INFLUENCE OF THE LUBRICANT PROPERTIES ON FATIGUE RESISTANCE OF IC ENGINE SLIDE BEARING LINING

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Abstract  
In the paper the possible influence of the lubricant properties on the fatigue resistance of the IC slide bearing lining has been considered and some preliminary experimental tests were performed. The laboratory test stand SKMR – 2 for bending critical stress evaluation has been described. The test results obtained for half – bearing made of AlSn20Cu1 material, for reversed bending load at the temperature 20°C and two different test conditions: bearing being immersed in the lubricating oil and bearing without contact with oil, are presented.

1. INTRODUCTION

Development of the fatigue cracks of the IC (Internal Combustion) engine slide bearing lining, that can limit the life and load carrying capacity of the engine, is still the problem that needs to be fully explained and solved.

Fatigue damages can appear when the stress and strains in the sliding layer are reaching their critical level depended not only on the type of the material but also on bearing geometry (e.g. clearance, bearing lining to steel backing thickness) and other parameters including physical and chemical effects of the lubricating oil (especially the influence of lubricant active additives) on the bearing fatigue.

The complexity of the fatigue processes is the main reason that the experimental investigations with the use of laboratory testing devices are regarded as being the basic sources of information needed for the real bearing load carrying capacity predictions.

Recent approach to the bearing fatigue processes analysis is based on the model bearing testing integrated with the theoretical evaluation of the bearing stresses and strains. Idea of the analysis of the hydrodynamic bearing fatigue properties is presented in the figure 1 which is describing the recommendations of the International Standards: ISO7905/3, ISO7905/4, ISO7905/1.

At the Mechanical Engineering Faculty at the Gdańsk University of Technology some of the investigations have been being performed on bearing fatigue problems [5, 6, 7, 10, 11, 12] with the application of laboratory testers designed and built according to the recommendations of the Standard 7905.

Trying to investigate the lubricant effects on the bearing fatigue it has been found that the use of the tester ISO7905/4 might be rational.

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Real hydrodynamic plain journal bearing

ISO 7905/3 ISO 7905/4 ISO 7905/1

Fig. 1. Idea of evaluation of hydrodynamic bearing fatigue properties; 
\( \sigma_m \) - mean stress, \( \sigma_a \) - alternating stress amplitude, \( \sigma_{\text{red}} \) - reduced stress, \( \sigma_{\text{el}} \) - endurance limit, 
\( \sigma_i \) - principal stress \((i = I, II, III)\)

Fig. 2. Design scheme of the head of half-bearing tester; 1 - specimen, 
2 - adjusting screw, 3 - specimen fixture, 4 - movable specimen fixture,
5 - pusher, 6 - roll follower, 7 - eccentric, 8 - heater, 9 - compression spring
2. SKMR - 2 TESTER

In the figure 2 the tester SKMR–2 that can be used for testing of separate half – bearing under dynamic bending stresses is shown. One end of the tested half – bearing (1) is fixed to the stationary fixture (3) while the other is connected to the movable fixture (4) that is driven by the cam – follower mechanical system so the tested half – bearing is subjected to bending. Bending forces and moment of adjustable value are thus producing stresses fluctuating from tensional to compression with controlled maximum and minimum values. Tested bearing is immersed in the chamber filled with the lubricant of specified type and controllable temperature. Design of a typical half – bearing solution is presented in the figure 3. After an experimental verification of the tester characteristic it can be stated that the SKMR–2 tester is suitable for testing of the half – bearing multilayer metallic bearings. It is possible to obtain fatigue cracks in the bearing material lining after 20 hours of test duration.

3. PRELIMINARY INVESTIGATIONS

The tested half – bearing is shown in the figure 3. The bearing is made of bimetal shell consisting of steel backing of the nominal thickness 1,825 mm and slide layer made of AlSn20Cu1 with thickness 0,5 mm. Bush inner diameter is nominally 52,7 mm.

![Fig. 3. Standard tested half-bearing](image)

Half – bearing have been tested under reversed load of fixed adjustable maximum value and temperature 20°C for two cases:
1. for bearing which are fully in contact with the air,
2. for bearing which are immersed in the oil of temperature 20°C. As a lubricant the basic oil (without viscosity improver and without quality additives) SAE40/95 was used. For one specific bearing the duration of the test was 20 hours (3.6E6 load cycles) with the test result being either “passed” (serie 1) when no cracks appeared after test, or “not passed” (serie 2) when fatigue cracks appeared.

4. CONCLUSIONS

It can be said that the half – bearing tester SKMR–2 is working properly and according to our expectation.

Critical stresses of the tested bearing material AlSn20Cu1 has been experimentally determined and found as being at the level of 40 MPa (figure 4 – for reverse bending stresses, temperature 20°C and without contact with lubricating oil ) and about 34 MPa (figure 5 – for reverse bending stresses, temperature 20°C and slide layer of the bearing being in contactt with the basic lubricating oil of the temperature 20°C).

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\begin{array}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline
\text{Sample Nos} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 \\
\hline
\text{Bending stress in bearing lining [MPa]} & 48.6 & 42.6 & 42.6 & 42.6 & 42.6 & 42.6 & 36.6 & 36.6 & 36.6 & 36.6 & 36.6 \\
\hline
\end{array}
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Fig. 4. Test results for AlSn20Cu1 material, in the air of the temperature 20°C.

The obtained results seem to confirm the effect of lubricant on the fatigue properties of bearing material. However further investigations for higher test temperature (80°C and 100°C) and other types of lubricating oils are needed to attempt to explain this possible influence.
Fig. 5. Test results for AlSn20Cu1 material, in the lubricating oil of the temperature 20°C.

REFERENCES