46th International Scientific Conference EXPERIMENTAL STRESS ANALYSIS 2008
Department of Mechanics of Materials, VŠB - Technical University of Ostrava
June 2 - 5 2008, Horní Bečva, Czech Republic

Vojtěch DYNYBYL*, Pavel MOSSÓCZY, Jiří MRÁZEK*****

DEVELOPMENT OF TESTING EQUIPMENT OF MONITORING THERMAL CONDITION OF PRELOADED TAPERED ROLLER BEARINGS WITH INDEPENDENT COOLING

VÝVOJ EXPERIMENTÁLNÍHO STANOVIŠTĚ PRO MONITOROVÁNÍ PROVOZNÍCH STAVŮ PŘEDEPNUTÝCH KUŽELÍKOVÝCH LOŽISEK S NEZÁVISLÝM CHLAZENÍM

Abstract

This paper describes the development of tester and testing methods for monitoring temperature conditions of preloaded tapered roller bearings with independent cooling of inner and outer ring. Main purpose of tests is determination temperature characteristic of rings in relation to cooling mode and optimization of power balance in operating conditions. The operating parameters are monitoring continuously.

Abstrakt

Tento článek se zabývá vývojem zkušebního stanoviště a testovacích metod pro monitorování teplotních podmínek předepjatých kuželíkových ložisek s nezávislým chlazením vnitřního a vnějšího kroužku. Cílem testování je určení teplotní charakteristiky ložiskových kroužků v závislosti na způsobu chlazení a optimalizace energetické bilance v provozních podmínkách. Provozní parametry jsou snímány kontinuálně.

1 INTRODUCTION

This article is focused on development of test-bench to research behaviour of preloaded tapered roller bearings. High requirements on position accuracy and stiffness of shaft fits are required in some engineering constructions (e.g. spindles of machine tools, pinions of axle drives). Any operational clearance in these constructions is undesirable so roller bearings have to be preloaded. The main reasons of bearing preload are according to [1]:

- Enhance stiffness – elastic deformation of preloaded roller bearing is less than the not preloaded one.
- Reduce running noise – preloaded roller bearings have better movement of rolling elements in unloaded area and so the bearing running is quieter.
- Enhance the accuracy of shaft support – shaft support in preloaded bearings is guided more accurately because bearing stiffness is higher and loaded shaft has not got such a deflection in bearing as shaft in unloaded state.

* Doc. Ph.D., Department of Production Machines, Faculty of Mechanical Engineering, ČVUT Praha, Technická 4, Praha 6, tel. (+420) 224 352 417, e-mail: Vojtech.Dynybyl@fs.cvut.cz
** Ing., Department of Production Machines, Faculty of Mechanical Engineering, ČVUT Praha, Technická 4, Praha 6, tel. (+420) 224 352 409, e-mail: Pavel.Mossoczy@fs.cvut.cz
***Ing., Department of Production Machines, Faculty of Mechanical Engineering, ČVUT Praha, Technická 4, Praha 6, tel. (+420) 224 352 415, e-mail: Jiri.Mrazek@fs.cvut.cz

- Compensate for wear and settling (bedding down) processes in operation – effect of wear and deposition of rolling elements in bearing rings induces bearing clearance which is compensated by bearing preload.
- Give a long service life – right choice of preload leads to positive distribution of loading in the bearing and thereby operating reliability increases and bearing life lengthens.

2 METHOD OF MEASUREMENT

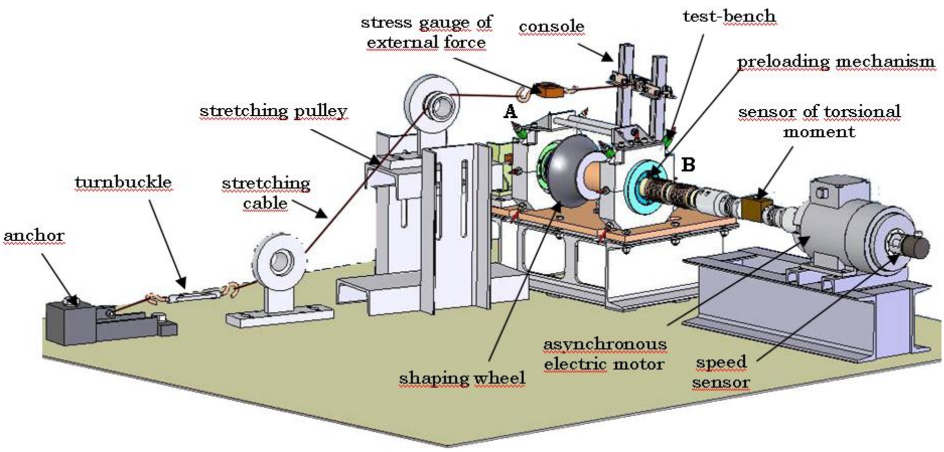
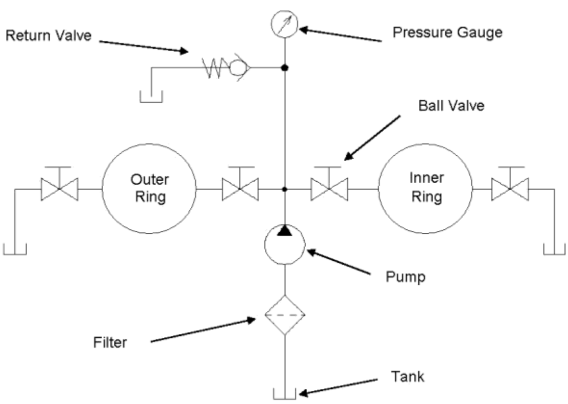


Fig. 1 Test-bench arrangement

Experimental measurement runs on the test-bench, which was designed specially for this experiment (Fig. 1). Test-bench consists of two parts – bearing unit and power unit. There are bearing houses mounted on the rigid frame. In these bearing houses a sturdy shaft is supported by two tapered roller bearings. Bearings can be loaded by radial and axial force in variable ratio by using a shaping wheel, which is situated on the shaft. Intensity of bearings axial preloading can be adjusted with mechanism. Power unit consists of supporting frame and asynchronous electric motor with diagnostic appliances.



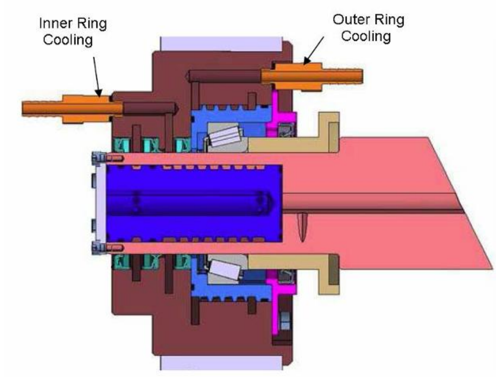


Fig. 2 **Fig. 3**

Measurement on test-bench includes: lost power with/without radial oil seal, effect of axial preloading and of external load force, and effect of lubrication. Basic bearings monitoring parameters are torsion moment to calculate of power lost, axial and external force and temperature.

Principal objective of measurement is to determine intensity of passive resistances, which originate at variable axial preloads, and temperature behaviour of the bearings during test-bench running. Monitoring of bearings thermal conditions in various operating states and monitoring of the whole system status towards thermal actions in bearings are the main aim of the task.

As it was mentioned in the introduction, the important feature of the preloaded bearings system is its stiffness. It affects accuracy of position of rotating parts and system's vibrations. On the other hand the preloaded system (usually highly preloaded) is thus very sensitive to changes of operating conditions. Changes in transmitted power appear immediately in system's thermal balance. Different heat expansion of materials and different heat flow into the stationary and rotating parts results in changes of axial preload. System's thermal stability is very important for security of service in these cases.

Independent cooling is one of the methods to improve heat flow away from bearing, shaft and bearing house. Fig. 2, 3 shows scheme of designed construction. Flow of cooling medium is controlled by ball valves independently for inner and outer ring.

3 CALCULATING BEARINGS SERVICE PARAMETERS USING BY FEM

Development of FEM model is another field, which can describe structural and thermal behaviour of roller bearing and complements experimental measurement. Results of experimental measurement can help to set border condition and verify FEM model.

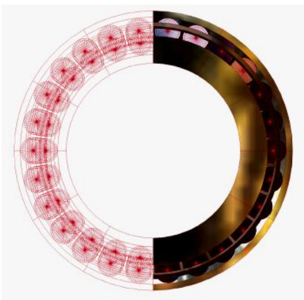


Fig. 4

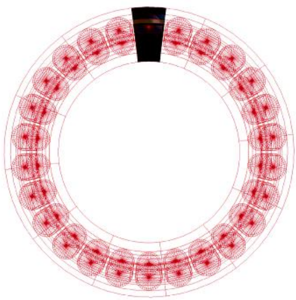


Fig. 5

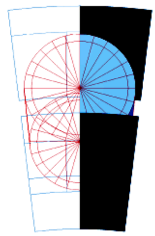


Fig. 6

Since many contacts exercise is solved it was necessary to simplify whole model greatly. So for the first approximation simplify exercise must be selected, when we think over only axial load of taper roller bearing. By it is attain that all rolling body are loaded identical. Fig. 4 shows symmetrical simplification of problem, Fig 5 periodical simplification in singles segments and Fig. 6 symmetrical simplified segment.

4 RESULTS OF MEASURING

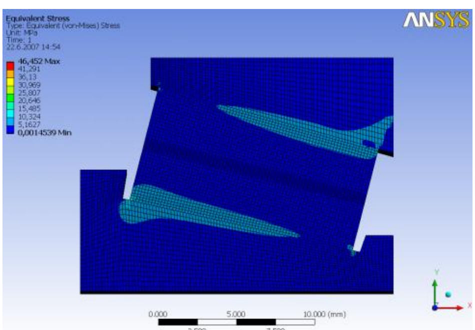


Fig. 7 Stress

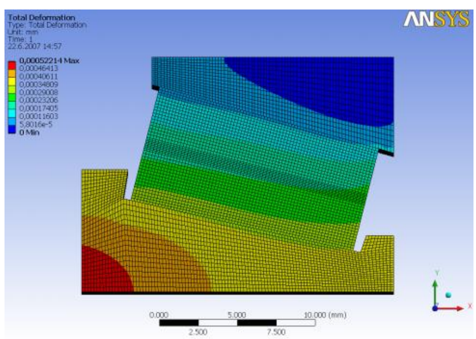


Fig. 8 Deformation

Fig. 7, 8 shows results FEM model calculation. For the first approximation the symmetrical simplified segment of taper roller bearing loaded only by axial force is used. By it is attained that all rolling body are loaded identically.

Monitoring of testing process provides multifunction PCI DAQ cards. To built monitoring and data processing application the development system with graphical language LabVIEW is used. Result of testing process with independent cooling shows Fig. 9.

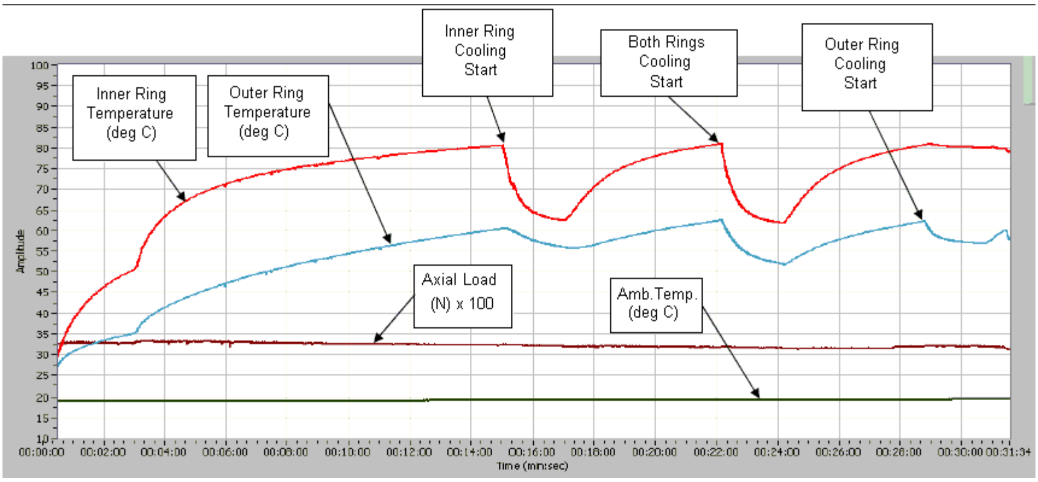


Fig. 9

5 CONCLUSIONS

Designed tester presented in this article allows quick and exact research behaviour of preloaded taper roller bearings. To describe structural and thermal behaviour of roller bearing the modern calculating method FEM is used.

REFERENCES

[1] FRÖHLICH J., *Technika uložení s valivými ložisky.* 2. vyd. Praha : SNTL, 1980. 448 s.

[2] LYSÁK, P., *Řízení provozního chování vysoce předepnutých valivých ložisek.* Praha : ČVUT. Fakulta strojní. Ústav výrobních strojů a mechanismů, 2007. 94 s. Vedoucí diplomové práce Doc. Ing. Vojtěch Dynybyl, Ph.D.

[3] ZELENKA, J. *Řízení provozních podmínek předpnutých ložisek.* Praha : ČVUT. Fakulta strojní. Ústav výrobních strojů a mechanismů, 2007. 74 s. Vedoucí diplomové práce Doc. Ing. Vojtěch Dynybyl Ph.D.

[4] DYNYBYL, V. & MOSSÓCZY, P.: *Experimental Assesment of Preloaded Tapered Roller Bearings.* Acta Mechanica Slovaca. 2006, vol. 10, no. 4-B/2006, p. 141-148. ISSN 1335-2393.

[5] MRÁZEK, J. & DYNYBYL, V.: *Calculation Bearing´s Service Parameters Using FEM.* 48th international Conference of Machine Elements and Mechanisms Departments 2007- Proceedings of Abstracts. Bratislava: Faculty of Mechanical Engineering of the Slovak Technical University, 2007, p. 84. ISBN 978-80-227-2708-2.

This research has been supported by Czech Science Fundation grant 101/05/2173.

Reviewer: MSc. František FOJTÍK Ph.D., VŠB - Technical University of Ostrava