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DISCUSSION

M. M. Athavale[1] and A. K. Singhal[1]

This is an interesting study of the flow interaction in pockets of hydrostatic bearings and offers considerable insight into the complexity of the flow that exists in these pockets under different flow regimes considered in the paper. There are two issues that the discussers would like the authors to comment on:

1) Effects of the curvature of the shaft on the flow dynamics. These effects are expected to be small for the flow in the clearance, but can become important for the deep pockets.
2) The present simulation is done using a 2-D approximation. The pocket is in actuality three-dimensional. Although the 2-D study is an important step in the understanding of the pocket flows, how far is the applicability of such a study to an actual pocket?

Authors' Closure

The authors want to thank Drs. Athavale and Singhal for their comments and insightful questions. In order to effectively answer we have exercised a novel computer model, written by the authors, that allows the three-dimensional (3-D) parametric modeling of hydrostatic pockets, their restrictors, and adjacent lands. In fact this is the 3-D version of the two-dimensional code used in the writing of this paper. Figure 11 presents the geometry of the 3-D pocket. The effects of the curvature of the shaft on the flow patterns and pressure distribution as well as 3-D effects are presented in Figs. 12 and 13 for the deep pocket geometry shown in Fig. 11.

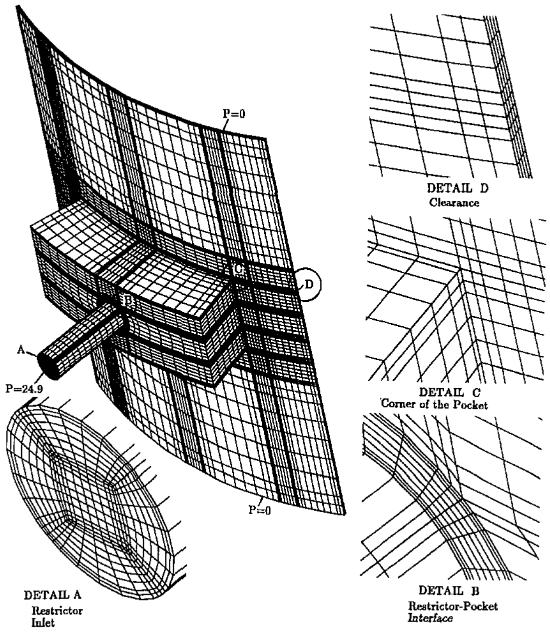

Fig. 11 Geometry of the three-dimensional pocket

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[1] CFD Research Corporation.

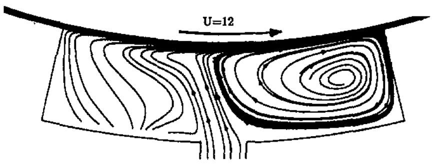

Fig. 12 Flow patterns in the symmetry plane of the three-dimensional deep pocket (Re = U = 12, P = 24.9, C = 6.66)

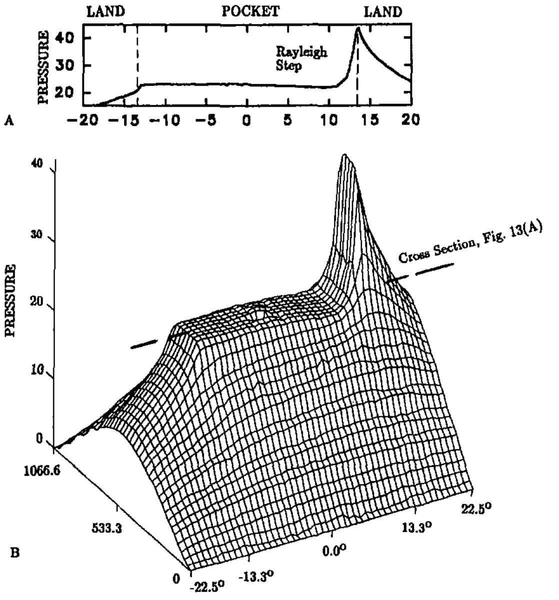

Fig. 13 Pressure distribution under the runner for the three-dimensional deep pocket (Re = U = 12, P = 24.9, C = 6.66)

The geometry of the 3-D pocket at its longitudinal axis of symmetry is similar, to that of the 2-D deep pocket, but the dimensions are slightly different. The shaft radius is the same $R_s = 1000$ (see Table 1), but the depth of the pocket is somewhat smaller $D = 133.3$. The capillary feedline has a length $L_2 = 200$ and a diameter $B = 66.6$. The side walls in the circumferential direction subtend a total angle of 26.6 deg and the width is 200. The total length of the bearing is 1066.6. These are the same dimensionless units as shown in Table 1. The multiblock grid applied to this three-dimensional geometry is shown in Fig. 11. Details A, B, C, D have been added in order to give the reader a better insight into the grid formations that are of particular interest in overall grid picture.

For these calculations the shaft is concentric with the bearing and the clearance is $C = 6.66$. The pressure boundary condition at the feedline inlet is $P = 24.9$, while the axial ends are at $P = 0.0$. While Fig. 11 shows only the lands adjacent to the pocket, the actual computational domain in the circumferential direction subtends the rest of the 360 deg of a smooth (no other pockets) circle. The dimensionless circumferential velocity of the runner is $U = 12$, and indicates a Couette dominated flow.

The flow pattern in the circumferential symmetry plane of the pocket is presented in Fig. 12. The flow structure in the downstream half of the pocket is similar to the flow pattern obtained for the 2-D calculation (see Fig. 2(A1)). However, the influence of the jet is stronger due probably to the different smaller dimensions in D, B, and L_2. As a consequence the jet penetrates vertically almost all the way to the rotating shaft, without the strong deviations observed in the upstream regions of Figs. 2(A1-A3), and 4(A1-A3). We believe that due to this stronger jet the flow pattern in the upstream half takes a different configuration. On the whole, however, the flow patterns in the symmetry section does not offer a significant departure from the 2-D model.

The pressure distribution under the runner in the circumferential symmetry plane is shown in Fig. 13(A). The profile is qualitatively and quantitatively close to the 2-D results shown in Fig. 5(A1). One can observe here the spectacular pressure rise due to the Rayleigh effect, as well as the inertia induced pressure drops in the regions where the pocket joins the lands. The pressure rise due to the Rayleigh effect is stronger than that of the 2-D study due to the greater velocity of the shaft used in this numerical experiment ($U = 12$ instead of $U = 8$).

The 3-D pocket pressure distribution under the runner is presented in Fig. 13(B). Note that the pressure distribution in the axial direction, for the symmetric axial boundary conditions is rather uniform. This may indicate that a 2-D study would suffice if there is axial symmetry in the boundary conditions.

One can conclude that the curvature effects for the cases presented here are not significant enough when compared with the straight lines geometry of the pocket that makes the subject of the paper. The pressures yielded by the 3-D model in the plane of symmetry normal to the shaft axis are quite similar to the results obtained by the 2-D model, and thus do justice to the 2-D approach. Thus, it would be fair to state that for particularly favorable conditions (symmetry in geometry and boundary conditions, no dynamic effects) the 2-D model may suffice.

However, experimental and numerical evidence born by the flows away from the plane of symmetry, shows patterns quite different in structure, and we believe that these flows play a significant role in the mixing of the jet with the layer carried around by the shaft. One can safely surmise that this situation is bound to play a major role in the development and management of the fluid and pocket thermal profiles. In addition if the axial pressure boundary conditions were not symmetrical, or if the feedline had an inclination different than 90°, it is more than probable that the 2-D model would not be appropriate for the design of an actual pocket.

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