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Investigation of bearing clearance effects in dynamics of turbochargers

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Abstract

Turbochargers are modern and very interesting dynamical systems used in various engines in order to increase their power. They are operated at hundreds of thousands revolutions per minute and tend to be fatigue and stability prone. For this reason, a turbocharger rotor has to be designed carefully with respect to its dynamic properties. The following article deals with effects of radial bearing clearances on the dynamical response of the turbocharger rotor. The influence of a bearing clearance on stiffness and damping of a single-film journal bearing is well known and documented. Turbochargers, however, are often supported by floating ring bearings. Such bearings have two bearing clearances — between a journal and a floating ring and between a floating ring and a housing — which are determined by different temperatures of oil films. Turbocharger analysed in the article is modelled by means of flexible multibody dynamics approaches. Bearings' behaviour is described using Reynolds equation, which is solved numerically. It is shown, but not mathematically proved, how the outer clearance and the ratio between the inner and the outer clearance affect amplitudes of sub-synchronous components in rotor's response.

Keywords: rotordynamics, turbocharger, journal bearings, floating ring bearings, steady-state response

1. Introduction

In the recent years, turbocharged engines have become more common because of better power-to-weight ratio (and thus lower consumption and emission of air pollutants). However, the better performance comes at a price because turbochargers operate at high speeds usually hundreds of thousands revolutions per minute and tend to be fatigue and stability prone. For this reason, a turbocharger rotor have to be designed carefully with respect to its dynamic properties, which could be a very interesting task due to the high non-linearity of turbocharger's behaviour, especially for floating ring bearings with a free ring between inner and outer fluid films [1].

The modelling of turbochargers consists of two main tasks. The equations of motion of a standalone rotor (shaft with compressor and turbine wheel) should be created on one hand and the problem of forces transmitted by floating ring bearings on the other hand.