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Dynamic of damage of aircraft engine high-speed rolling-element bearings tested in low-viscosity model mediums

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Abstract

Analysis of the results of studies in a low-viscosity model medium of high-speed ball bearings, racers and rolling elements made of corrosion-resistant 95H18Sh steel with a massive bronze separator on a special multipurpose installation was carried out. Water was used as the low-viscosity model medium in accordance with GOST 2874-82. The dynamics of damage formations on bearing working surfaces, depending on the level of load-velocity parameters and on the pumping rate of lubricoolant water medium, was demonstrated. A limit level of contact stresses was established, above which damages of working surfaces have a pitting character; while under contact stresses not exceeding this limit, working surfaces are exposed only to mechanochemical wear. Recommendations for developers of bearing assemblies on the ascertainment of permissible load levels on bearings in the design of rolling contact bearings were given.

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Keywords: rolling-element bearing; low-viscosity model medium; permissible load level; pitting; corrosion-mechanical wear.

1. Introduction

During the creation of aircraft engine high-velocity rolling contact bearings, it is required to solve problems connected, firstly, with the durability of the bearing main elements, the rolling bearing which usually function in low-viscosity liquid fuels (kerosene, cryogenic mediums etc.). As it is well known, rolling element bearings with solid bronze or polymeric fluorine separators are used for the mentioned operating conditions, while racers and rolling elements made of corrosion-resistant steel type 95H18Sh. Complexity of development of the calculation

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methods for prognostication of the durability of the mentioned rolling element bearings caused by complexity of the process dynamics in their working zone.

The internal dynamics of the processes in bearings, which forms a degree of breakdown of the working surfaces, as shown in work [1-3], depends on many influencing factors. Above all, it depends on the nature of the low viscosity medium, defining the boundary friction mode on the contact area, depends on the level of the load-velocity parameters, on the pumping rate of the lubricoolant and on some other factors. Now in scientific and technical publications, there are very few papers work devoted to the research of problems durability of rolling element bearings with low viscosity greasing and cooling with working fluids. An analysis of the available research results of their performance [1-3; 10-12] has shown that main damages of working surfaces are mainly wear and in some cases, pitting with the destruction of the bearing. However, these mentioned studies did not consider the problems of occurrence manifestation dynamics of bearings degree of breakdown and assessment of the limit contact load parameters that determine the changing of one type of damage (wear) to the other type (pitting). It should be noted that wear is generally not considered as a failure if the bearing provided the given service life and its technical condition after tests conforms to requirements of the product technical specifications, while pitting damages of working surface lead to failure of bearing performance.

2. The aim and objectives of research

The purpose of this work is to define permissible and limit values of load parameters, for aircraft engine rolling element bearings, operating in low-viscosity media, characterizing the changing of damage mechanism from permissible gradual corrosion-mechanical wear to an impermissible catastrophic pitting of bearing working surfaces.

To reach the set objectives, the research problem of the dynamics of contact damages of bearings at bench-tests in a wide range of stresses, speeds of rotation and pumping rates of low viscosity model medium was solved with the consecutive assessment of bearing wear factor and the conditions of their working surfaces.

3. Testing aids and methods of testing

The testing of rolling element bearings was conducted on a multifunctional bench tribounits, which meets the specific operating conditions of various tribological units in the low viscosity medium of the working fluids. The bench tribometer consists of a test head 1, an actuator from a single-stage axial air turbine 2 (see figure 1) and control panel of monitoring and recording control console (not shown on the diagram). The test head consists of a common case 3 and the actuator shaft 4, combining all its main components. Shaft 4 is supported at one end on a carriage support bearing 5, con-structed with the capability of self-adjustment during shifts, and at the other end on the test bearing 6, placed in a sealed compartment 7. Axial 8 and radial 9 loading mechanisms of the test object are located in the middle section of actuator shaft 4.

The tribometer makes it possible to conduct studies of different tribological unit, include radial and radial-stop rolling element bearings, with racer internal diameters from 25 mm to 45 mm. During tests, basic operational parameters were implemented in a wide range, including full-sized: for pumping the lubricoolant medium (water, kerosene, etc..) from 0 to 2 dm3/sec; rotational speed from 0 to 30 000 per minute; stress if could be implemented either as radial loading from 0 to 7,5 kN or axial – in the range of 0 to 10 kN, and combined loading with the simultaneous application of radial and axial loads in any combination in specified intervals. A special information-measuring system based on a computer system was used while conducting tests for the measurement and recording of all the parameters, including test tribological unit parameters as well as technical machine unit parameters.