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CHEMMOTOLOGIC ASPECT OF AIR POWER PLANTS RELIABILITY

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The problem of chemmotologic fundamentals development of air propellants operational quality is reviewed. Having analyzed some physicochemical properties of propellants to reliability of air power plants reliability, in particular on the combustion chamber and also design measures, existing in air practice, which will allow to expand propellants assortment in further.

Problem

Comparing to propulsive masses, which have been used in airplane hydraulic, oil systems long enough, fuel burns down during the flight. Therefore, at early stages of engine building of operational properties underestimation of propellants took place. The gained flight exploitation experience of airplanes has shown that the simplified consideration of fuel as a one-time use liquid can result to reliability drop of a fuel system and engine [1–8]. Therefore the rigid requirements to fuel parameters and properties were determined.

At the same time, the advance successes in materials technology, modern know-how's and design solutions have allowed today to lower unfavorable fuel factor operating considerably.

However, local normative requirements to quality of air propellants have remained practically at a former level. The modern petroleum production technologies and maintenance in Ukraine, especially their economical compounding, make us to look at quality of propellants newly. All this also has defined such scientific problem as chemmotologic fundamentals development of air propellants operational quality by optimization of their properties. Meaning "the operational quality" of fuel implies, its physicochemical properties and their changes both during haul and storage, and at opening-up for charging, finding in an airplane fuel system.

The purpose of the given activity is the definition of influencing rate of propellants physicochemical properties on air power plants reliability, in particular to the combustion chamber, and analysis and estimation of design measures, existing in air practice, which will allow to expand assortment of propellants in further.

Base material summary

The maintenance practices of local and foreign turbine jets have shown, that each hour of their activity the engine functional parameters are degraded: the thrust decreases is augmented to 1,5–3%, the specific consumption of fuel to – 2,0–6%. In many respects, it is connected to burn deposition. It is necessary to mark, that its formation goes into number of engine operational lacks.

As a rule, the burn is sidetracked in a combustion zone on sides of the flame tube body, on elements of the front device, on end surfaces injectors [9].

In some cases, the layer of a burn can completely superimpose outlets of fuel injectors. Thus, for example, in some engines 2–3 g of a burn can be put aside for one operating hour.

The carbon deposition depends on many factors and, first, on combustion chamber design, engine operation conditions and, certainly, on fuel properties (fig. 1). What among them are dominating and what methods of protection exist today and will be in future - that is the problem, which we shall try to answer.

The combustion chambers can be of personal type (MiG-15, MiG-17, Il-28), ring-type (Il-62, Tu-154, Tu-334, An-124, An-224, An-72, An-74), tubular – ring-type (Tu-124, Tu-134, Tu-204, Il-96). As has shown in-service experience and researches [8], with other things being equal by virtue of design defects some types of engines are capable to accumulate in one combustion chamber of personal type up to 1, 5 kg of a burn. The advancing of jet engine parameters and design-layout schemes has resulted today to preferential use of ring-type and tubular - ring-type types of combustion chambers.

Experimentally it is established, that the burn is formed, first, in engine zones strongly enriched by fuel, its quantity depends on air propellants properties [10]. At the same time, as has shown in-service experience and researches [3; 9–11], the fouling also depends on engine design and operational technologies. There are combustion-chamber pressure, engine operation time, combustion chamber design, heat input of primary and secondary air. From design of air vortex generator, front device, way of heat input along the chamber of secondary air the organization depend both perfection of mixing processes and combustion.

Therefore, for example, the increase of heat input of air to the front device promotes fall-off of quantity of carbon depositions [9; 12].

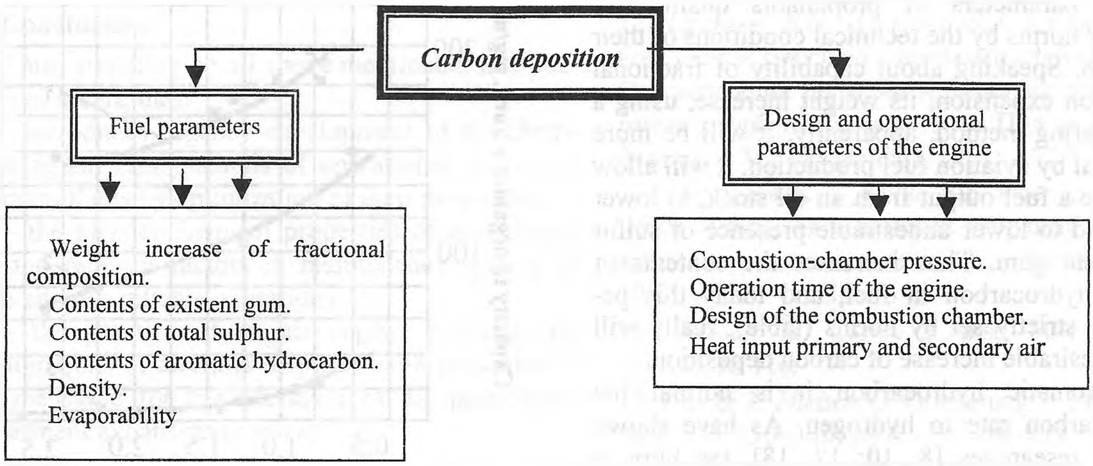

Fig. 1. Influencing fuel, design factors on parameters of the engine

In activities [9; 13] is paid attention to organization of definite airflow flow, which provides canceling a contact of fuel air mix with sides of the flame tube body.

In 1947 E. Watson, I. Clarke in the researches showed legible relation of burn of deposition in the combustion chamber to mixture enrichment rate [14]. The increased heat input of primary air to the combustion chamber with other things being equal, reduces sharply hydro carbonaceous depositions quantity. And the way of air delivery along sides of the combustion chamber, as operational experience has shown [14; 15], reduces notably fouling intensity (fig. 2).

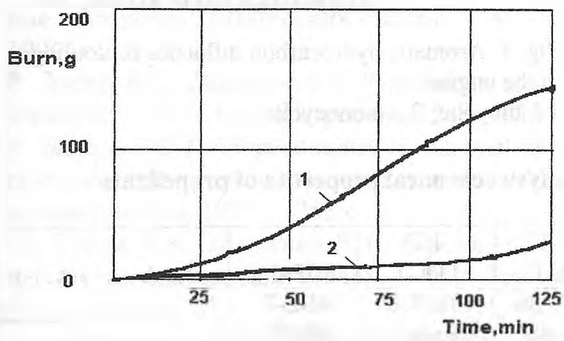

Fig. 2. Quantity of a burn depending on receipt of secondary air:
1 – secondary air absences; *2* – secondary air goes near a wall of the combustion chamber

In researches [16] it is established, that the fouling is influenced by injector design of air passage, which determines air flow consumption through a channel. The increase of injector passage diameter reduces quantity of burn.

The recompression before injectors, increase of air temperature, which goes to the combustion chamber, also promote reduction of burn, improvement of fuel sputtering and its evaporability.

The improvement of mixing process is promoted also by quantity increase of fuel supply points (up to 100–160 and more). It results to intensive process of fuel - air mixing.

There is an opinion [17], that combustion chambers creation of a turbine jet, which will provide fuel combustion without fouling and smoke, is quite probably but for an aero-engine it is less suitable because of narrow limits of stable combustion.

Nevertheless, constant process of combustion chambers advancing, namely their gas-dynamic and design characteristics [11; 18], allows to conclude reality of steps to this direction. It is necessary to pay attention to development of combustion chambers at this connection [18–23], grounded on the essence new schemes, of working process organization: homogeneous, micro combustion, with replaceable geometry and others.

Let's consider in more details the influence of propellants physicochemical properties on engine function ability.

First of all here it is necessary to note, that fuel grade drop expresses in disturbance of engine power settings, drop of its power, heightened fouling, destruction of turbine blades [8; 10; 17].

Speaking about the combustion chamber, from the point of view of its normal activity maintenance to propellants are showed series of the obligatory requirements. First of all, these are good capacity to sputtering (viscosity of fuel), good evaporability, absence of mechanical impurities which are capable to drive of an injector, and certainly, minimum propensity to cause fouling and smoke in exhaust gases.

The propensity of propellants to carbon deposition is predetermined, first of all, the aromatic and naphthalene hydrocarbon, heightened contents sulphur compounds and existent gum. It is established also, that the heightened contents of sulfur connections promote seal and strengthening of burn [17].

These parameters of propellants quality are strictly set norms by the technical conditions of their production. Speaking about capability of fractional composition expansion, its weight increase, using a hydro clearing method, apparently, it will be more preferential by aviation fuel production. It will allow to increase a fuel output from an oil stock, to lower its cost and to lower undesirable presence of sulfur and existent gum. Thus increases the contents of aromatic hydrocarbon in fuel, and today this parameter is strictly set by norms (table); really will cause undesirable increase of carbon deposition.

For aromatic hydrocarbon it is normal the greatest carbon rate to hydrogen. As have shown numerous researches [8; 10; 17; 18], the burn is formed in zones considerably enriched with fuel, as a result of three mutually bounded processes.

These are: cleavage reacting of a hydrocarbon output molecule, reacting of thermal dehydrogenation (splitting of hydrogen atoms) and polymerization of the formed fragments of rigid carbon, which also make the fundamentals of smoke and burn.

Laboratory and flight tests [8; 10; 24] were defined, that by the greatest capacity to organize burn has bicyclical aromatic hydrocarbon (fig. 3, 4).

The monocyclic aromatic hydrocarbons are less inclined to carbon deposition and the paraffin – naphthenic hydrocarbon practically does not organize burn. As drop of carbon deposition it is possible to use the dopes against a burn, which until present have not received broad applying at quantity production of air propellants. Today, by consideration the capability of qualitative characteristics change of propellants, it is very important to adapt them for modern engineering. And development in the field of dopes to propellants is great enough [16; 19].

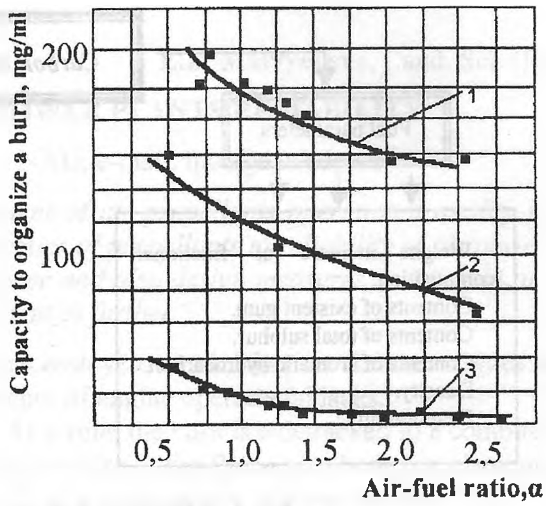

Fig. 3. Capacity to organize fuel burn of the TC-1: *1* – bicyclic aromatic hydrocarbon; *2* – monocyclic aromatic hydrocarbon; *3* – paraffin – naphthenic hydrocarbon

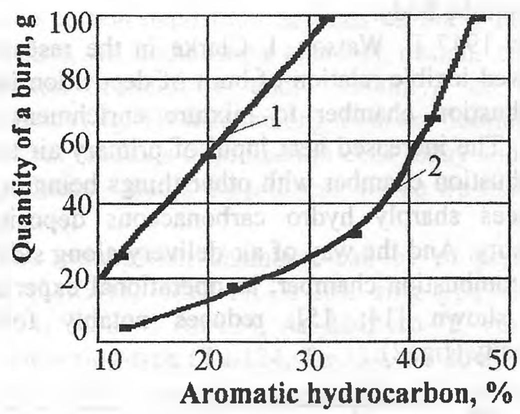

Fig. 4. Aromatic hydrocarbon influence on fouling in the engine:
1 – bicyclic; *2* – monocyclic

The comparative characteristic of the main physicochemical properties of propellants

The naming of parameters	TC-1 ГСТУ 320.00149 943.011-99 (Ukraine)	PT ГСТУ 320.001149 943.007-97 (Ukraine)	TC-1 ГОСТ 10227-86 (Russia)	PT ГОСТ 10227-86 (Russia)	JP-5 MiL-7-5624M	Jet A	Jet A-1
						ASTM 1655	
The contents of aromatic hydrocarbon, % vol., no more	22	22	22	22	25	25	25
The contents of naphthalene hydrocarbon, % of weights, no more	1,5	–	2,0	1,5	–	3,4	3,4
Concentration of existent gum, mg on 100 $sм^3$ of fuel, no more	5	–	3	4	7	7	7
Mass fraction of total sulphur, %, no more	0,2	0,2	0,2	0,1	0,4	0,3	0,3
Mass fraction a mercaptan of sulfur, %	0,003	0,003	0,003	0,001	0,002	0,003	0,003

Conclusions

Thus, summing up all above mentioned, it is possible to assert, that:

– introduces urgency development of the chemmotological fundamentals of operational quality of air propellants by optimization of their properties;

– the physicochemical properties of propellants are the relevant factors in maintenance system of aero-engines reliable operations;

– the practice of an air engine building and exploitations of aircrafts disposes experience that is indispensable for consideration of air propellants assortment expansion problem.

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О.Л. Матвєєва

Хіммотологічний аспект надійності авіаційних силових установок

Розглянуто проблему розробки хіммотологічних основ експлуатаційної якості авіаційних палив. Проаналізовано вплив деяких фізико-хімічних властивостей палив на надійність авіаційних двигунів, зокрема, на камеру згоряння.

Е.Л. Матвеева

Химмотологический аспект надежности авиационных силовых установок

Рассмотрена проблема разработки химмотологических основ эксплуатационного качества авиационных топлив. Проанализировано влияние некоторых физико-химических свойств топлив на надежность авиационных силовых установок, в частности, на камеру сгорания.