INVESTIGATION OF VIBRATIONS IN DRY FRICTION PAIR USING PNRP METHODS

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Methods of periodical non-stationary random processes (PNRP) we applied to analysis of vibration time series of dry friction pair. Three different stages of surface frictional destruction during experiment were detected using spectral and correlation properties of vibration signals.

Keywords: vibration signal, dry friction, periodically non-stationary random process, correlation, spectrum

The SMC-2 installation (test methods of group A according to GOST 23.224-86) to determine the vibration signals under dry friction in laboratory conditions was used. Testing methodology consists in determining the wear (or intensity of wear) of materials of the friction pairs and the friction coefficient in the «disk-block» coupling according to the scheme of the planar contacting surfaces [1].

A disk sample with an outer diameter 42±0.02 mm was used for the tests paired with a pad (outer diameter 70±0.02 mm and inner diameter 42±0.02 mm). The drawing of the samples is given in Fig. 1. The mutual radial beat between disk and pad did not exceed 0.04 mm.

The data of the vibration signals, current values of the friction coefficient, temperature on testing surface and electrode potential were digitized by analog-to-digital converters (ADC) and recorded on a PC.

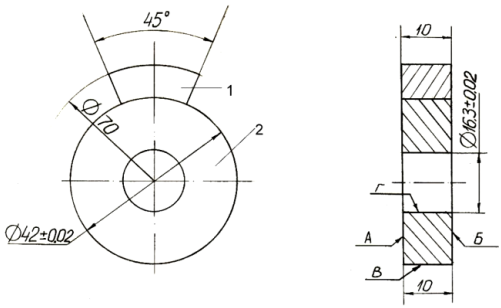

Fig. 1. Samples for research: 1 – pad, 2 – disc.

The series of experiments to collect vibration signals caused by dry friction in pair were performed. The friction moment on this installation was measured by a non-contact inductive sensor mounted on its shaft. The temperature around the contact zone was measured with a chromel-alumel thermocouple mounted in a pad at a distance of 0.5 mm from the contact zone. Electrical signals from the measurement of the friction moment and temperature were recorded with a sampling step 0.2 s. Rotating frequency of disk during experiment was set to 1200 rpm and controlled by frequency meter.

Three separate fragments of data which corresponded to three-time stages (initial, middle and final) of the experiment were selected. Conventionally, they were called the first, second and third stages. The pad was pressed against the disc with a force value of 2 Pa. Under such conditions, the temperature of the friction pairs was significantly increasing during the experiment and the friction coefficient was changing.

At the first stage, the increasing of temperature in the range from 34°C to 40°C and the value of friction coefficient ~0.2 were recorded. At the second stage, the increasing of temperature in the range from 40°C to 56°C continued and the value of friction coefficient increased to ~0.5 were recorded. On the third stage, the critical wear of the surface, an intense increase of temperature – from 60°C to 99°C, and increase of the friction coefficient value to ~0.9 were observed.

Time series of vibration signals were considered as realizations of PNRP [2] and appropriate processing methods were applied to them. In order to establish their properties, in that their spectral composition, an analysis of the correlation-spectral structure under stationary approximation were carried out. It was established that during dry friction at the initial stage the vibration power spectrum is concentrated in the low-frequency range up to 2.5 kHz. These vibrations characterize the natural oscillations of the system elements. At the second stage, the power of low-frequency oscillations increases, higher harmonic components appear. A characteristic feature of this stage is the excitation of high-frequency oscillations in the interval 20…30 kHz. The source of such oscillations probably is the appearance of near-surface cracks in bodies that form a friction pair. At the third stage, the power of high-frequency oscillations increases significantly, while the power of low-frequency oscillations, on the contrary, decreases. Such a vibration state corresponds to well-developed damages of friction surfaces.

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