UDC 629.7.067

A.S. Bychkov, PhD Law
(State Scientific and Research Expert-Forensic Center
of the MIA of Ukraine, Ukraine)

Criteria of safety and effectiveness of replacing materials for tribotechnical purposes for aircraft friction units

The classification scheme of basic types of compositions, the flow diagram of forming operational characteristics of antifriction materials and the criteria of safety and effectiveness of replacement in aircraft friction units have been synthesized and major purposes for replacement of basic antifriction materials have been set forthв.

Around ¾ of units' failures are caused by wear and tear of friction pairs. If considering that the aircraft control system, landing gear, hydraulic system, etc. are the systems that work as their elements move, it is then understood that reliable operation of the elements is vital [1 – 3].

Tribotechnical materials are conditionally divided into antifriction materials and friction materials which are meant to convert mechanical energy to heat energy, however, the conversion should be minimum in the first case and maximum in the second case [2].

Considered below are antifriction materials.

An analysis of relatively numerous information sources generalized in monographs [1 – 3] allowed a synthesis of the classification scheme of basic types of antifriction material compositions (Fig. 1) including two primary subclasses - casting alloys and sintered materials.

Basing on an in-depth analysis of the information sources [1 – 3] *et al.,* a block-diagram for establishing chief operational characteristics of antifriction materials has been synthesized (Fig. 2). The block-diagram includes basic functional antifriction properties which make up 3 group characteristics and additional functional properties which support regulated operating modes for relevant friction pairs, 4 group characteristics and 12 complex properties which determine single and/or group properties of friction pairs.

The antifriction materials of basic compositions (Fig. 1) have been studied in sufficient detail for marshalling their primary operating characteristics systemized in the block-diagram (Fig. 2). At the same time, the problem of a system synthesis of criteria of safety and effectiveness of antifriction materials replacement is at the outset of solution.

Let us start realizing the conceptual approach to the criterial assessment of effectiveness of rational replacement of various compositions of antifriction materials as set out in [4]. Complex criteria of operation [4], such as reliability, cost effectiveness, performance are in complete accord with the operating characteristics shown in Fig. 2. A number of operational properties (static and dynamic strength, hardness, bearing capacity, wear resistance, fatigue strength, fracture toughness) are components of the complex criterion 'Limit states'.

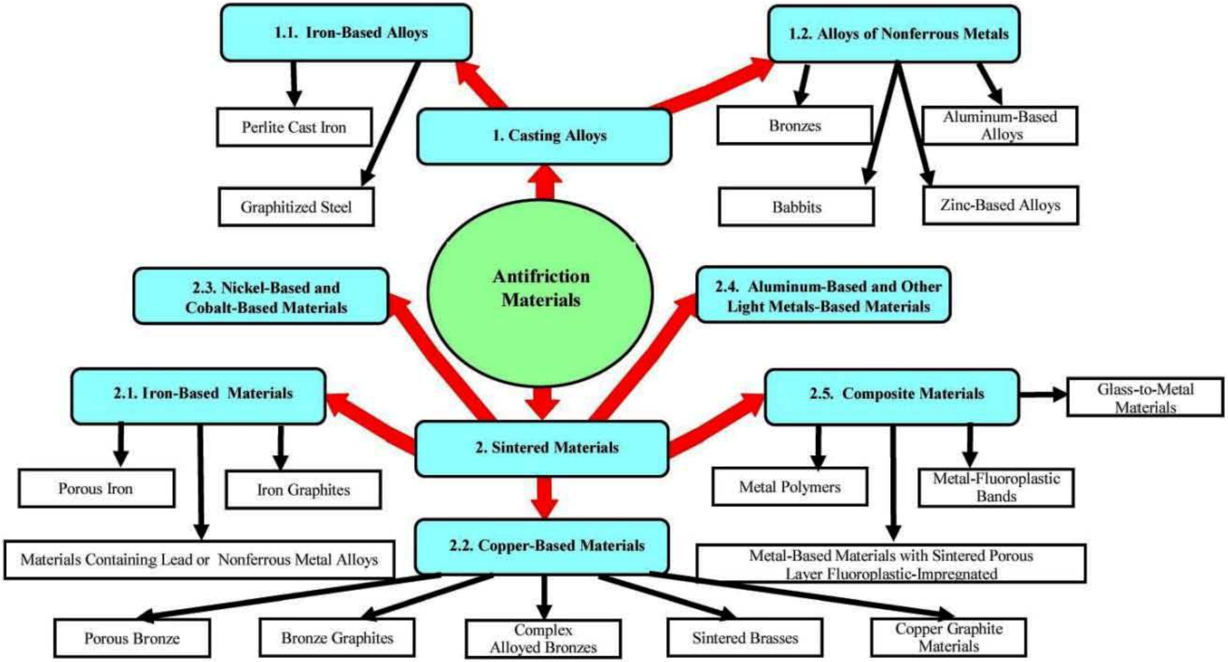

Fig. 1. Classification scheme of basic types of antifriction materials compositions

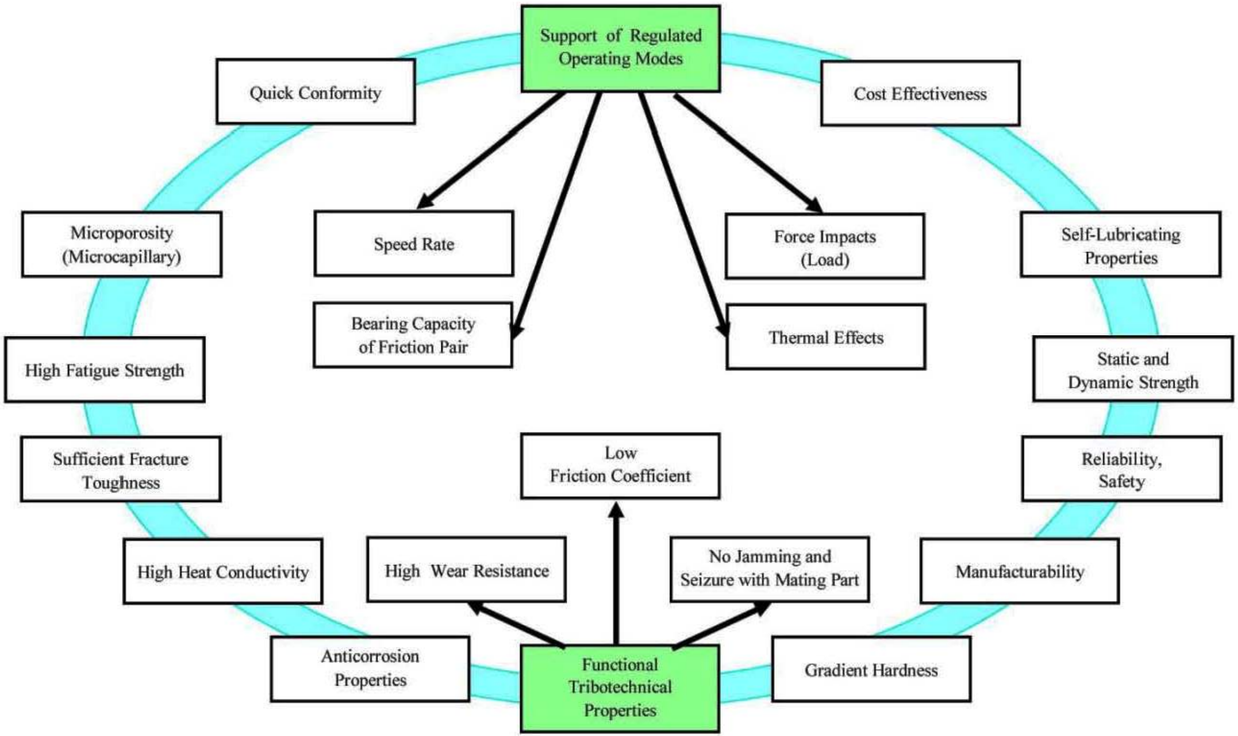

Fig. 2. Block-diagram for establishing basic operational characteristics of antifriction materials

By analogy with [4], the relative integral criterion of replacing antifriction material $\overline{K}_{\text{int}}$ is found by the relationship

$$\overline{\mathrm{K}}_{\text{int}} = \sum_{i=1}^{n} \alpha_{\text{i}} \overline{R}_{\text{compl i}} \left(\overline{K}_{\text{i}} \right) > 1, \qquad (1)$$

where $\overline{R}_{\text{compl i}} \left(\overline{K}_{\text{i}} \right)$ is the i -th complex criterion of replacing antifriction material $R_{\text{af i}}$ related to the similar criterion of the basis material $R_{\text{af bas i}}$

$$\overline{R}_{\text{compl i}} \left(\overline{K}_{i} \right) = \frac{R_{\text{af i}}}{R_{\text{af bas i}}}, \qquad (2)$$

α_{i} is a rating factor for relevant complex criteria (Fig. 2) that is defined by way of expertise.

The relative complex criteria $\overline{R}_{\text{compl i}} \left(\overline{K}_{\text{i}} \right)$ as part of (1) as constituents include relevant group criteria

$$\overline{\mathrm{K}}_{\text{compl i}} = \sum_{i=1}^{m} \beta_{i} \overline{R}_{\text{gr i}}, \qquad (3)$$

$\sum_{i=1}^{m} \beta_{i} = 1,\ \beta_{i}$ are the rating factors for relevant criteria $\overline{\mathrm{K}}_{\text{gr i}}$ assigned by the decision-maker basing on appropriate expertise of assessments.

In turn, $\overline{\mathrm{K}}_{\text{gr i}}$ include single criteria $\overline{\mathrm{K}}_{\text{sin i}}$

$$\overline{\mathrm{K}}_{\text{gr i}} = \sum_{i=1}^{r} \gamma_{i} \overline{R}_{\text{sin i}}, \qquad (4)$$

$\sum_{i=1}^{m} \gamma_{i} = 1,\ \gamma_{i}$ are the rating factors for criterion $\overline{\mathrm{K}}_{\text{sin i}}$.

If, when lowered, the complex criterion constituents as part of the material to be replaced tend to enhance, by their nature, the efficiency (growth) of the complex criterion, the relative complex criterion of such a replacement should be reflected by inverse dependence in relation to (1).

The analysis of the most significant aims of replacing basic antifriction materials highlighted the following:

– longer life and higher reliability of antifriction friction pairs in aircraft through improvements in the functional tribotechnical operational characteristics of materials;

– lower cost of antifriction materials;

– lower operational expenditures for fabrication of antifriction parts for friction pairs;

– phased-out imports of antifriction materials;

– higher production safety, labor protection, and environmental requirements to industrial standards to meet.

Conclusions

1. The classification scheme of basic types of antifriction material compositions which differ in performance values in given friction pairs operating conditions has been synthesized.

2. A block-diagram has been elaborated for establishing primary operational characteristics of antifriction materials including basic and additional functional antifriction properties which ensure regulated working modes for appropriate friction pairs as well as 12 interrelated complex properties which make up any particular group and single characteristics.

3. Relevant classification components of the operational characteristics tally with relative criteria of effectiveness of antifriction materials that have been defined numerically within the proposed conceptual approach to the criterial evaluation of a possible increase in performance of aircraft parts.

References

1. Special Technologies and Materials of Powder Metallurgy / D.S. Kiva, S.A. Bychkov, O.Yu. Nechyporenko, I.G. Lavrenko. – K.: KVITS, 2014. - 664 p.

2. Structural Materials in Aircraft Construction / A.G. Molar, A.A. Kotsyuba, A.S. Bychkov, O.Yu. Nechyporenko. – K.: KVITS, 2015. - 400 p.

3. Powder Materials for Aviation and Rocket-Space Technology / A.A. Kotsyuba, A.S. Bychkov, O.Yu. Nechyporenko, I.G. Lavrenko. – K.: KVITS, 2016. - 304 p.

4. Bychkov A.S. A Conceptual Approach to the Criterial Assessment of Possibilities for Improving Performance of Aircraft Parts Molded by the Methods of Powder Metallurgy [Text] // Design and Manufacture of Aircraft Structures: Proc. of N.E. Zhukovsky National Aerospace University “KhAI”. – Issue 4(92). – Kharkov, 2017. – P. 42 – 53.