HINTS FOR DETERMINATION OF THE REASONS OF IC ENGINE CRANK MECHANISM BEARINGS DAMAGE

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Abstract

In order to reduce the risk of premature wear or sudden failure of slide bearings it is necessary to take the relevant preventive steps. These can be determined on the ground of damage investigation and analysis of their causes. This paper presents some suggestions as to find causes of bearing failure, taking into account operational conditions, loads, applied lubricant and the quality of mating surfaces. A precise recognition of different causes of bearing failures should allow to reduce the hazard of premature wear and to take relevant preventing steps.Remarks on determination of bearing damage presented above and examples of damage presented in references try to show both to user and manufacturer their possible causes. If frequency of definite failure is occasional, most probably it results from unsuitable conditions of bearing operation (e.g. contaminated lubricating oil, oil film rupture, high temperature) or improper assembly (e.g. unsuitable bolt tightness, erroneous bearing clearance) of a certain engine. If damage concerns an entire engine family, one common cause should be defined. A precise recognition of damage various causes allow to diminish the hazard of premature wear by taking the appropriate preventing steps. Because of that very careful examination of the nature and distribution of any damage traces is recommended. Most often the research provide valuable hints how to construct, manufacture, assembly and operate bearings.

Keywords: *combustion engine, slide bearing, damage, remarks on failure causes*

1. Introduction

In order to diminish a threat of a premature wear or sudden failure of slide bearings there is a need for investigation on damage and establish its causes. Most often the research provide valuable hints how to construct, manufacture, assembly and operate bearings.

Damage that occurred during operation most probable would be revealed during inspection of engine parts when the engine is brought for service or repair. However, if damage occurs at the beginning stage of their operation it means that operational conditions defined for certain construction are too difficult to be met, in other words the construction is not fit for predicted conditions of operation. When bearing shells show a moderate wear - evenly distributed over bearing length, minor scratches caused by dirt that entered with lubricating oil between collaborating surfaces or are the result of shell wear, do not have any traces of frictional corrosion on mating surfaces and on the plane of shell partition one can assume that the operational conditions are correct.

Evaluation of any bearing should include:

- evaluation of slide surface, back and contact surface (to other half-shell) condition,
- evaluation of shell resilience (for thin shells).

Very often it is quite difficult to establish the causes of shell failure because in majority of cases a number of causes contribute to the premature breakdown.

2. Causes of crank mechanism bearings damage

Four basic errors, i.e. constructional, manufactural, assembly and operational lead to the slide bearing damage. Classification of errors is presented in Fig. 1.

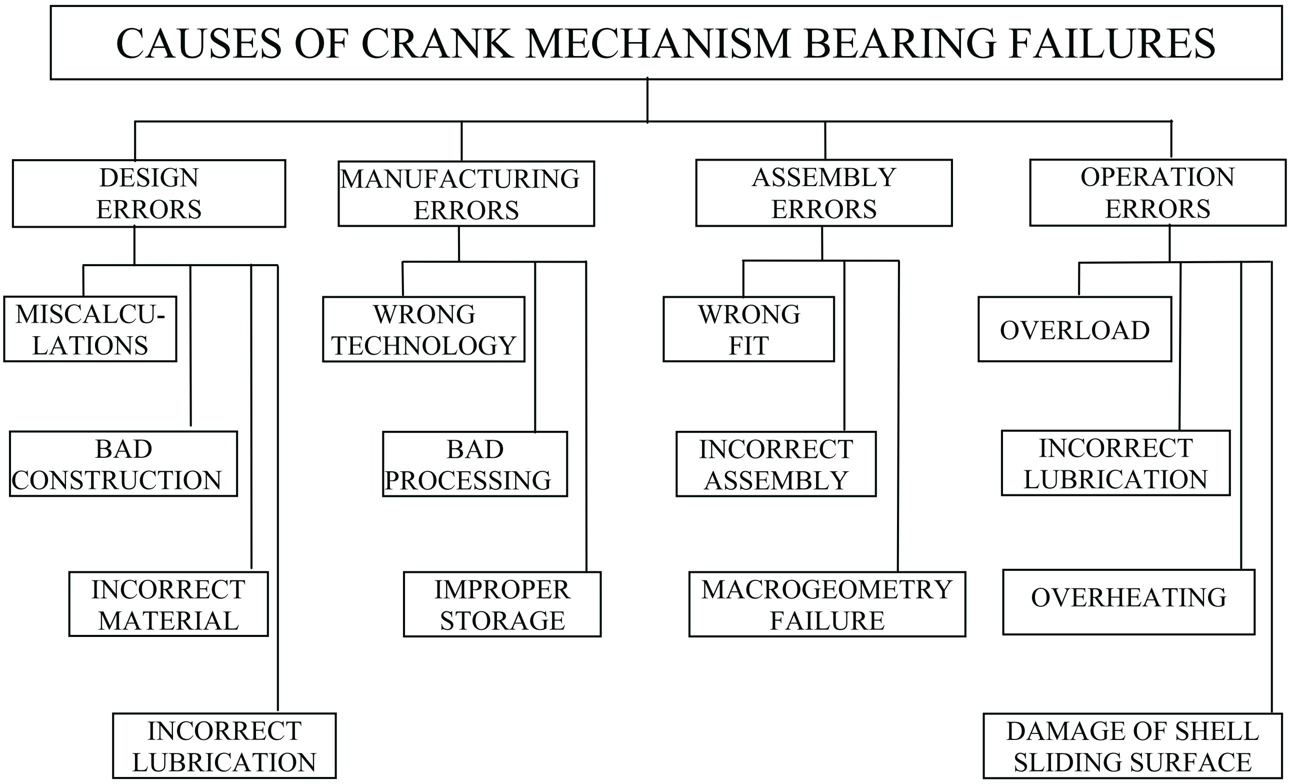


Fig. 1. Classification of errors leading to failure of crank mechanism bearings

In the group of constructional errors the main cause of damage is an imperfection of design manifesting in inappropriate location of oil holes and grooves, unsuitable lubrication or wrong selection of bearing material. The constructional errors can be avoided thanks to thorough analysis of operational conditions carried out using modern methods of computation.

In order to avoid the manufactural errors the requirements of proper technology and machining should be observed as well as careful examination of shells and mating journal quality should be carried out. Journal incorrect shape leads to unilateral contact with a shell, increased pressure on the bearing material or a partial disappearance of oil film on this surface. These phenomena lead to eventual bearing rapid wear.

The assembly errors most often result from an inappropriate conduct at the stage of assembling process. This concerns first of all carelessness during cleaning and errors resulting from improper fit or shell incorrect clamp in housing. Misalignment at the assembling stage results in increased local loads (edge) which eventually lead to the fatigue wear.

However, the most frequent cause of bearing failure are the errors of improper operation that include incorrect engine run and negligence of technical service. The latter result from bearing overload (fatigue of bearing alloy, surpass of yield point), incorrect lubrication (insufficient oil flow, inappropriate or contaminated oil, bad filtration or oil pressure).

3. Main directions of bearing damage cause determination

Following criteria have been chosen in order to determine the primary causes of engine bearing damage:
- engine operational conditions,
- bearing load,
- lubricant applied,
- quality of mating elements.

Following parameters should be taken into consideration when evaluating conditions of bearing operation:
- conditions of bearing run (application, load),
- engine construction,
- damage of mating parts,
- damage of crank mechanism elements like piston, gudgeon pin, connecting rod,
- inappropriate lubrication,
- dirt in subassemblies.

If the bearing itself was selected as criterion of classification of bearing damage, the design of bearing would be the characteristic parameter subjected to testing (see Fig. 2). For newly designed engines the fundamental parameter is a bearing loading and journal center path, and eventual comparison of the results with those for existing engines.

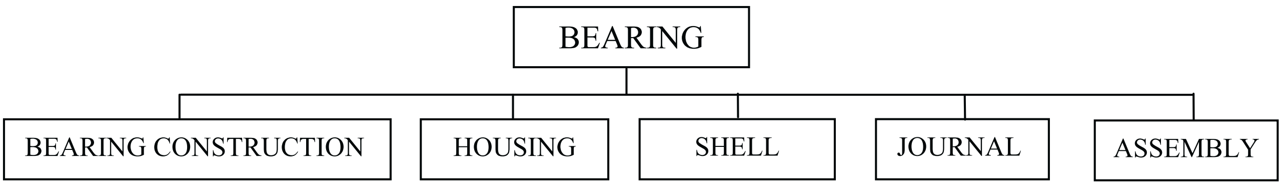
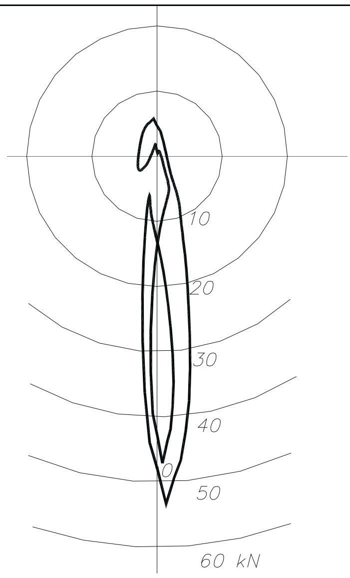


Fig. 2. Bearing as a hint to establish causes of its damage

Determination of loads and hydrodynamic parameters - including the journal center path - is being carried out using computational procedures allowing for evaluation of bearing operational reliability. The specific pressures calculated on the basis of load courses are compared with the values admissible for given alloy and then evaluate if the alloy has been selected properly. The journal center path and corresponding lubricant layer minimum thickness serves for evaluation of lubrication type present between the journal and shell. An example of proceeding by the evaluation of bearing design is presented in Fig. 3.

Another criterion are the elements of bearing construction, i.e. shell, journal and housing. Metalographic structure and surface condition evaluated from the point of corrosion and cavitation are the examined parameters of shell and crankshaft journal. The shell should be correctly installed in housing - too low clamp can cause a shell rotation, shear of the location notches and eventual bearing seizure. Moreover, the state of shell back should be evaluated. Since the assembly is concerned, the geometric data as well as results of post assembly measurements should be available and subjected to examination in order to found the cause of failure.

<table>
<tr><td>1. Determination of bearing load course
(P_{max}, P_{mean})</td><td>
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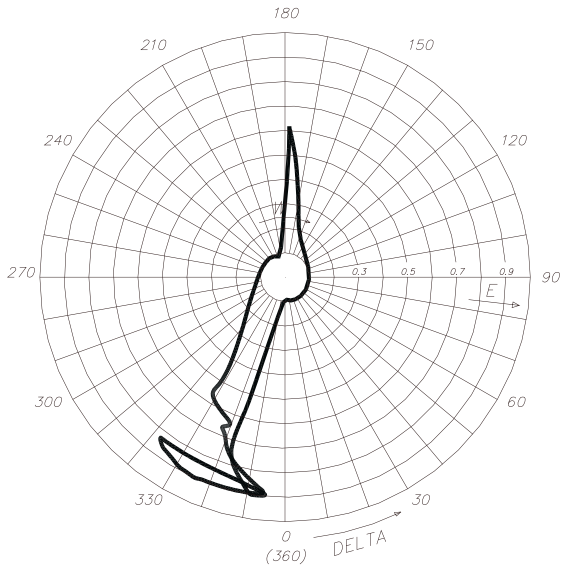
<tr><td colspan="2">2. Calculation of maximum and mean specific pressures (according to the dependence: $p_{max} = P_{max}/b \cdot d$, $p_{mean} = P_{mean}/b \cdot d$) and comparison with admissible values for the alloy applied</td></tr>
<tr><td>3. Course of journal center path</td><td>
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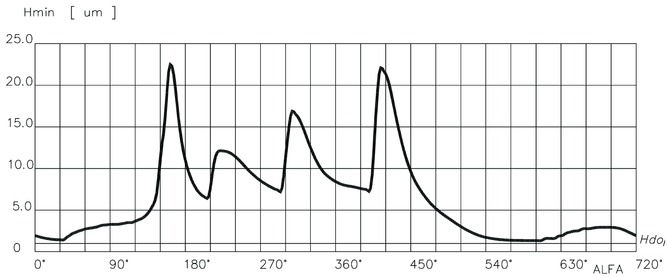
<tr><td>4. Oil film thickness - evaluation of fluid film lubrication ($H_{min} > H_{adm}$)</td><td>
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<tr><td colspan="2">5. Estimation of places vulnerable to fatigue damage (on the basis of the journal center path)</td></tr>
<tr><td colspan="2">6. Frequency of maximum hydrodynamic pressure $(p_{max})_{max}$ - comparison with bearing alloy yield limit with consideration of bearing run temperature</td></tr>
</table>

Fig. 3. Key parameters of bearing design subjected to verification in order to establish the causes of damage

As the lubricant choice is concerned (Fig. 4) first of all its utilitarian properties should be taken into consideration. The most important properties of lubricants are: viscosity (viscosity index), lubricity, total base number, total acid number, flash point, foaming suppression, content of water, fuel and dirt. One of the most important parameters examined is evaluation of lubricant quality through the analysis of its basic properties and content of additives.

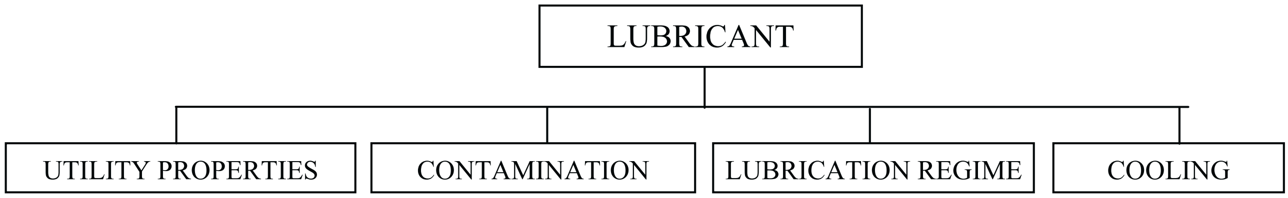

Fig. 4. Parameters connected with the selection of lubricant and its performance during operation

Scratches and scorings on shell running face are the dirt related bearing damage and most often result from improper assembling or insufficient filtration. On a sliding surface, especially in vicinity of oil ducts the dirt particles can be found in sliding layer. Oil viscosity and quality, rotational speed and load affect the regime of lubrication present at bearing operation. It is generally known that boundary or mixed lubrication occur during engine start or stop whereas the fluid film lubrication emerges with the speed increase. In order to avoid the boundary (or dry) lubrication in bearings a pressurized oil flow before engine start is practiced on highly loaded engines.

One of oil basic tasks is engine cooling. When a bearing runs in particularly difficult conditions, e.g. at high temperature effectiveness of cooling should be increased in order to lower temperature. However, if bearing overheating already occurred, depending on period and level of overheating melting can start and bearing material can be rubbed out, rolled or even crankshaft damage can occur. In such situation a metalographic analysis of mating elements should be performed and bearing temperature before failure should be determined.

Another important factor affecting the determination of bearing failure causes is the quality of collaborating parts. Quality of manufacturing should fulfill requirements of crankshaft, shell and housing producers. In the case of crankshaft beside the journal tolerances, measurements of shape (circularity, cylindricality), coaxiality of principal journals and parallelism of crank journals should be carried out as well. For housing and crankshaft journals the measurements of surface asperities have to be carried out as well. Thin wall shells should be examined towards the deformations caused by housing shape errors. As far as proper interference fit is concerned, the circumferential length of the bearing shell is larger by a factor of the crush height than the base bore of the housing; the circumferential pressure in the bearing causes a radial holding pressure between the bearing back and the housing that prevent shell turning in the housing. It should be emphasized that any machining of thin shell run surface is unacceptable because it damages this surface. Thin shells are made by specialized manufacturers as spare parts at nominal and repair dimensions and are subjected to careful examination (check of dimensions, condition of surface, material).

4. Summary

Remarks on determination of bearing damage presented above and examples of damage presented in references [2, 3, 5, 6] try to show both to user and manufacturer their possible causes.

If frequency of definite failure is occasional, most probably it results from unsuitable conditions of bearing operation (e.g. contaminated lubricating oil, oil film rupture, high temperature) or improper assembly (e.g. unsuitable bolt tight, erroneous bearing clearance) of a certain engine. If damage concerns an entire engine family, one common cause should be defined.

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