

Features of aircraft operation in tropical climate conditions

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Abstract. The paper considers the issues of climatic resistance of materials and means of protecting aircraft (AC). It has been established that the solution of these issues is at the intersection of several sciences, primarily applied climatology, materials science and the science of the reliability of complex technical systems. Particular attention is paid to the consideration of corrosion processes that aircraft are exposed to in the humid tropics and subtropics (India, Venezuela, Cuba, Indonesia, Vietnam, etc.), which is due to the intensive operation of Soviet and Russian-made aircraft in these regions. **Keywords:** aircraft, corrosion processes, climatic factors, technical climatology, tropical resistance, microbiological damage.

1 Introduction

The continuous impact of the external environment greatly complicates the solution of the problems of maintaining aircraft (AC) in good condition, ready for use, ensuring a given service life and reliability indicators.

Changes in the functional properties of materials used in aircraft structures (metals, plastics, rubber, etc.) or in operation (technical fluids, lubricants, etc.) lead to a decrease in the operational properties of structural elements, assemblies, assemblies, etc. In general, the impact of climatic factors reduces the reliability of the aircraft [1].

The ability to maintain the properties of materials and means of protecting the aircraft used in the manufacture, for a given time of exposure to adverse climatic factors, is conveniently characterized by climatic resistance.

The issues of climatic resistance of materials and aircraft protection means are at the intersection of several sciences, primarily applied climatology, materials science and the science of the reliability of complex technical systems.

Currently, depending on the accepted criteria, several climate classifications have been developed (Köppen, Berg, Budyko, Thorndike, Alisov).

Köppen climate classification — one of the most common classification systems. In the Koepper-Geiger edition, all climates of the Earth are divided into five groups according to

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the temperature regime and the degree of moisture, with the assignment of a specific designation to each group, while each group includes several subgroups [2]:

- tropical climate (A);
- dry climate (B);
- temperate climate (C);
- continental climate (D);
- polar climate (E).

The characteristics of the climatic criteria of the groups are largely determined by the geographical location of the territory and remoteness from the ocean and are characterized by certain intervals of temperature, precipitation, humidity and other meteorological and special parameters [3].

2 Model and method

Technical climatology — branch of applied climatology. Applied climatology studies the causes of climatic differences and changes, their practical consequences for human activity, technical climatology studies the consequences of climate influence on the technical condition of technical products [4].

One of the main tasks of technical climatology is to identify external influencing factors, the mechanism and degree of their influence on equipment and materials. As a rule, there is a simultaneous action of several factors in various combinations.

As an example, for metals, the most significant factors on the impact of which the development of the corrosion process depends are the duration of the metal surface wetness, the level of concentration and type of corrosive components polluting the atmosphere, and temperature.

For polymer materials, the most significant factors that affect the intensity of physical and chemical processes are the presence of moisture on the surface, the dose of the ultraviolet component of solar radiation, the surface temperature of the material, the concentration level and the chemical composition of particles in the atmosphere.

The influence of some factors (for example, solar radiation or wind), in some cases, is partially offset by the placement of equipment in shelters or hangars [5].

In tropical conditions, where the presence of water vapor in the air causes or initiates chemical, physical and biological processes, constant monitoring of air humidity is of great importance.

Figure 1 shows a fragment of a map with a classification of groups of climate zones in Southeast Asia [2].

According to this classification, there are only 16 main climates on Earth.

To draw conclusions about the features of the climate, long-term observations of the weather are necessary, for example, for a tropical type of climate, 5-10-year observations are used. The minimum duration of a weather type is determined by a period of one year.

Classification of climate according to meteorological and special parameters makes it possible to classify aircraft operating conditions and assess the aggressiveness of climatic factors in relation to various materials and means of protection and unify the requirements for the resistance of products to the effects of climatic factors [6].

The statistical values of the parameters of climatic factors are established by GOST 24482-80, GOST 25650-83, GOST 25870-83 and are used in the development of aircraft operation and storage modes, rules for their maintenance and repair (TO and R), predicting the service life of products, changing the properties of materials and means of their protection in specific areas of operation.

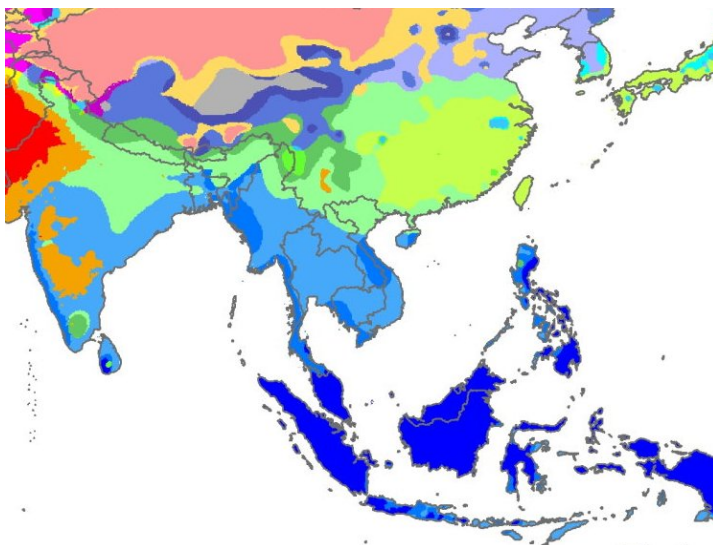


Fig. 1. Fragment of the map with the designation of the Earth's climate groups (Southeast Asia) in the Köppen-Geiger classification.

Therefore, state and industry standards that establish the requirements for the resistance of products to the effects of climatic factors, primarily the class of EUZKS standards, should be systematically reviewed, refined and contain up-to-date information on the impact of climate on products in the respective geographical areas of their operation. To do this, it is necessary to have an idea about the processes that change the functional properties of materials and protective equipment, and therefore it remains relevant to study the processes of corrosion, aging and biodamage (CSB) under the influence of both individual natural and climatic factors and their combinations [7].

The ESZKS class of standards is designed to ensure and maintain a given level of quality of products, structures and materials, means and methods of protection against corrosion, aging and biodamage, taking into account the requirements of safety, ecology, compatibility and interchangeability, as well as the competitiveness of products and structures in the world market [8].

This class of standards includes more than 150 standards developed on the basis of the standards of the International Organization for Standardization (ISO) taking into account the requirements of the standards of other international and regional standardization organizations (IEC, CEN, etc.).

On the globe, the humid tropics and subtropics occupy about 20% of the land surface. In these regions of the world (India, Venezuela, Cuba, Indonesia, Vietnam, etc.), Soviet and Russian-made aircraft are intensively operated. Therefore, accurate and objective information about the characteristic damage to materials of parts, assemblies and assemblies of systems operated in these areas is important.

Tropical regions are characterized by:

- long periods of high temperature and relative humidity, and their significant fluctuations during the day;
- condensation of moisture on the hidden surfaces of the equipment, due to a decrease in the nighttime and morning hours of air and material temperatures below the dew point;
- intense solar radiation;
- high activity of microorganisms that damage the surface of products and affect their performance.

Long-term and simultaneous impact of these climatic and biological factors on the materials of parts, assemblies and systems leads to acceleration of metal corrosion processes, aging of non-metallic materials and their biodamage, leads to a decrease in the electrical characteristics of materials and a decrease in their mechanical strength, causes chemical degradation of varnishes, paints and most plastics [9].

Ultimately, in the tropics, all this affects:

- decrease in the reliability indicators of electrical and radio products in the first 2-3 years of operation (mainly due to elevated temperature and humidity);
- reduction by 1.5-2 times of the service life of rubber products (located on the outer contour of equipment products) [10].

The experience of long-term operation of modern aircraft has shown that the most significant external influencing factors of the tropical climate that have a negative impact on their technical condition include:

- high levels of relative humidity and ambient temperature;
- solar radiation;
- the presence of corrosive impurities in the air (chlorides, sulfides, nitrates, etc.);
- biological factor in the form of a wide variety of microorganisms, mold fungi, bacteria, termites, insects.

The combined effect of these factors contributes to more intense corrosion damage to metal parts of the airframe, failures of aircraft electrical and radio equipment units, aging and biodamage of parts made of non-metallic materials.

3 Research and results

Tropical resistance - this property of aircraft protection materials and means to maintain the required level of functional characteristics during and after exposure to tropical climate factors and biodamages for a given period of time.

Aircraft tropical resistance studies, as a rule, are combined with the performance of maintenance and repair work.

Work on the study of the tropical resistance of aircraft includes the following stages:

I - study of operational documentation, industry bulletins by type of equipment;

II - study of the numbered documentation (forms and passports) of the aircraft, logs for recording failures and malfunctions located in the operating organization (EO), obtaining meteorological data for the period that has passed since the date of the last study of the technical condition of the aircraft;

The study of aircraft number-by-number documentation is necessary to clarify the lists of replacements of blocks and assemblies for the period that has passed since the date of the last study of the technical condition of the aircraft, and the logs of failures and malfunctions - in order to collect information on failures and malfunctions of the aircraft for the same period. The possible causes of the identified failures and malfunctions are discussed with the senior engineering staff, including those due to corrosion, aging and biodamage [11]. Meteorological data are necessary to determine the climatic conditions of operation in the region:

- average daily maximum and minimum temperature;
- average daily maximum and minimum humidity;
- average annual temperature and humidity;
- average daily temperature fluctuations;
- average annual rainfall;
- average annual precipitation;
- average annual number of days per year with dew formation;

- change in average monthly air temperatures, relative humidity, number of sunny days, amount of precipitation.

III - study of the technical condition of the airframe structure, aircraft systems and removable units.

These studies are carried out by external examination of all the load-bearing elements of the product design, blocks and assemblies of equipment, aircraft airframe skin, etc. available for this.

Corrosion damage of metal parts of the airframe, components and assemblies, as well as the condition of products made of polymeric materials is assessed by a general visual inspection of the structural elements of products both outside and inside in accessible places to the maximum extent possible using a magnifying glass of 4-7 times.

As a result of the study of the tropical resistance of the aircraft:

- the effectiveness of the applied means and methods of protection against CSF;
- list of malfunctions (damages) associated with the influence of external influencing factors of the tropical climate;
- type and degree of corrosion damage, aging and biodamage, possible causes of their occurrence, the degree of their compliance with the allowable specified operational documentation;
- type and scope of necessary repair and restoration work to eliminate corrosion damage, aging and biodamage;
- the possible impact of the detected damage associated with the CSF on the performance of products during their further operation.

IV - in-depth study of aircraft electrical and radio equipment units with a low level of reliability when operating in tropical conditions;

An in-depth study of aircraft equipment units and system assemblies, when operating in tropical conditions, is carried out by personnel of relevant specialties.

V - drawing up a report with an analysis of the influence of tropical climate factors on the damage of airframe metal parts, components and assemblies, products made of polymeric materials and equipment blocks of the unit's aircraft [12].

The following information is included in the report:

- information about the aircraft of the operating organization and the conditions of their operation;
- a list of parts, assemblies or assemblies that have undergone corrosion, aging or biodamage, with a description of the type and degree of damage;
- analysis of the causes that caused the CSF (low effectiveness of protective equipment, improper operation, CIT, etc.);
- conclusion on the technical condition of the aircraft;
- practical recommendations for operating organizations to reduce the impact of adverse climatic factors on equipment in operation and refined requirements for tropical resistance [13].

A systematic approach to identifying the general patterns of degradation of materials and means of their protection under the influence of climatic and microbiological factors of the tropics provides:

- analysis of external influencing factors on the aircraft in the tropics;
- collection, processing and analysis of statistical information on aircraft failures and malfunctions;
- identification of general patterns of degradation of the functional properties of materials of the most damaged parts, assemblies, electrical and electronic components of the aircraft and means of their protection under the influence of climatic and microbiological factors of the tropics;

- selection of methods for monitoring the technical condition of the most damaged parts, assemblies, electrical and electronic components of the aircraft;
- solving problems of predicting changes in the tropical resistance of aircraft and materials;
- study of new methods of integrated protection of aircraft and technical means for implementing these technologies;
- development of methods and practical recommendations for improving the performance properties of materials of insufficiently reliable parts, assemblies, electrical and electronic components of the aircraft and means of their protection.

4 Aircraft biodamage

The reliability of technical products, in particular aircraft, is largely determined by their resistance to the influence of the external environment, the natural component of which are microorganisms (microscopic fungi, bacteria, yeast, etc.). Microorganisms-destructors (biofactor, biodestructors), acting on aircraft objects, cause damage to the latter (biodamage, microbiological damage): a change in structural and functional characteristics up to destruction [14]. The processes of biodamage are especially active in tropical conditions at elevated temperature and humidity. It should be noted that the features and patterns of the impact of the biofactor have been studied to a much lesser extent than the effect on the objects of technology of non-biological factors such as temperature, mechanical stress, light radiation, aggressive environments of technogenic origin, etc.

World damage from biodamage in the 1950s was estimated at 2% of industrial output, in the 1970s. it exceeded 5%. Currently, losses from biodamage reach enormous proportions: more than 7% of the total cost of industrial products on a global scale, which amounts to hundreds of billions of dollars [15].

The emergence and widespread use of new generation materials stimulated the formation of new forms of microorganisms that adapt to living on new substrates that did not previously exist in nature. Thus, there is a real threat of the impact of technophilic microorganisms on aircraft facilities, accompanied by accelerated destruction and aircraft equipment failures. Systematic cases of occurrence of violations in the onboard equipment of the aircraft were registered during the operation of the aircraft in tropical conditions. Underestimation of this factor has a consequence - a decrease in the reliability and non-failure operation of products [16].

Biodamage (biological damage)— this is any change (violation) of the structural and functional characteristics of an object of anthropogenic origin or natural objects used as raw materials that arise as a result of the activity of living organisms (biological factors). Biodamage is considered as a negative consequence of the vital activity of biodestructor organisms for structural materials [17].

Arising as a result of the relationship of biological and anthropogenic-technological factors, biodamaging effects develop in time and space.

A **biological factor** is understood as living organisms or their communities, the impact of which on an object causes a change in its properties in an undesirable direction for a person. Such organisms are also called biodamaging agents or damaging organisms.

The intensity of biodamage characterizes the bioresistance of an object. Biostability is the ability to maintain the value of indicators within the limits established by regulatory and technical documentation for a specified time in the process or after exposure to biodamaging factors [18].

One of the factors aggressively influencing aircraft materials and parts is biodamage by microorganisms. In this regard, the problem of VS biodamage is one of the important.

It is known that parts made of non-metallic materials used in aircraft (rubber products, parts made of nylon, foam plastic, leather and various fabrics) are subject to aging processes and the effects of mold microorganisms, especially under conditions of high temperature and humidity. A favorable combination of high temperature and humidity contributes to the intensive development of molds that cause biodamage of non-metallic materials. The appearance of microfungi is facilitated by water contained in the nutrient medium or material, as well as unventilated and darkened compartments of the aircraft, which do not get ultraviolet rays [19].

There is an assumption that even corrosion and especially rusting of iron is caused by microbes that feed on iron and obtain energy from its oxidation. Of these microbes, feeding on the energy of chemical oxidation reactions (initiated by them), Chemobacteria are the best known. Among them, iron bacteria were also discovered that oxidize iron. So why not be microbes that feed on other metals as well? Why not assume that it is they who cause the infection of the metal, its disease - corrosion, which spreads like an epidemic? The very nature of metal damage during corrosion, rusting most of all resembles that found on plants affected by a fungus. There is a powdery coating, round plaques, foci of oxides that grow radially, like the mycelium of a fungus (round spots of mold and mushroom rings in the forest), and peeling, rust flakes, scars, ulcers, like late blight potatoes, and uneven growths, layers. These structures bear little resemblance to the usual forms of excretion of products of chemical reactions, but they have much in common with the picture of plants affected by the fungus. It is not for nothing that our ancestors aptly dubbed the red, noxious plaque caused by the fungus on the golden ears of wheat with the same terrible word - "rust". Apparently, they were well aware of the analogy between the diseases of iron and wheat [20].

5 Conclusion

It has been established that for metals the most significant factors that influence the development of the corrosion process are the duration of the metal surface wetness, the level of concentration and type of corrosive components polluting the atmosphere, and temperature. For polymer materials, the most significant factors that affect the intensity of physical and chemical processes are the presence of moisture on the surface, the dose of the ultraviolet component of solar radiation, the surface temperature of the material, the level of concentration and chemical composition of particles in the atmosphere. In addition, it was found that the long-term and simultaneous impact of climatic and biological factors on the materials of parts, assemblies and systems leads to an acceleration of metal corrosion processes, aging of non-metallic materials and their biodamage, leads to a decrease in the electrical characteristics of materials and a decrease in their mechanical strength, causes chemical degradation of varnishes, paints and most plastics

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