

### **Materials of new generation for perspective aerospace engineering**

*The article reveals the prospects of transition to a new technological level of development of the aerospace industry, ways to implement developments on the introduction of new aviation materials and technologies on the basis of research and experience of leading foreign specialists.*

As international experience shows, it is impossible to create competitive products out of the foreign materials available in the world market, that is, without the creation of new materials of the domestic industry, it is extremely difficult to make progress in technologies and maintain advanced positions in the world market.

Prospects for the transition to a new technological level for the development of the aerospace industry, the implementation of innovative, breakthrough developments in the introduction of new aviation materials and technologies on the basis of research and experience of leading foreign specialists should provide for the creation of a state program, the main conditions for implementation, according to experts [1], are:

1. Creation of advanced scientific and technical reserve. This is possible only in the case of the development of broad fundamental and fundamentally oriented research in cooperation with the institutes of the National Academy of Sciences of Ukraine in cooperation with the leading branch institutes and universities.

2. Development of technologies and materials that have minimal impact on the environment, the so-called green technologies. New technologies should be based on closed processes, using information technology to model the composition, structure and properties of materials, technology of molecular assembly, nanotechnology, when waste is either minimal and safe, or completely absent (with waste not only chips, waste rock and waste water, but also heat emissions, irrational energy use).

3. Realization of the complete life cycle of the material from its creation, maintenance (taking into account the possibility of extending the life of the material in the finished product) prior to its utilization with minimal losses and damage to the environment.

At present, work is underway to improve the reliability, mass efficiency of aviation and space equipment, its strength and resource characteristics through the development and implementation of a new generation of structural materials with better performance characteristics and properties than those used [2].

Work is under way to develop new compositions and technologies for the production of thin but solid rolled products, as well as hybrid structures using a new class of materials - laminated aluminum-plastic materials called "sial", and abroad - "glare". Resource tests showed that the crack in such material under working loads practically does not increase [3].

Work is underway to create high-temperature alloys of a new generation, which improve the reliability and life of gas turbine engines.

In addition, in order to reduce the mass of gas turbine engine designs, in particular, to reduce the mass, increase reliability, increase the life and reduce the prime cost of turbine blades and rotor components and the stator of a high-pressure compressor, work is underway to create heat-resistant materials based on titanium intermetallic compounds.

Importance of high-temperature heat-resistant alloys for dies and special protective antioxidant coating, which is simultaneously a high-temperature lubricant during deformation, is of great importance [4].

Coatings increase the durability of the die tooling by two or three times. The implementation of the developed manufacturing techniques for stamping provides an increase in the metal utilization factor by two to three times due to the reduction of technological allowances during the stamping and machining process and the reduction of the labor input of production by three to five times due to the reduction of operations during stamping and final machining of parts, cost of stamping in one and a half to two times.

Alloys and coatings for dies will allow small-sized gas turbine engines to be manufactured with high-quality disc blanks from high-strength nickel and high-strength titanium alloys by a new economical method of thermomechanical processing - isothermal stamping in air (this procedure is carried out in a vacuum throughout the world, which significantly increases the cost of production).

In solving problems of improving the mass, strength and resource characteristics of aircraft, polymeric composite materials (PCM) have become one of the main places among structural and special materials in aircraft, helicopter and space engineering [5].

A wide range of PCM: carbon, glass, organoplastics and hybrid materials based on them - is in demand by various enterprises of the aviation, space industries and the defense-industrial complex. The volume of their application reaches 50% of the weight of the airframe, ensuring its reduction by 20...25% (with the share of aluminum reduced to 15%) [3].

Work is underway to develop heat-resistant ceramic composite materials that are operable to temperatures of 1600°C without cooling (based on the prototype of a flame tube), work on the development of a new generation of structural ceramic, glass-ceramic monolithic and composite materials based on refractory compounds capable of operating up to 2500°C, resistant to corrosion, with high wear resistance.

Great importance is attached to the protection of materials, parts and structures of aircraft against corrosion, aging and biodeterioration (experts have calculated [2] that in developed capitalist countries the cost of losses associated with corrosion is 3...4% of gross national income, and metal losses from corrosion in the world already make up about 30% of its annual production).

In addition, in terms of protecting the material from corrosion, erosion and even from charging static electricity, work to increase the longevity, as well as thermal, wear and erosion, paint coatings. In the foreseeable future, multi-layer, thermo-, wear-resistant, erosive and nano-modified paint coatings capable of self-

diagnostics and reproductivity will appear longer (30...35 years of service), and these works include work to reduce the visibility of aircraft.

One of the main conditions for the implementation of the program for the transition to a new technological level for the development of the aerospace industry is the solution of the problems of utilization and the minimum impact on the environment. To do this, it is necessary to create a production facility equipped with modern technological and testing equipment.

One of the important directions for the development of the science of materials in the near future is the creation of "smart" designs. Intellectual materials for their creation have such properties as:

- shape memory (restoring the initial configuration of the part after the load is removed);
- the ability to self-repair, for example, restoration of continuity after the formation of a crack;
- the ability to reversibly change the internal structure of the material, depending on the operating conditions.

Some metals already have such properties, but in the near future there will appear similar in properties polymers and composite materials that will be able to adapt to aerodynamic and other mechanical loads, will be able to signal a change in the stress-strain state. Probably, this will be achieved due to the inclusion of fiber optic, resistor and piezoelectric sensors in the composition of materials.

Of great interest are the work on the creation of "foam metals" for products that replace cellular structures in the hulls of aircraft, some elements of the construction of cars and ships. In the future, a foamed material based on iron and nickel with a density of 6 times lower than that of a monolithic but sufficiently high modulus of elasticity will be created.

It should be noted that in solving all these problems, it is very important to achieve cooperation between national research universities, research institutes and aerospace industry enterprises, including training (such results can only be achieved with specialists of the highest qualification) and in improving the management system quality.

The use of new materials and technologies entails an increase in aircraft technical and resource indicators, but is associated with an increase in the market value of the product [6].

## **Conclusions**

As promising tasks for manufacturers of aircraft (and the creators of new structural materials for their solution) can be called:

- development and serial production of aircraft entirely and on the basis of domestic materials. In new aircraft, intelligent polymer composite materials with the function of adaptation to aerodynamic loads, materials with variable surface geometry based on piezoelectric or polymeric components with shape memory, and many others will be widely used;
- in civil aviation, it is required to significantly increase the life of aircraft engines, to increase their economy by 10 ... 15%, to achieve a significant reduction in emissions of harmful substances and noise levels, to halve the laboriousness of

maintenance of gas turbine engines through the use of new heat-resistant materials, materials for high-gradient heat-shielding coatings of turbine blades, structural composite materials capable of operating at operating temperatures up to 2200 K (without cooling and coatings) under vibration and thermal conditions loadings with an overhaul life of not less than 4000 hours.

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