the flange forces. This is analogous to a highly damped spring mass system under forced vibration where the unbalance of the roller is the forcing function, the roller-flange contact is the spring force and the roller-race lubricant layer provides the damping. With low values of viscous damping from a low viscosity fluid, high values of flange forces can occur.

An explanation for the flange loads associated with balanced rollers is more difficult to construct. One possibility is that these loads could arise as a result of roller skewing. This skewing introduces an axial component of velocity of the roller relative to the race as shown in Fig. 12. This velocity component results in axial roller-race slippage and an associated viscous force, the magnitude of which will increase with the viscosity of the fluid. The direction of the axial velocity vector and hence the force will oscillate as the roller oscillates to produce time dependent impacts.

The experiments discussed in this paper show the effect that the lubricant plays in the magnitude of the roller/flange forces. The flange wear problem is an important one for high-speed roller bearings and future work along the lines discussed here, as well as analytical modeling, will be needed to understand the source of these forces. The net result of such research should be bearing geometry specifications and lubricant requirements necessary to reduce the magnitude of the flange loads to acceptable values.

**References**


**Discussion**

L. J. Nypan

The authors are to be complimented for what they have accomplished in evaluating roller flange forces, a very difficult measurement. They deserve thanks for making this information available to the technical community.

In view of the somewhat large clearance in the bearing used, what was the extent of the loaded zone and how would this affect roller to flange interaction?

What was the amount of misalignment that could exist in their apparatus? Was this ever measured?

The authors mention that the modified section of flange was extremely thin and flexible. What was the effect of this on forces that might be developed? How might these be different if the flange were rigid?

The data presented always show the indication of strain gage 1 positive, and strain gage 2 negative. Did the authors ever observe these indications reversed? What is the significance of this?

---

1. California State University, Northridge, Calif. 91330.
Author's Closure

The internal clearance in the test bearing was 0.5 mm (0.020 inches) which is significantly higher than would typically be used with this type of bearing. The exact load zone has not been calculated, but it is probably no more than 3 to 5 rollers. This geometry may also influence the magnitude of the flange loads, but the experiments clearly demonstrate that the lubrication does influence the roller flange loads. The influence of other geometrical factors in the bearing deserve feature research effort.

The bearing was initially aligned using a dial indicator mounted on the inner race reading the relative “runout” of the outer race. The outer race was adjusted to produce less than 0.25 mm (0.001 in.) runout. However, the outer race was held by links with standard spherical end joints. These joints may have allowed some variation in alignment for different load conditions.

The instrumented flange section was a beam 0.5 mm (.020 in.) thick and approximately 2.5 mm (0.1 in) wide. If the peak load measured in the tests occurred in the center of this section, the deflection would be approximately 0.1 mm (0.004 in.). However, the data indicates that the impact occurs at locations other than the center; and therefore, the deflection will be less than this value. The thin flange section will only have this deflected shape when the roller hits it at the highest loads measured. The nominal roller clearance is 0.02 to 0.05 mm (.007-.001 in.) which is the same order as the beam deflection. Therefore, under non-impact conditions, the instrumented section should not influence the roller motion.

The data do not always show the output of gage 1 as positive and gage 2 as negative, although that is the predominant mode of output. Gage output in figures 9 and 10 show both positive and negative output from each gage, but the maximum values occur as positive on gage 1 and negative on gage 2. No reason for this behavior has been hypothesized.