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A Comparison of Design Methodologies for Journal Bearings under Pulsatile Loads

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Abstract
The paper expands the work by Kinnear and Weston[1] on squeeze film bearing design to the general case and compares the revised methodology with classical bearing design[2,3,4] and hybrid bearing design[5]. The analysis, which employs a partial differentiation of the Poisseuille and Hagen-Poiseuille bearing flow equations, enables a mathematical model for the bearing squeeze film to be developed. This yields a transfer function between bearing displacement and load. Subsequent parameter maps are developed from the transfer function for stiffness and damping coefficients.The method enables hybrid journal bearings under pulsatile load to be considered. Current design methodologies employed do not cater for this situation adequately which limits effective design of these bearings in applications such as in internal combustion engine crankshaft bearings.

Key words
Hybrid bearings, Squeeze film effect, Power savings, Friction losses, ic engine bearings

1. Introduction
Journal bearings provide a cylindrical bearing face on which the shaft running through the bearing lies. This creates wear between the bearing face and shaft reducing bearing performance and shaft life. To combat this many journal bearings are lubricated to reduce the wear and resistance. Hybrid journal bearings are so named as they combine the features of hydrostatic externally pressurised bearings with those of plain lubricated journal bearings. Three different phenomena provide support for the shaft within the bearing.

Hybrid bearings use orifices to supply fluid under pressure to effectively lift the shaft away from the face when there is zero or low speed operation of the shaft. (figure 1.1) This removes the metal to metal contact normally found in a lubricated journal bearing, reducing wear at start up. However, as the operating speed increases the effectiveness of this phenomenon is reduced and the pressure at which the lubricant must be supplied increases.

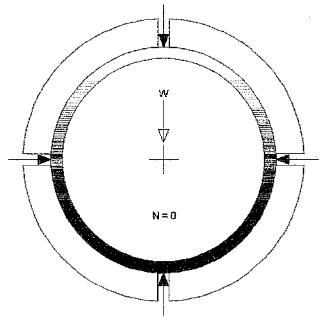

Figure 1.1 Hydrostatic effect

When the shaft is rotating at the operating speed it will rise upon a film of oil as, through viscous drag forces, the shaft creates a film between itself and the bearing face. (figure 1.2) This reduces wear and resistance within the bearing but requires the shaft to be turning at speed to provide adequate support. By combining this effect with the hydrostatic effect at start up a hybrid bearing is able to provide a stiff, smooth bearing with very attractive wear and resistance properties.

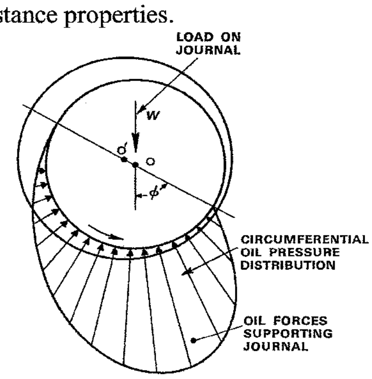

Figure 1.2 Hydrodynamic effect