Application of the method of fractal dimension in the recognition of defects of the surface layer of bearings

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Abstract.
The problem of recognition of defects in the surface layer of polished raceways of bearing rings according to the fractal dimension of the signals of the eddy current sensor is considered.

1. Introduction
In the technological process of manufacturing high-precision products at the grinding stage, many factors affect both the processing results and the process itself, which leads to the need for multiple controls during the work shift. The solution to this problem is seen in the use of automatic control devices, as well as in the use of means of monitoring the geometrical parameters of accuracy and the physicomechanical properties of the surface layer of the processed and machined parts, processing the measurement data and making the manager's decision on adjusting the process mode and adjusting the machines [1-2].

To control the uniformity of the surface bearing structure (rings and rollers), since defects in them reduce the reliability of the bearings, automatic recognition of rolling surface defects using the fractal dimension method is proposed.

2. Intelligent technology of the bearing manufacturing process
A fractal is a structure consisting of parts that are similar to the whole. Fractals - a set of points embedded in space. The set of points forms a line in ordinary Euclidean space.

In this case, the sign that allows recognition of the type of defect is the fractal dimension of the graph reflecting the eddy current image of the defect obtained by computer processing of the HTD signal, and in this case the fractal dimension is from 1 to 2.

Figure 1 demonstrates the algorithm for the functioning of the program for determining the defect of bearings manufactured at EPK-Saratov JSC using the method for calculating the fractal dimension of amplitude signals from a vortex monitoring sensor.
Figure 1. The algorithm of the program operation

This algorithm is implemented in a specially written program, the window of which is shown in Figure 2.
Figure 2. The program window for determining the fractal dimension

In Figure 2, a nick defect is considered, as a result of calculating the fractal dimension $D = 1.435$

The following defects were analyzed: nick, ring burnout; forge stamping; metallurgical crack; metal crack; spotted burn; troostite stain; grinding crack. To ensure accuracy, calculations were performed in each case for 30 defects of the same type. In this case, the confidence interval for the values of the fractal dimension is 0.02.

Calculations performed on the amplitude component (AC) of the HTD signal using specialized software showed (figure) that the fractal dimensions of the surface without defects (0) and defects 1 and 4 are quite different, so that they are automatically recognized. However, the fractal dimensions of defects 5 and 6, 7 and 8, 2 and 3 practically do not differ, that is, defects are not recognized. Calculations performed on the phase component (FS) of the HTD signal showed that in this case the fractal dimensions of the defects are different, that is, they are also automatically recognized.
3. Conclusion
The high degree of automation of eddy current testing of the rolling surfaces of bearing parts allows significantly reducing the influence of the human factor in determining the type of defect. This contributes to the decision either to adjust the processing mode or to take preventive measures on the machines, which significantly reduces or completely eliminates the appearance of defective parts.

Figure 3. The location of the fractal dimensions of the main defects on the plane in two ways, where: 0 - surface without defects; 1 - nick; 2 - ring burnout; 3 - forge stamping; 4 - metallurgical crack; 5 - metal crack; 6 - spotted burn; 7 - troostite stain; 8 - grinding crack

The fractal dimension of the amplitude component

The fractal dimension of the phase component
Thus, the use of an automated eddy current control of the fractal dimensions of information signals within the process monitoring system framework allows recognition of the main defects in the ground surface layer, which makes decisions for the formation of a given quality of rings, increases the efficiency of manufacturing parts and bearings in general.

References

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