EHD Analysis on Lubrication Mechanics of Connecting Rod Bearing

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The main subject of this paper is analyzing the patterns of maximum oil film pressure and the minimum oil film thickness under various pre-conditions of geometric shape as functions of bearing groove and journal oil hole in the connecting rod bearing. As the major analytical tool, elastohydrodynamic lubrication analysis has been applied and two-intertwined results of maximum oil film pressure and minimum oil film thickness have been compared and analyzed using EXCITE program. From computed results, the optimal lubrication conditions as geometric shape of bearing groove and the journal oil hole have been investigated. This may be useful for the bearing designer as a firm reference.

Keywords: Connecting rod bearing, groove, oil hole, minimum oil film thickness

1. INTRODUCTION

Connecting rod bearing runs under the conditions of both heavy pressure of cylinder combustion and inertia load of each element of engine. Thus, the connecting rod bearing is regarded as one of the most important components in an automotive engine. It is driven mostly under the conditions of either high-speed hydrodynamic or elastohydrodynamic regimes[1,2]. But, the rubbing contact of a journal bearing does not guarantee the full lubrication condition in actual running conditions.

Moreover, unprecedented trends of engine development (seeking higher thrust anger, high-speed and light weight anger) ask ever more demanding performance of connecting rod bearing, which is the key component especially under the severe load with a high-speed in recent.

Connecting rod bearing is located on the hitching grade with connecting rod and crank arm, which transfers up and down exercise of piston into rotation movement of crankshaft. Therefore, it runs by resisting heavy combustion pressure and inertial force from piston department and connecting rod. During a high-speed circular motion along crank arm, connecting rod bearing also receives ditto combustion stress and inertial force[3]. Under these rotation motions, the oil film formation becomes very hard. Especially, the heavy load from cylinder combustion is likely to cause a serious problem to connecting rod bearing. For example, the adhesion status of bearings may stem from improper oil film formation and direct abrasion wear between journal and bearing. Minimum oil film thickness that comes from the cylinder combustion is regarded as the key element for evaluating bearing's durability. While, the peak oil film pressure is an essential parameter for measuring the internal stress that interacts with bearing.

In this numerical study, the special analysis program of EXCITE[4] has been used to analyze the lubrication problems of connecting rod bearings. This paper may present the optimized design data of connecting rod bearings as functions of the geometrical shape of bearing groove and oil hole.

2. COMPUTER SIMULATION

2.1 Governing Equation and Boundary Conditions

Extended Reynolds equation to analyze the pressure distribution of oil film that considers mass conserving n journal bearing is given as following.

$$\frac{\partial}{\partial x}\left(\frac{1}{12\eta}h^3\theta\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial z}\left(\frac{1}{12\eta}h^3\theta\frac{\partial p}{\partial z}\right)=\theta\frac{u_1+u_2}{2}\frac{\partial h}{\partial x}+h\frac{u_1+u_2}{2}\frac{\partial\theta}{\partial x}+\frac{\partial(h\theta)}{\partial t}$$

p : pressure
θ : fill ratio
h : clearance height
η : viscosity
$u_{1(2)}$: circumferential velocity of journal
t : time
$x(z)$: coordinate in circumferential (axial) direction

Boundary conditions to analyze the extended Reynolds equation are given as follows.

- Axially

$p=p_A$ at bearing edge

- Circumferentially

Sommerfeld: $p_{x=0} = p_{x=2r\pi}$

3. RESULTS AND DISCUSIONS

The film analysis is very important to evaluate the pressure distribution and the optimized design of connecting rod bearings. The groove width, diameter of journal oil hole, and the position of the oil hole have been used as design variables.

In Fig. 1, the minimum oil film thickness is changed as functions of crank angles for various values of bearing grooves size. In this result, the minimum film thickness radically decreases for the given bearing width, 16% and 33%.

In Fig. 2, the minimum oil film thickness is shown as functions of the crank angle. The results indicate that the diameter of the journal oil hole does not strongly influence by the size of hole. But, when the diameter of the hole exceeds 30% of the bearing width, the film thickness reduces radically.

In Fig. 3, the minimum oil film thickness is shown as functions of the crank angle. This may be strongly related to the position of the journal oil hole. In this result, the minimum film thickness may occur at the angle of 180 degree. This means that the ultra thin film produces at the explosion stroke as we expected.

In Figs. 4 and 5, the typical patterns of film pressure distribution in the oil film have been presented as functions of bearing groove and journal oil hole. In Fig. 4, the split film pressure shows on the thin film thickness. The parabolic pressure distribution near the oil hole is shown. These results indicate that the peak pressure occurs at the minimum film thickness area due to a reduced real contact film thickness.

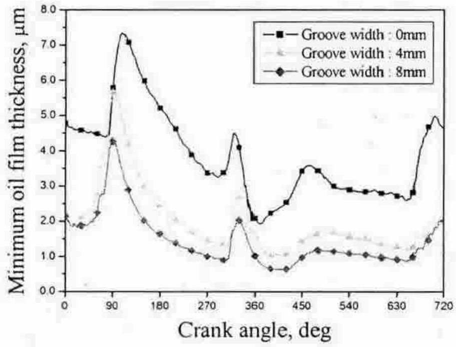

Fig. 1 Minimum oil film thickness distribution for various bearing groove width.

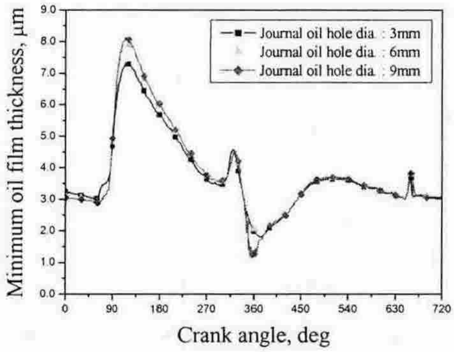

Fig. 2 Minimum oil film thickness distribution for various journal oil hole diameter.

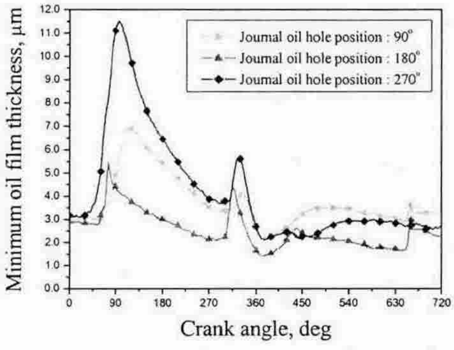

Fig. 3 Minimum oil film thickness distribution for various journal oil hole angle.

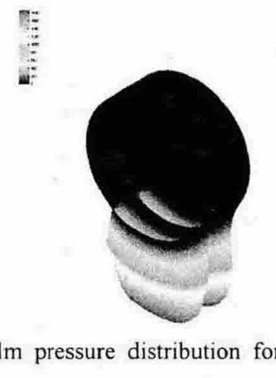

Fig. 4 Oil film pressure distribution for the given bearing groove.

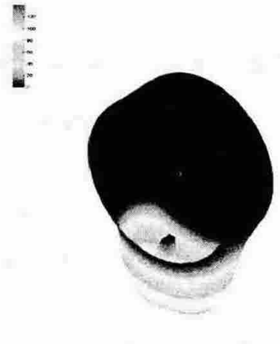

Fig. 5 Oil film pressure distribution for the given journal oil hole.

4. CONCLUSIONS

1) From the result of numerical analysis, the width of bearing groove may be designed as 16% of the bearing width.

2) The diameter of journal oil hole may be kept under 30% of the bearing width.

3) The position of journal oil hole is more influential factor compared to the size of oil hole diameters. The result suggests the optimized position of a oil hole of 90 degree or 270 degree. When the oil hole is positioned at 180 degree, the rubbing surface of connecting rod bearing may be damaged seriously.

5. REFERENCES

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