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Analysis of the influence of engine oil aging on flow- and operational parameters of a journal bearing

Abstract

This dissertation presents the analysis of engine oil aging impact on the flow- and operational parameters of a journal bearing. Performed analysis includes theoretical deductions, experimental research and numerical calculations. Dissertation was divided into seven research chapters and five formal and organizational chapters.

The first chapter presents current state of knowledge about lubrication of journal bearings and oil aging. As a part of the literature review, no studies were found which consider simultaneous impact of non-Newtonian lubricating oil properties, temperature, pressure and aging of engine oil on flow- and operational parameters of journal bearings. Due to this fact that the oil viscosity throughout the operating time changes by up to several dozen percent, it was considered that this could have a large impact on the flow and operating parameters of journal bearings. On this basis, aims and the following thesis of the work were formulated:

*„**Changes of oil dynamic viscosity, associated with its aging and the effect of shear rate, pressure and temperature have a significant impact on the operating and flow parameters of journal bearings**”.*

In the second chapter of this dissertation, models and assumptions for the considered bearing were adopted. The proposed models and assumptions concerned the geometrical relationships in the friction node as well as lubricant model and heat exchange in a thin layer of oil film.

The third chapter is a comprehensive derivation of the hydrodynamic lubrication theory from basics. The model with apparent viscosity found in the literature was adopted as a constitutive model. On the other hand, apparent viscosity was described as the product of dynamic viscosity under reference conditions and dimensionless viscosities depending on individual influences: non-Newtonian properties, pressure, temperature and aging. Non-dimensional viscosities dependent on individual influences are introduced into basic equations of the hydrodynamic theory of lubrication by models from literature and own ones. These models are supplemented by material coefficients, obtained from experimental research. In this way described constitutive model enables the study of cross influences and takes into account the real nature of viscosity changes.

The fourth chapter describes the experimental studies carried out. This research were performed on samples taken from six internal combustion engines at various stages of their operation. Viscosity measurements were performed using a Haake Mars III rheometer equipped with various sets of instrumentation. Measurements of dynamic viscosity dependence on shear rate, pressure and temperature were performed for individual oil samples. In addition, aging characteristics were created based on all samples for each oil.

The mathematical description of the examined dependences is included in chapter five. The characteristics of viscosity dependence on shear rate, temperature, pressure and aging were prepared for each oil. To describe the relationship between dynamic viscosity and shear rate, the Cross model found in the literature was used, while the dependence on temperature was described by the popular exponential model. The viscosity change model from pressure and the oil aging model was developed by the author of this dissertation based on experimental research.

The results of research and analyzes from previous chapters were used in sixth chapter for numerical calculation of flow and operational parameters of journal bearings. Calculations were performed by the method of successive approximations using Mathcad 15 computer software. Calculation results of the dimensionless carrying capacity, dimensionless friction force and friction coefficient were presented in tabular form separately for individual influences, oil exploitation periods, as well as for different bearing lengths. Percentage changes in relation to the basics were calculated for each of the analyzed impacts. Numerical calculations show that the dependence of viscosity on changes in temperature, pressure and shear rate in a thin oil film, for the considered bearing causes a decrease in carrying capacity by over 60%. Taking the oil aging into account causes a lift of an additional over 20%.

Chapter seven summarizes all the research results and refers to the thesis. Based on the presented research, it has been proved that oil aging, the effect of non-Newtonian properties, as well as the effects of temperature and pressure have a very large impact on the flow- and operational parameters of the journal bearing.

Chapters 8-12 include lists of figures and tables, a bibliography and abstracts of this dissertation. All studies presented in the work were carried out based on the assumed general research plan and detailed plans described in the chapters.