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Thermal behavior in rolling bearing applications: comparison of steel and ceramic materials applied to tapered rollers

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Due to their properties, ceramic materials can improve both reliability and efficiency of rolling bearings. It was shown that less power is dissipated by ceramic balls than steel ones. This study then focuses on tapered rollers. Thanks to experimental and numerical means, the thermal behavior of tapered roller bearing is investigated for both steel and ceramic rollers. The effect on heat flows and bearing temperatures is then compared.

Keywords: rolling element bearing, ceramic, thermal behavior, heat flow

1. Introduction

The use of ceramic material in bearings offers new possibilities in terms of performance. The aeronautic industry is particularly interested by developments of this technology with two focuses: reliability and efficiency. Indeed, several improvements could be expected:

1) Ceramic has a lower density than steel; the weight gain is interesting for efficiency perspectives; regarding ceramic rolling elements, it could also decrease centrifugal forces and so bearing stress.

2) Ceramic has a better reliability than steel regarding pollution and lubrication starvation [1]; bearing rating life will be improved.

3) Ceramic rolling elements appear to dissipate less power than steel ones [2]; so, bearing efficiency can be improved; it could also induce a lower lubricant temperature and so improve bearing operating conditions.

The aim of this study is to compare the use of steel and ceramic (Si3N4) tapered rollers and to evaluate the impact on heat flows and bearing temperatures.

2. Testing campaign

2.1. Test rig

The standard bearing rig illustrated on Figure 1 is used; two bearings are tested at a time. This rig allows applying axial and/or radial loads, and varying oil temperature and flow rate. Component temperatures are also monitored: bearings inner and outer races, oil inlet and outlet, various points on housing and base. Several temperature sensors were added specifically for this study.

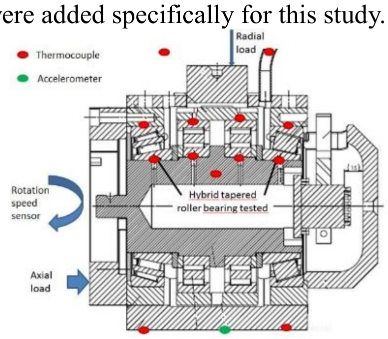


Figure 1: Test assembly with thermal sensors (red dots)

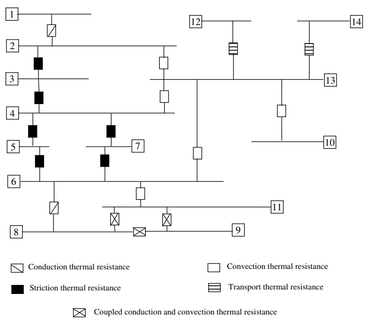
2.2. Test plan

First, a calibration test is performed to characterize the thermal behavior of the test rig. Then, parametric tests are performed on both types of tapered roller bearing (with steel or ceramic rollers). Test results will allow a first comparison of bearing thermal behavior with steel and ceramic rollers.

3. Thermal modeling of the test rig

The thermal modeling is done by using the thermal network method, which is a nodal approach.

The components of the test rig are modeled by single nodes (shaft, housing...), while the tested bearing itself is composed of several nodes, as illustrated on Figure 2. This model will allow more detailed investigations on the effect of steel and ceramic solutions on bearing thermal behavior.



N°	designation
1	Housing/OR interface
2	OR
3	Roller/OR contact
4	Roller
5	Roller/IR contact
6	IR
7	Roller/Rib contact
8	Shaft (beneath bearing)
9	Shaft (shaft end)
10	Cage
11	Ambiant fluid
12	Oil in
13	Oil within bearing
14	Oil out

Figure 2: Thermal network of the tapered roller bearing

4. References

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5. Acknowledgement

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