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DETERMINATION OF TECHNICAL STATUS, CAUSES OF WEAR AND FAILURE OF MACHINE PARTS USING THE METHODS OF METALLOPHYSICAL ANALYSIS

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Abstract: The use of the scanning electronic microscopy and other methods of metallophysical analysis as well as the methods of nondestructive testing allows objectively identifying failure causes connected with the wear and breakdowns of machine parts and implementing the monitoring of their status in operating tectnical equipment.

Key words: Technical status; metallophysical analysis; wear; failure; machine part.

The on-condition operation of technical equipment implies the availability of reliable methods and means allowing in field conditions the life-limiting defects of machine parts to be detected. The analysis of results obtained over the 15-year examination of the causes of failures of aeronautical engineering associated with breaking down or wearing parts makes it possible to conclude that these cases are as a rule of law-governed in character and attributable to one of the following causes: imperfection of a design or manufacturing techniques, low quality of part manufacture, or operating errors.

A system of techniques, criteria and potrable flaw-detector devices was developed and introduced in the practice of operational engineering service which allow both promptly detecting the pre-failure status and causes of breaking down and wearing machine parts based on the metallophysical analysis. The effectiveness of this system is well illustrated by an example presented of estimating the serviceability of standard-type machine units like rolling-contact bearings, gear transmissions, spool-and-sleeve pairs in early stages of their operation or tests.

As applied to precision spool-and-sleeve friction pairs of control devices of fuel and hydraulic units of aeronautical and other complicated equipment operating under conditions of oscillatory movements of their parts, considered as hezardous are the seizure taking place even at microscopic segments of their actual contact.

In spool-sleeve control devices even a temporary augmentation of friction violates the principle of monitoring the variations in pressure or working fluid consumption and leads to defective operation of the entire system.

The character of damages appearing in the course of operating fuel-control and hydraulic units could not be explained by actions of solid particles becoming trapped between parts. The cause of part damages which result in disrupting friction stability of little-moving spool-sleeve pairs is the seizure of mating surfaces over the segmant of their contacting.

Considered in terms of modern ideas regarding the conditions of the origination of inter-part seizure in friction, this phenomenon as applied to above-mentioned spool-sleeve pairs did not find explanation, which hampered woking out the measures aimed at its prevention.

Finding out the seizure causes and possible failures of spool-sleeve pairs created a demand for studing both the peculiarities of part damages and the loading conditions including the absorbed contact loads and relative movements.

The damages caused by the seizure of mated moving parts operating under the conditions of contact-vibratory loading is characterized by the following indications.

Such damages have the form of senarate breakaways, accumulations of metal particles and scratches directed along the generatrixes of cylindrical surfaces of the parts. Sometimes damage dimensions are so small that they can only be revealed with the aid of a metallographic microscope with a magnifying power of 30-100.

The damage of above-mentioned character on one of the part of a precision pair have alwais the reciprocal ones on the mated surface of the other part. This being so, by the shape, dimensions and relative positions of the damaged segments on mated surfaces of the parts look like the mirror images of each other.

The dimensions of individual local damages on the spool and reciprocal ones on the sleeve are incommensurably less than the working stroke of the spool relative to the sleeve, which is indicative of appearing the seizure as a result of micromovements vibratory in character. In controlling spool-sleeve pairs this corresponds to a steady-state mode of controling device operation.

During seizure on the furfaces of the parts in the contact zone changes in metal state occur accompanied by its significant hardening. When etching the surfaces of the precision pair, the regions not etched are revealed called white layers, which are formed in the damag ezone. This suggests that phase transformations take place in part's matarial cccompanied by not only hardening but also changing magnetic properties in microvolumes of the material subjected to seizure with the mated part.

All the aforesaid enables the methods of nondestructive testing to be used with the aim of revealing seizure indications considered as the causes of failures of precision control devices. In so doing, the identification of objective indications of the changes in physical and mechanical properties of parts' material makes it possible to predict potential seizure-induced failures of movable joints in further operation.

Concrete methods for identifying microindications of structural and phase changes in parts' material with the aid of the methods of nondestructive testing are the know-how and a constituent of the database of the expert-examination computer system intended for assessing the technical status of machine parts and structures.

The metallographical analysis of fractures and materials is the necessary means for objectively ascertaining the causes of breaking down the parts of various techinical equipment. Scanning electronic microscopy, X-ray diffraction analysis, metallography and other methods including methods of nondestructive testing are successfully used for these purposes.

Taken as a pictorial example can be the employment of metallophysical analysis for identifying the cause of breaking down the titanium engine compressor disk. As a result of the analysis, the cause of the disk breakdown associated with a metallurgical material defect was found out and the measures for preventing its manifestation in other aircraft engines were developed.

The presence of extraneous impurities of the same density as that of the main material with no interface discontinuity is reliably detected with the aid of the ultrasonic inspection method. In so doing, the diagnostic chech of engine compressor disks was proposed and successfully accomplished immediately in the course of aircraft operation.