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Automobile designs have evolved continuously to suit specific application needs of the users. Quality of journal bearings used in automotive accessories, such as oil pumps are crucial for the trouble free functioning of the whole engine. It is necessary that the magnitude of wear should be minimum for a bearing. Deployment of 'six sigma' concept and demand for `fit and forget' designs are accelerating the changes. Many of the above factors pose unpredictable challenges to the designers of automotive engine parts and electrical sub assemblies for applications in local and international markets. Cylindricity errors introduced in the manufacture of bushes, non conformity of the bearing dimensions of mass produced parts with design specification and inadvertent process mean shifts in the manufacturing line will result in significant bearing clearance variation; the latter in turn affects the wear characteristics of journal bearings. Testing practices for oil pump and hence the bearing performance validation in the manufacturing line, lack design inputs like, variations in engine speed, engine vibration, oil condition, line pressure etc. and moreover the testing processes are tedious.

Experimental wear data and correlation of the laboratory wear test with that of the field performance would assist the designer in rationally selecting the design parameters to minimise wear of these bearings.

Based on the above considerations, the main objectives of the work are grouped under the following categories:

i) Study of bearing manufacturing practices to analyse geometric errors.
ii) Identification of application specific design inputs for testing the quality of oil pump bearings.
iii) Development of a new wear test practice of shorter test duration.
iv) Determination of conditions favouring minimum wear.
v) Correlations between wear test practices and field data.

Specifically, the following aspects are addressed:

Study of Bearing Manufacture: The bearings under investigation employ bushes manufactured by powder metallurgy (P/M) process and the study was carried out in one of the premier two wheeler-oil pump manufacturers in the country.

Bearing assembly process consists of shrink fitting of the bush in the housing followed by burnishing operation to limit the cylindricity errors. Geometric measurement and surface finish analysis of journal and bushes were undertaken at these critical stages of manufacturing. Effect of burnishing tool size and its surface finish had also been investigated experimentally. Optimum processing parameters and finishing recommendations were arrived. Experimental studies on the shrink fit assembly were carried out and the results were compared with that of the ANSYS analysis of the model of the bearing assembly.

Statistical Analysis of Bearing Clearance: Geometric and positional errors from manufacturing and assembly processes affect bearing clearance. The latter was estimated by actual measurements on parts drawn from manufacturing line and subsequently, statistical analysis of journal and bush dimensions were carried out based on the cumulative probability plots. Application of numerical convolution, sure-fit and normal laws for the bearing under investigation were done to predict the bearing clearance. The clearance value ranged from 26.5 μm to 41.5 μm as against the design clearance range of 13 μm to 43 μm; appropriate process improvements in the bearing manufacture were recommended to minimise the process mean shift.

Collection of Additional Design Inputs for Testing: Vehicle manufacturers have the practice of road testing for a specific duration, prior to the release of product approval. The usefulness and limitations of the existing laboratory test practices in terms of design inputs were analysed. Application specific design inputs collected in the work include speed spectrum, vibration spectrum, variation in lubricating oil pressure data, changes in noise and vibration pattern; appropriate `improved test practices' for testing of oil pumps and bearings were recommended.

Accelerated Wear Test and Correlation with Field Data: Industry's need for reducing the test duration and costs was also recognised. An Accelerated Wear Test (AWT) was designed and developed as part of the investigations. The 100 h test so developed was observed to substitute the existing 1000 h product validation test, based on the journal wear volume. It was observed that in the case of journal bearings of diameter range 7 ~ 9 mm, wear volume of journals in the range of 6 mm^3 could be generated through the accelerated wear test in a shorter duration of 60 h.

Wear Experiments: Experiment planning and statistical analysis of wear data were carried out based on Taguchi's orthogonal arrays; minimisation of weight loss of the bush was chosen as the objective function for the above wear experiments. Among various factors, which influence the wear of journal bearings, the

following four factors were considered in the present experimental study, involving steel - on - sintered steel bearings:

- Sintered part density of bearing bush
- Surface roughness of bearing surface of the bush
- Material mix for the bush fabrication and
- Bearing clearance.

Analysis of mean and variance of test results, and also surface topography changes of mating parts were carried out.

Experimental studies reveal that the minimum specific wear rate of the bush can be expected to occur for the following combination of test factors analysed: (i) P/M part density : 6.2 g/cm^3 (ii) Surface roughness of the bearing bore R_a value equal to: 0.4 µm (iii) Material mix : 0.6% Carbon, 99.4% Iron and (iv) Bearing clearance: 28 µm. Among the test factors considered, influence of material mix and part density of the sintered bush on the specifc wear rate of the bearing are relatively significant.

The above optimum factors on a new bush-journal pair were found to result in a 25 percent reduction in journal wear volume and thus providing improvement in the wear performance of the oil pump bearings.

Selective assembly procedure for the journal and bush involving three groups was recommended based on the optimum clearance values arrived at in the experimental study.

On the whole, this thesis evolves some guidelines for the factors related to design and manufacturing of precision journal bearings with methodology for short duration testing as applicable to oil pumps in automobiles.