ANALYSIS OF EXTERNALLY PRESSURIZED CONICAL BEARING WITH COUPLE STRESS LUBRICANT

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ABSTRACf

Theoretical analysis of the characteristics of conical bearing with couple stress fluid as lubricant is made. Analytical expressions for the pressure distribution, flow rate, load carrying capacity and frictional power due to rotation are derived. It was found that, for a given flow rate a bearing with a couple stress fluid can sustain more load, while a given load can be supported with less pump work when the lubricant is couple stress than when it is newtonian. However, the frictional power due to rotation remains without change.

1. INTRODUCfION

The requirement for many bearings to operate at high speeds under heavy loads has lead to the increasing use of lubricants which contain additives. The presence of additives improves the bearing performance by enhancing the effective viscosity and increasing the temperature range in which the bearing can operate. These additives are long-chain organic compounds. e.g. the length of the polymer chain may be a million times the diameter of a water molecule. Thus couple stresses might be expected to appear in noticeable magnitudes in liquid containing additives with these large molecules. These couple stresses may be significant particularly under lubrication conditions where thin films usually exist.

Various theories have been postulated in recent years to describe the flow behaviour of non-newtonian fluids. One theory due to Stokes [1] allows for polar effects such as the presence of couple stresses and body couples. This theory has been applied to the study of simple lubrication problem [2-5]. However, its potential has not been explored fully.

Extemally pressurized conical bearings have several advantages over plane thrust bearing, e.g. the capability of carrying combined axial and radial thrust, and the self guiding nature of the conical surfaces. Therefore externally pressurized bearings find wide applications especially in the area of machine tool industry. Motivated with this there have been numerous analytical studies of externally pressurized conical bearings which include work by Salem and Khalil [6], El-Kayar et al [7], Prabhu and Gansean

[8,9], Kalita et al [10,11] and Kennedy et al *[U].* They confined their studies to either Newtonian fluids or power law non-Newtonian fluids as lubricants.

The present work focuses on the effects of couple stresses on the performance characteristics of externally pressurized conical bearings. A Stokes couple stress fluid model is used. Solutions for various bearing characteristics are obtained and these results are elaborated through figures and compared with well-established results applicable to newtonian fluid. The analysis for a plane thrust bearing can be obtained by making the semi cone angie equal to (90~.

2. BASIC EQUATIONS

The basic equations of fluid motion with couple stresses are (1]

$$V.v = 0$$

(1)

1

$$pA = VP + pF + -V\,x(p1) + j.LVlV - llV'V \quad (2)$$

2

where V, A,F and T are the velocity, acceleration, body force per *unit* mass and body couple per unit mass respectively, *p* is the density, P is the hydrodynamic pressure, JL is the newtonian viscosity and '1 is a new material constant defining the couple stress property.