, this is the consumption of propellant components in solid state and transforming they in gas state before feed in engine. At second, this is the use of rocket structure elements as propellant components.

The variant of the ideas realization based on advanced achievements is presented in the fig. 1. The traditional liquid oxidizer is in the tank. The solid tank shell is used as fuel. The shell material is gasified in the melting chamber and is fed in the engine by means of the compressor. The engine is approached at the cargo compartment by means of thrust as fuel is consumed [2].

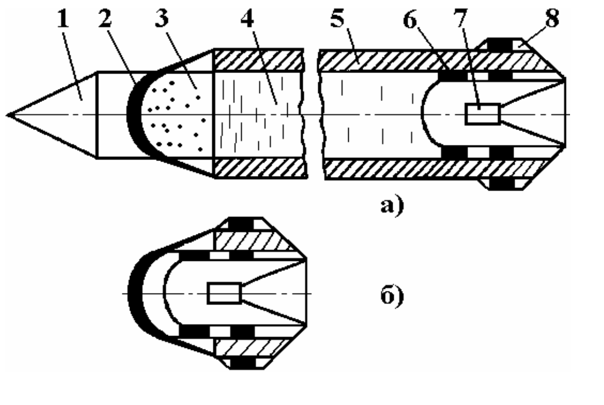

Fig. 1. The scheme of reusable launch vehicle with combustion of tank shell: 1 – cargo; 2 – reenter module; 3 – gas pad; 4 – liquid oxidizer; 5 – solid fuel; 6 – magnetic powder adaptive seal; 7 – engine; 8 – melting chamber; a) – at the start; б) – after propellant was consumed, at the reenter to Earth

As we think, the hydrocarbon polymers are very expedient materials for the shell of the combustion rocket. For example, polyethylene (PE) is fully transformed at gaseous products of thermal destruction by temperature near 750 K [2]. PE as rocket fuel is better of wide using up-to-date kerosene because PE content more amount of hydrogen and have more high density etc. (see tab. 1, 2). The possibility of filling of polymers by powder with metal contents, for example, metal hydrides is special advantage of these materials. The advantage will allow to increase the specific impulse of thrust and to deliver from the fuel stability problem, which is stumbling-block for use of the suspensions based on traditional liquid propellants. The polymers will protect hygroscopic hydrides having high reaction ability from environment also.

The main part of PE is transformed at the gas and is fed in the engine by means of the compressor. The lesser part of PE is melted and is fed in the engine together with the filler in the suspension or colloidal solution state by means of the friction or volume pump or the injector.

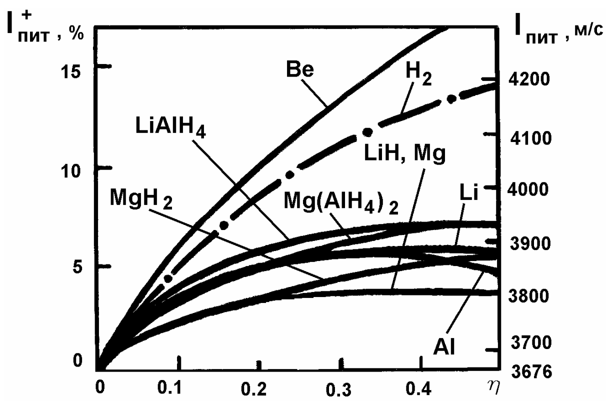

Fig. 2. The theoretical specific thrust impulse $I_{ПИТ}$ and his increase $I^{+}_{ПИТ}$ vs. the filler mass part in fuel η for PE-oxygen propellant

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Table 1

Some characteristics for PE with kerosene comparison

Fuel	Contents of carbon in 1 kg, kg	Contents of hydrogen in 1 kg, kg	Enthalpy (293 К), kJ/kg	Symbolic chemical formula	Density, kg/m^3	Toxic property, mg/m^3	Need to have the tank for keeping on a rocket
PE	0,86	0,14	–1330	$(C_2H_4)_n$	0,91...0,97	Non toxic	No
Kerosene	0,87	0,13	–1840	$C_{7,21}H_{13,29}$	0,82...0,85	300	Yes

Table 2

Main theoretical characteristics for the PE and kerosene based propellants.
The pressure in the combustion chamber is 25,3 MPa. The pressure in the nozzle outlet is 0,02 MPa.

Oxidizer	Fuel	Heating value of the propellant, kJ/kg	Vacuum specific thrust impulse, m/s	Temperature in the combustion chamber, К	Temperature in the nozzle outlet, К	Stoichiometric course of the propellant components
Oxygen	PE	6100	3680	3900	2400	3.4
	Kerosene	6000	3640	3890	2400	3.4
Hydrogen peroxide (98%)	PE	5130	3320	3020	1100	7.4
	Kerosene	5070	3300	3000	1100	7.3

According to our calculations the maximal increase of the specific impulse (near 5 %) will be realized by means of filling PE by 20...30 % (at mass) of lithium or magnesium aluminium hydrides [3], fig. 2. The minimal effect will be in case of lithium hydride use by reason of his low enthalpy of formation.

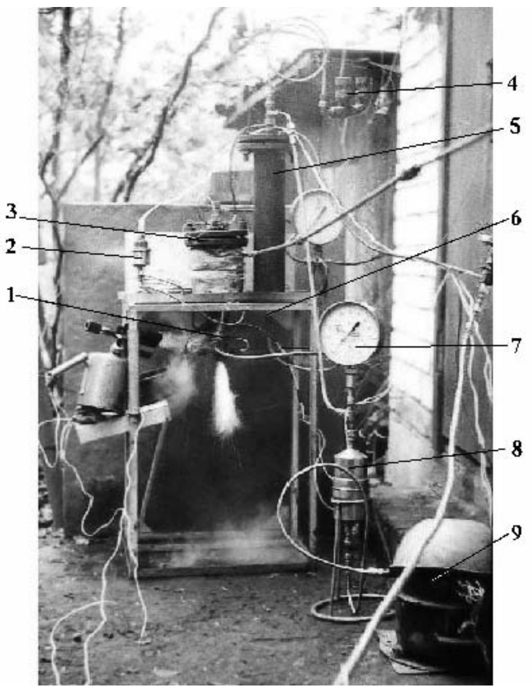

Fig. 3. Overview of the experimental installations: 1 – combustion chamber; 2 – oxidizer valve; 3 – chamber for gasification of PE; 4, 5, 6, 7, 8, 9 – cooling system elements

The combustion of metal hydrides will give possibility to increase the cargo mass at 20 % in case of single stage launching on the low Earth orbit.

We made the successful experiments with the model of rocket engine on the PE-gaseous oxygen propellant. Solid PE was transformed at the gaseous products of thermal destruction by means of the electric heater. These products were ejected in the combustion chamber, fig. 3. The experimental results show that proposed propellant can be used in the rocket technology.

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