MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

A DIRECT TECHNIQUE FOR JOURNAL BEARING ANALYSIS

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ABSTRACT

Todate the design of journal bearings depends on the solutions of Reynolds equation by iterative techniques. In this paper, the Tri Diagonal Matrix Algorithm (TDMA) is modified to fit boundary valued two dimensional problems and is used to find direct and rapid reliable solutions. With this direct technique, Sommerfeld numbers and attitude angles are derived with less than 2 percent deviation from the results of conventional bearing numerical analysis but around 50 times faster. The pressure distributions obtained from both iterative and direct techniques are compared with those acquired from experimental testing. The TDMA solutions show reliability for wide ranges of L/D and eccentricity ratios.

INTRODUCTION

The performance characteristics of journal bearings are commonly obtained from the numerical solutions of Reynolds equation by iterative technique, [1]. Although these methods are reliable when a large number of nodal points are considered, the computational cost involved can be prohibitive, particularly in rotor dynamic analysis, transient studies and bearing design optimization which call for extensive computer search processes. Instead, current practices adopt approximate methods to obtain relative performance values. These include Ocvirk approximate solution which assumes a parabolic pressure distribution in the axial direction, or the use of modified parabolic exponents, Shelly [2]. Errors involved with such methods are found to increase rapidly with journal eccentricity and aspect ratios. The numerical scheme presented in this paper is a direct method of solution based on the Tri Diagonal Matrix Algorithm (TDMA), which is developed to suit two dimensional boundary value problems, [3], [4], [7]. A study of this algorithm, known sometimes in the literature as the Thomas algorithm, revealed the fact that it can be used to analyse bearings with film rupture. Brearings under pure spin with aspect ratios

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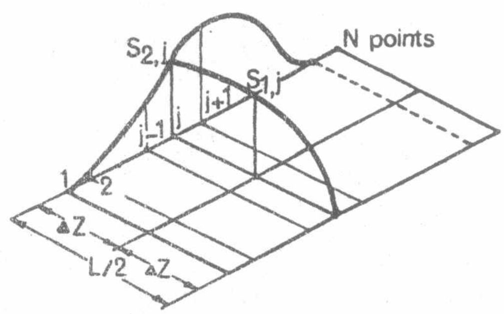

Fig. 2 Grid for the TDMA

One Axial Nodal Point Solution (M=1)

Considering the past efforts to use the short bearing theories and the refined residual error in Eq.(3), the number of points in the circumferential direction (N) is taken equal to 121 with the axial half length divided into only one space (M=1), Fig. 2 . From mid plane symmetry Eq.(3) becomes:

$$S_{1,j-1} - \left(2+2 \left(\frac{\Delta\theta}{\Delta z} \right)^2 + \frac{5}{6} G_j \Delta\theta^2 \right) S_{1,j} + S_{1,j-1} = R_j \Delta\theta^2 \qquad (4)$$

where $\Delta z = \frac{L}{D}$, $\Delta\theta = \frac{2\pi}{N-1}$

The residual error for this finite difference form is

$$\frac{1}{240} \Delta z^4 \frac{\partial^6 S}{\partial z^6}$$

Eq.(4) arranged in a matrix form create a tri-diagonal matrix. In such cases the solution may be obtained directly by the TDMA if the two boundary values are known, (appendix I). For a journal bearing subjected to pure spin, positive S starts at θ=o and the Christopherson cavitating approximation simply demands that the calculated pressure is not allowed to become negative, [5] . The nature of the TDMA calls for calculations of two coefficients α and β begining at θ=o, (appendix I). The cavitation boundary is found at the location where β changes sign from positive to negative. Thus, the trailing edge is determined without iteration leading to a great reduction in the computational time.

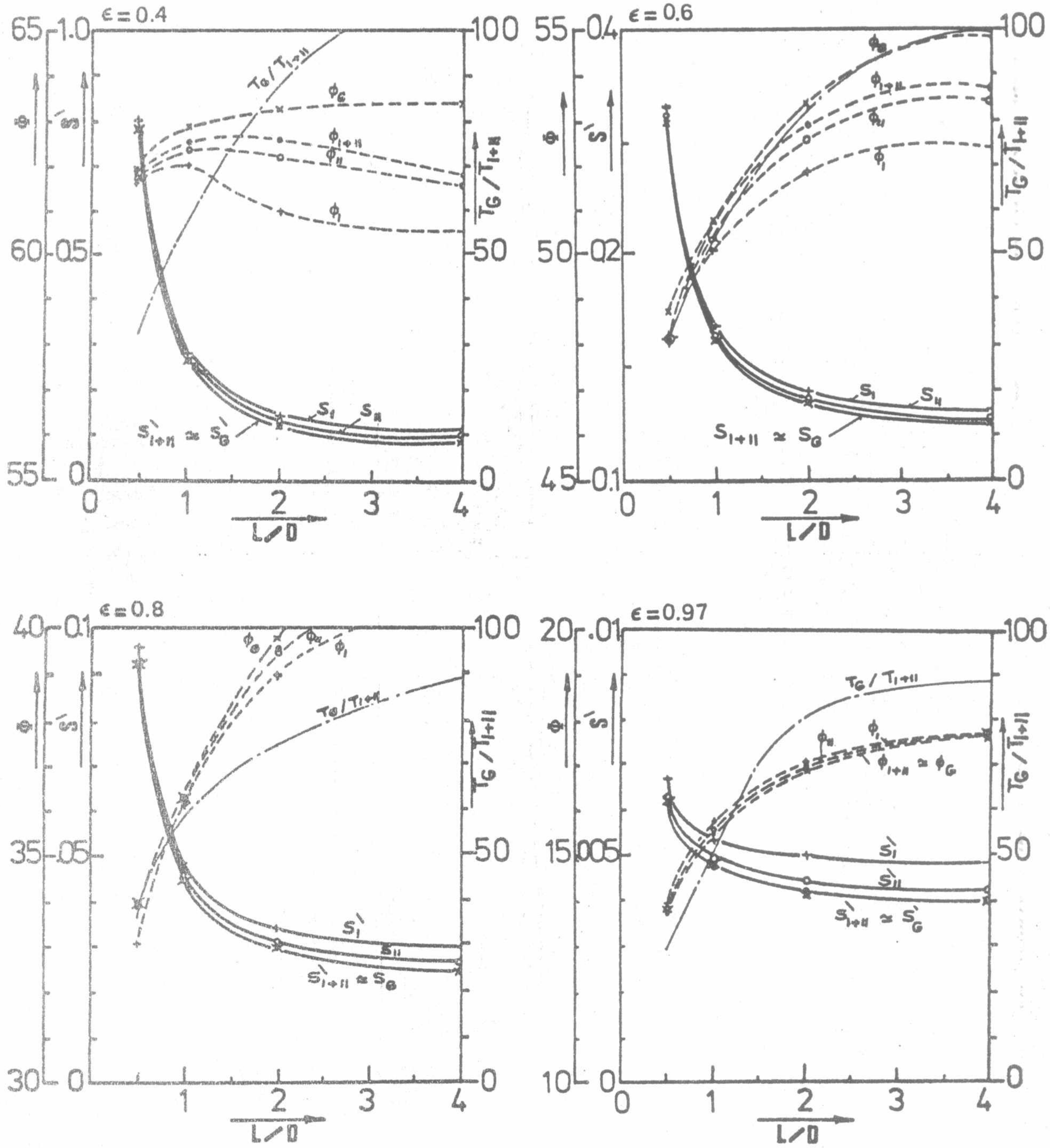

Fig. 3 Variations of the characteristic parameters for different aspect ratios (L/D).

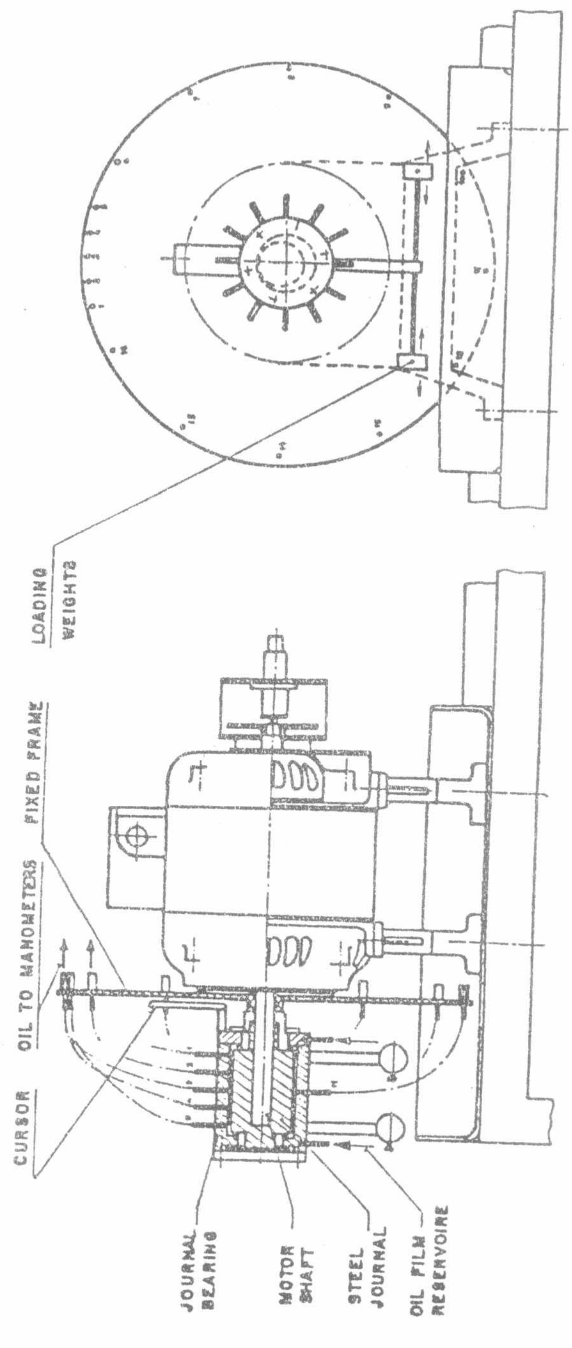

Fig. 4 Schematics of test rig.

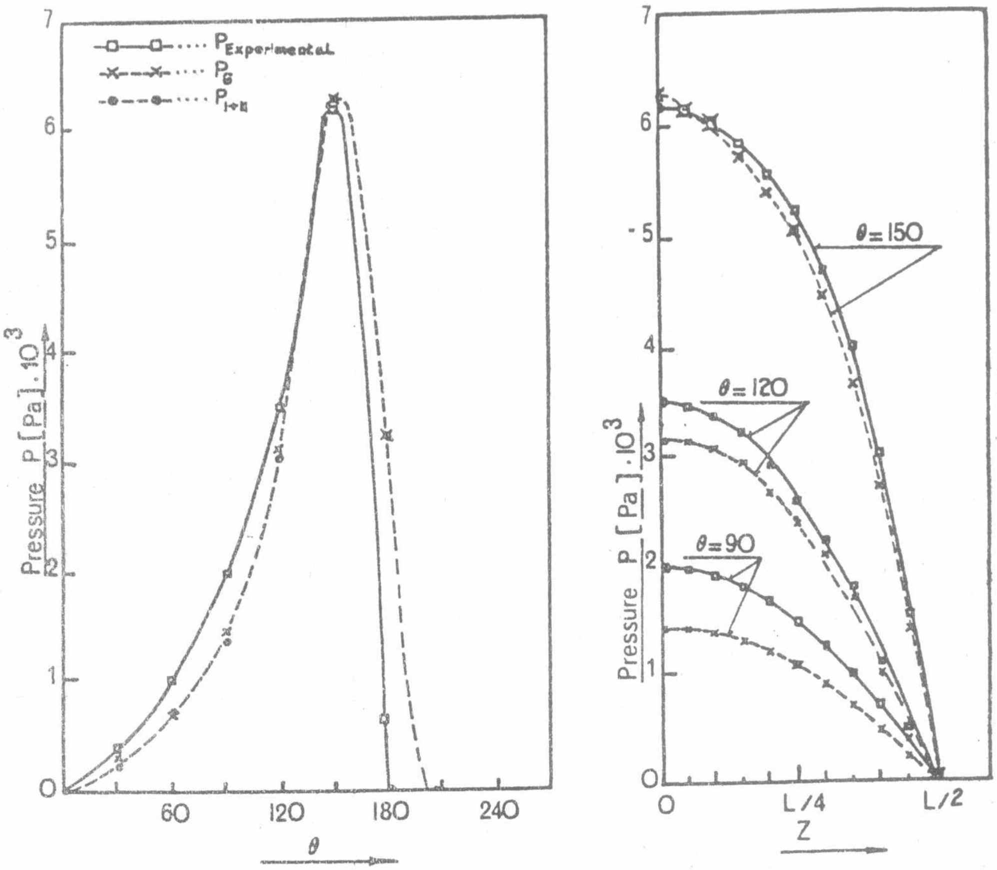

Fig. 5 Typical hydrodynamic pressure distribution
RPM=1000, W = 850 gr, Shell B 30

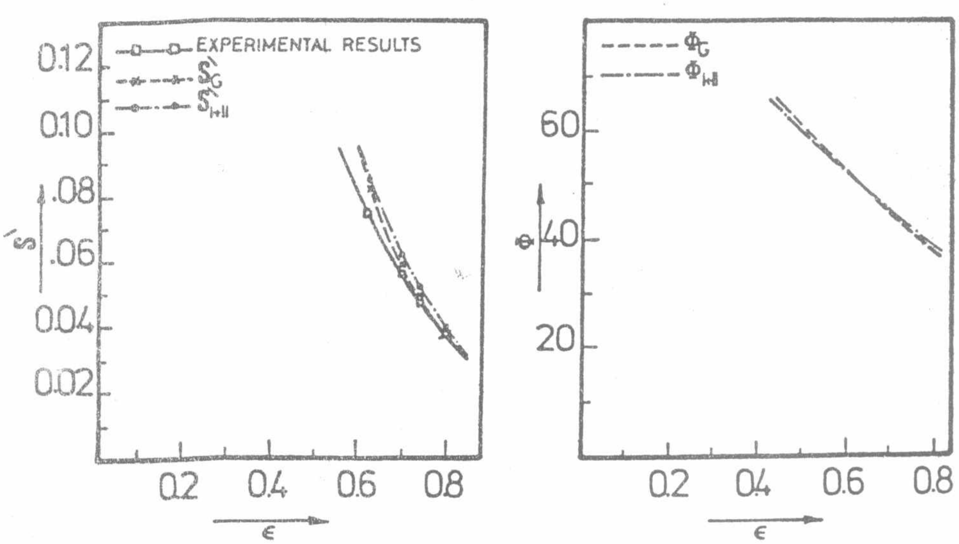

Fig. 6 Comparative results for Sommerfeld numbers and attitude angles.