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Studuing Lubrication System of Turbocompressor Rotor with Integrated Electronic Control

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Abstract

Forcing of engines together with positive properties – uprating within 5–50 % has a considerable drawback, i.e. the decrease of its service reliability. The performed analysis of literature points at a considerable increase in the number of turbocompressor failures. The main causes are as follows: nonobservance of the startup and shutdown modes by the operators; breach of the maintenance standards; high randomness of the load modes of 10-150%. The operability and increase of the failure-free performance of the turbocompressor and its elements can be achieved by the application of the suggested lubrication system of the turbocompressor internal combustion engines. The use of the lubrication system of the turbocompressor internal combustion engines with an autonomous lubrication-brake device and an autonomous control system of the turbocompressor rotor braking prevents coking of lubricant oil residues in channels of the turbocompressor lubrication system in case of a sudden (emergency loaded) shutdown of the internal combustion engine in the mode of the turbocompressor rotor rundown, and implies a regulated supply (by the volume, time and temperature) of oil in the turbocompressor bearing, as well as a regulated (by temperature) supply of the air compressed by the turbocompressor pump wheel to the inlet of the turbocompressor turbine wheel, which reduces the temperature of the turbine parts with the temperature of 600–700°C, wherein the service reliability of the bearings, rotor, body and the turbocompressor in general is increased. The application of engineering samples of the autonomous lubrication-brake device on car-and tractor and combine machine diesel engines of vehicles allows decreasing the number of turbocompressor failures by 10–15 %. The estimated economic effect comprises 50–80K rubles per season of operation of mobile energy-converting machinery with the increased unit capacity.

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Keywords: engine; turbocompressor; lubrication; pressure; rundown.

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1. Introduction

It is known that turbocompressor failures comprise 7–15% of the total number of engine failures [1,2]. In this regard, the downtime of tractors and combined harvesters with defective turbocompressors is much higher than the cost of the turbocompressor itself [3]. Analysis of the available works dealing with this problem allows to reveal causes of a low service reliability of turbocompressors (TCR) [4-6]. They primarily include nonobservance of the algorithms of startup, heating and, what is most important, shutdown of the diesel engine fitted with the TCR, incorrect selection of the engine modes, structural deficiencies and omissions in the work of the operating service [7]. It is possible to exclude the influence of the said factors on the service reliability of the TCR-fitted engine by means of its equipment with the autonomous lubrication-brake device (ALBD) and the electronic control system (ECS) of the TCR rotor braking.

Based on the aforesaid, it follows that it is necessary to carry out researches aimed at increase of the service reliability of the TCR [8-10]. Thus, the objective of this work is increase of the TCR reliability by means of the ECS and the ALBD.

2. Theoretical studies

The main task of our work is development of a controllable model of TCR bearing lubrication, TCR rotor rundown and shutdown [11-13]. For this purpose we have defined a theoretical dependency of the standard TCR rotor rundown in the course of time. This interconnection was obtained based on the experimental data presented in [6]:

$$\omega(\mathrm{t}) = 2817 - 55.8t + 0.289t^2 \tag{1}$$

t – rundown time, s; 2817, 55.8, 0.289 – regression coefficients.

The diagram was built according to the equation (1) (fig. 1 a)).

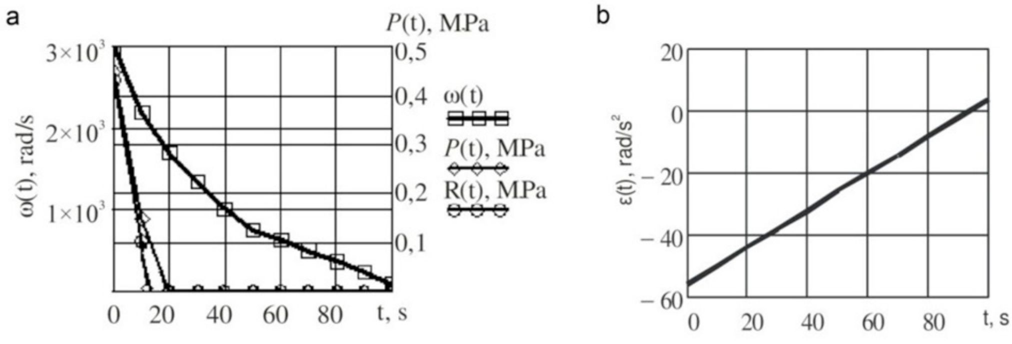

Fig. 1. Dependencies of: a) rotor speed ω(t), rad/s on time t, s; oil pressure P(t) in the main oil galley on time t, s; pressure R(t) in the oil galley of the TCR bearing on time t, s at a free rundown of the turbocompressor rotor; b) deceleration ε(t), rad/s^2 on the rundown time t, s.

In order to determine the brake torque of the TCR rotor at its rundown it is necessary to determine the deceleration value. Let us differentiate the equation (1) and obtain an expression to determine the TCR rotor deceleration at a free rundown:

$$\varepsilon(\mathrm{t}) = \omega(t)^{l} = -55.8 + 0.596t \tag{2}$$

Fig. 1 b) characterizes the connection presented in the expression (2).