



Fig. 20 Relationship of total tip leakage flow rate to tip clearance in a cascade

pressure difference to drive the tip leakage flow, as assumed by Chen et al. in the development of their model. It is shown by Storer and Cumpsty (1991) that the pressure distribution near the blade tip in a cascade changed due to the proximity of the tip vortex when the clearance was altered. The changes of pressure distribution gave rise to changes in the chordwise pattern of tip leakage flow, but nevertheless the *overall* tip leakage mass flow rate was not in fact changed by the vortex. (This can be seen since the flow rate increased linearly with respect to tip clearance, as shown in Fig. 3.) Therefore the average pressure difference driving the flow remained constant and a function of the flow conditions outside the endwall region, i.e., those at midspan.

## References

- Storer, J. A., 1990, "Tip Leakage Flow in Axial Compressors," Ph.D. Dissertation to be submitted, Cambridge University, United Kingdom.  
 Storer, J. A., and Cumpsty, N. A., 1991, "Tip Leakage Flow in Axial Compressors," ASME JOURNAL OF TURBOMACHINERY, Vol. 113, this issue.

## Authors' Closure

The authors thank Mr. Storer for his discussion. We view it as a valuable addition to the paper, which represents one of the beneficial aspects of the ongoing collaboration between the Whittle Laboratory and the Gas Turbine Laboratory. Mr. Storer has brought out very clearly some of the differences that exist between clearance flows in turbomachines and in cascades; further components on the topic are given by Chen (1990).

We also have been using three-dimensional computations to examine the tip clearance flow, as a parallel effort to that in the paper. To restate a position given in the paper, it appears to us that the combination of well-chosen "numerical experiments," such as Mr. Storer has done (see also Crook, 1989) with analysis, is indeed useful for developing understanding, not only on a case-by-case basis, but for a broad class of fluid dynamic devices of practical interest.

## Reference

- Chen, G. T., 1990, "Vortical Structures in Turbomachinery Tip Clearance Flows," Ph.D. Thesis, Department of Aeronautics and Astronautics, MIT, Cambridge, MA.