Mathematical Model of Lubrication Mechanism of Stepped Bearing

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Abstract- Presented herein are the analytical studies of lubrication mechanism of stepped bearing. The idealized model in to produce the result consistent with these in normal situation. It has been observed that pressure increases with the increase the value of μ, l and decreases with the increase with the value of h_1 and h_2. It has been also observed that the load capacity increases with the increase the value of l, L and viscocity and decreases with increase the value of h_1 and h_2.

Indexed Terms- Synovial fluid, synovial joint lubrication mechanism, viscosity

I. INTRODUCTION

Scientist have been greatly attracted to the physical problems arising in mechanism of the body functioning and are trying is analytically as well as experimentally. Biomechanics has attracted engineers mathematicians and other scientists to study the functional behaviour of human skeletal system. These studies have enabled the researchers to analyze the lubrication mechanism of joint along with the structural behavour of articular cartilage and synovial fluid.

The movement of the interstitial fluid within the cartilage and across the articular surface are two fundamental phenomena that govern the tissues mechanical response. Mansour and Mow [4] have studied the non–linear interaction between the tissue's deformation and its resistance to permeation. Mc.cutchan [5] has studied the hydraulic boundary for the cartilage. Lai and Mow [3] studied the concentration of synovial fluid and articular cartilage. They solved concentration in the synovial fluid region and used the interphase boundary conditions to evaluate the concentration in the cartilage region.

The flow of synovial fluid human joints facilitates lubrication and prevents bones from coming into contact with each other. There are many possible lubrication mechanisms for joints. The human joint can be considered as a type of bearing consisting of mating bones covered with spongy material called cartilage. Synovial joints are places where bones are connected, yet may be move freely relative to each other. Synovial fluids are another material in the synovial joints cavities and play an important role in the joint lubrication. Biochemically synovial fluid is a dialysis of blood plasma and hyaluronic acid protein complex which various from joint to joint and person to person. Lubrication theory normally starts with the plane inclined pad. Rayleigh [1] was first to analyze such types of bearing. He investigated that a combination of flat and inclined parts of a slider is definitely better than a simple slider. Prakash [2] discussed the effect of transverse magnetic field on the ratio of flat and inclined parts under general load condition. Yadav A.K. and Pokhriyal [6] discussed the load capacity of a composite slider for various values of parameter. Yadav A.K. and Kumar.S.[7] investigated the load capacity of a slider bearing.

In this paper we have made an attempt to study the pressure and load capacity of the stepped bearing.

II. FORMULATION OF THE PROBLEM

The proposed model may be considered the lubrication mechanism of stepped bearing. The governing equation of two dimensional squeeze film lubrication in the fluid film region are given below;

$$0 = -\frac{1}{\rho}\frac{\partial p}{\partial x} + v\frac{\partial^2 u}{\partial y^2} \quad (1)$$

The equation of continuity;

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (2)$$

When (u, v) are the component of velocities in x and y direction and p be the pressure in the fluid film region.

The solution of equation subject to the boundary conditions;

$$u = U, \quad \text{at} \quad y = h_1$$
$$u = 0, \quad \text{at} \quad y = 0 \quad (3)$$

The concentration on the left half of bearing is

$$\frac{\partial^2 u}{\partial y^2} = P \quad (4)$$

III. SOLUTION OF THE PROBLEM

Integrating equation (4) and using the boundary conditions (3), we get

$$U = \frac{Py^2}{2} + y\left(\frac{U}{h_1} - \frac{Ph_1}{2}\right) \quad (5)$$
$$= A\eta^2 + B\eta \quad (6)$$

Where $\eta = \frac{y}{h_1}$, $A = \frac{Ph_1^2}{2}$, $B = U - h$

Right half where $h = h_2$ and $P_{right} = -P_{left}$

The volume flow rate per unit weight is

$$Q = h_1 \int_0^1 u(\eta) d\eta \quad (7)$$
$$= h_1\left(\frac{A}{3} + \frac{B}{2}\right) \quad (8)$$

There is no change mass flow rate accurss in step, we have

$$Q_{left} = Q_{right} \quad (9)$$

From which

$$\Delta = p_{max} - p_0 = 6\mu l U\left(\frac{h_1 - h_2}{h_1^3 + h_2^3}\right) \quad (10)$$

The load capacity

$$w = 2\int_0^L \Delta p dx \quad (11)$$
$$= 12\mu l U\left(\frac{h_1 - h_2}{h_1^3 + h_2^3}\right) L \quad (12)$$

IV. RESULT AND DISCUSSION

The present paper proposes a more realistic model. The result of pressure and load capacity have been examined for different value of l, L, μ, h_1 , and h_2. It is clear that the pressure increases with the increase the value of l, μ, and decreases with the increase the value of h_1 and h_2. Again it is clear that the load capacity increases with the increase the value of l, L and μ, and decreases with the increase values of h_1 and h_2.

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