IAC-09.C4.8.13

DEVELOPMENT OF IGNITION SYSTEMS FOR 200N AND 500N THRUSTERS WITH ECOLOGICALLY – CLEAN PROPELLANTS: 94%HTHP+KEROSENE AND OXYGEN (GAS) + KEROSENE

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ABSTRACT

The important meaning for impulse LRE of small thrust (LREST) is dynamical characteristic of ignition, especially for non-self ignition propellants. MAI for LRE of small thrust development and research different type of ignition for components HTHP + Kerosene (catalyst, electrospark) and Oxygen (gas)+Kerosene (electrospark, glow plug).

The catalyst ignition system use solid catalyst (granules with special coating) development in GNIIChTEOS (Russia). The HTHP transmitted through the catalyst cartridge decompose with out temperature 1000K. The ignition arise in contact with cone of dispersion of kerosene from injectors. The experimental tests define the ration of mass flow of HTHP and mass of solid catalyst for preservation the activity of catalyst for ignition and define the function mass loss by burning time.

The base parts of electro spark ignition are high voltage transducer and build-in electro spark injector, that were development. Prechamber of electro spark ignition feed the small values of mass flow components because the goal of system is initialize the flame. To estimate of delay time of ignition the mathematical model of transient processes in combustion chamber is developing. The model includes geometry of mixing heads, model of valves, spark characteristic, gas dynamic heat transfer.

FULL TEXT

Using high concentration hydrogen peroxide

The use of high concentration hydrogen peroxide (HTHP) in the rocket engines was beginning in 30-th ears of last century as monopropellant. It was connected with putting into technology of its production in Germany.Verner Von Braun –designer of famous rocker V-2-was using 80% HTHP for the drawing of turbo pump of liquid rocket engine at propellant LOX +C2H5OH.

This direction use active till the presents in the engines RE – 107, RE – 108 and their last modifications at carrier rockets "Vostok", "Souse" and others for drive of turbo pump [1].

Next developments of rocket engines for different applications with the use HTHP as monopropellant and bipropellant also are continued. Among this development there are main engines, gas generators, thrusters, micro engines (see Table 1).

Positive properties of HTHP are ecological cleanness, high density and enough wide diapason of the existence in liquid phase. Besides, comparatively not high temperature of the products of decomposition lets to use its for drive of turbo pumps and to organize the afterburning in combustion chamber.

To the negative properties of HTHP may relate its inclination to the decomposition by contact with many materials and substances [2]. However, with fulfilling main exploitation requirements (right choice of design materials, the cleanness own HTHP and feed system) the stability of HTHP is guaranteed.

The mixture HTHP with fuel is non self ignition, therefore engine must have ignition system.

Purpose	Country	Rocket	Oxidizer	Fuel	Thrust	Isp	Combustion chamber pressure	K_m
Gas generator	Germany	V-2	80%H_2O_2	-	-	-		
Gas generator	Russia	Carrier rocket “Souse»	82%H_2O_2	-	-	-		
Main engine	England	Black Knight launch,1-stage, Gamma-8	85-88% H_2O_2	Kerosene	256 KN	2457 m/sec ε=80	4.8 MPa	8.2
Main engine	England	Black Knight launch,2-ст, Gamma-2	85-88% H_2O_2	Kerosene	69.4 KN	2600 m/sec ε=350	4.8 MPa	8.2
Main engine	Russia	РД 161П 3-d stage of carrier rocket «Souse»	90%H_2O_2	kerosene	24.5 13.7	319c 317c	12.23 MPa	5.9
Main engine	US General Kinetiks Corporation	AR-2-3	90%H_2O_2	JP-5	1485-2970 kg	256c	19 atm	8
Monopropellant thruster	General Kinetiks Corporation	GK-PD006-201-001	85% H_2O_2	-	25lbf	143c		
Thruster	General Kinetiks Corporation	GK-PD035-201-001	90%H_2O_2	RP-1	250lbf		Inlet pressure>500psia	
Thruster	China,Shanghai Institute of Space Propulsion		H_2O_2	kerosene	200N	2850 m/sec	0.8 MPa	7.0
Thruster	Россия МАИ	ДМТ МАИ-500	93%	kerosene	500N	2950 m/sec	1 MPa	7.2
Micro engine		TRF-MRE	80-96%	ethanol	1N	230s		

Table1. Engines with HTHP oxidizer.

Ignition systems.

Analyzed in the work [3] ignition systems – electro spark ignition, plug ignition, catalyst and gas dynamic ignition system may by used, in principle, and for propellant HTHP + kerosene.

For the gas dynamical ignition it is necessary to have source of gas and feed system by resonator. Besides, it is necessary to place resonator at limited on sized mixing head. These conditions except the use gas dynamical ignition for thrusters at liquid propellants.

Electro plug system has big inertia, need special forchamber and its use for pulse regimes is enough problematically. For stationary regime work electro plug ignition find application [4].

Design of electro spark ignition system consists from transformer of board voltage and spark candle, mounted in central part of mixing head. Developed in MAI electro spark system showed good results at LREST DMT MAI-200-OKer at propellant O2gas + kerosene (Fig. 1). Small size of transformer of voltage (24v →10Kv) let to assembly its with mixing head, don’t increase admissible dimension. Analogically electro spark ignition system for propellant HTHP + kerosene was placed at the head of LREST DMT MAI-500-HTHP. Section of the head’s design is introduced at Fig.2.

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Fig. 1 Mixing head with electro spark Ignition, engine DMT MAI-200-OKer

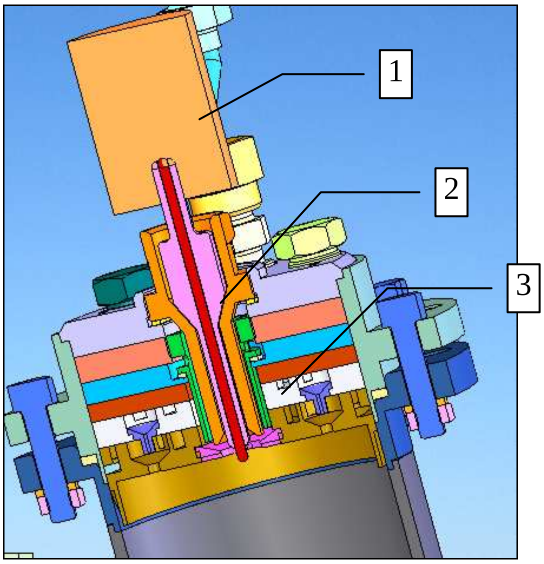

Fig. 2. Section of DMT MAI-200-OKer mixing head. 1 – transformer, 2 – electrospark, 3 –mixing head.

Using the properties of HTHP, two types of catalytic ignition of propellant HTHP + kerosene were tested with dissolved in kerosene catalyst Mn(C5H7O2)2 – acetilacetonat magnum of germane fabrication (Merck, Schuchardt, 85662, Hohenbrunn) with decomposition HTHP at solid catalyst and following ejection of kerosene in the products of decomposition.

In the first case, if mass part of catalyst consist ≥ 2%, propellant becomes self ignition with time delay of ignition about o.o3s. However, acetilacetonat magnum don't dissolve in kerosene directly, therefore it is necessary intermediate dissolver. We used xylidin – C6H3 (CH3)2NH2 . Laboratory testes was shown [5] reliable ignition kerosene with catalyst during contact with HTHP.

After the mixing with catalyst, dissolved in ksilidin, kerosene can not considered ecological clear fuel (limited admissible concentration 3mg/m3). Besides, during the long time keeping is realized isolation of catalyst from kerosene and its sedimentation under influence of gravitation field.

It is necessary to continue search of new possibilities for dissolution acetilacetonat magnum in kerosene, because the obtaining ecological clean and self ignition propellant at the base HTHP and kerosene is very perspective direction.

The engines DMT MAI-200-HTHP with 1 and 7 injectors were developed with decomposition HTHP at solid catalyst (see Fig.3). In the both mixing heads was used solid catalyst Ж-30-С-О, developed in State Research Center of Russian Federation «GNIIChTEOS». Catalyst was filed in corresponding cavities in form of grains with size of grain ≈2*2*2mm. The tests were shown reliable ignition of the mixture during the single and repeated starts.

Fig. 3 Photography the one-injector mixing head of the engine DMT MAI-200-HTHP with catalyst ignition system

For finishing of engines DMT MAI-200-HTHP and DMT MAI-500-HTHP with spark and catalyst ignition systems was used fire stand of department №202 of MAI.

Conclusion

Short fire tests were fulfilled at the head of engine DMT MAI-200-OKer with electro spark ignition (Fig.4), at the head of engine DMT MAI-200-HTHP 1-injector (Fig.5) and at the head of engine DMT MAI-200-HTHP 7-injector (Fig.6) with catalyst ignition system. Analogically fire tests were fulfilled at the fire stand “NADEJDA” Chungnam National University.

All fulfilled tests submitted the design solution of the mixing head and possibility of use investigated ignition systems.

Fig. 4. Ignition test of mixing head of engine DMT MAI-200-OKer (HTHP + ker, electrospark ignition)

Fig. 5. Ignition test of mixing head of engine DMT MAI-200-HTHP 1-injector (HTHP + ker, catalyst ignition)

Fig. 6. Ignition test of mixing head of engine DMT MAI-200-HTHP 7-injector (HTHP + ker, catalyst ignition)

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