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Discussion

Authors' Closure[1]

We are grateful for the meaningful discussion to our paper presented by Dr. Starken. When we said our method "provided accurate detailed information about the flow through the cascade," our emphasis was first on the "detailed information," such as those along the mean streamline. The "accuracy" is of course limited by the inviscid model.

In the comparison between the theoretical calculation and experimental data, it is important that, first of all, the effect of the axial velocity density ratio be taken into account. The theoretical calculations given in our paper were all made for this ratio equal to unity, i.e., a true plane cascade. However, it was recently shown that the axial velocity density ratio in the DFVLR cascade test data is 1.05. When the theoretical calculation is made for this axial velocity density ratio the pressure distribution around the blade is much closer to the test data than that previously calculated for this ratio equal to unity (see Fig. 15). It is to be noted that instead of Mach number, pressure is used here for comparison, because the decreasing stagnation pressure downstream of the passage shock is not available from the test data and Mach numbers calculated from the pressures measured at the blade surface and an undecreased value of stagnation pressure would give values of the Mach number higher than the actual values, such as in the case of the comparison given by Dr. Starken (Fig. 14). Furthermore, due to the very strong viscous effect in the region downstream of the passage shock, in order that the result of inviscid calculation would still be comparable to the test result, it is necessary to account, in some way, for the large viscous effect. A simple approximate way is to compute the entropy increase from the passage shock station to the blade exit station according to the stagnation pressure measured there. Assuming a linear variation of this entropy increase along the stream line downstream of the passage shock and using an overall "axial velocity density ratio" of 1.18 in order to include the effect of reduction in effective flow area in the calculation, the result of theoretical calculation is now much closer to the test data (see Fig. 15). It seems that when a suitable "overall" axial velocity density ratio and entropy increase downstream of the passage shock are included, the simple inviscid calculation is still capable of giving some useful information. Of course, for high inlet Mach number, a viscous solution is more desirable and is eagerly sought. It is also desirable to have more detailed measurement of flow along surfaces of revolution in turbomachines so that the three-dimensional effects can be fully included and the serious effect of side walls in a cascade can be avoided in assessing the accuracy of theoretical inviscid transonic flow calculations.

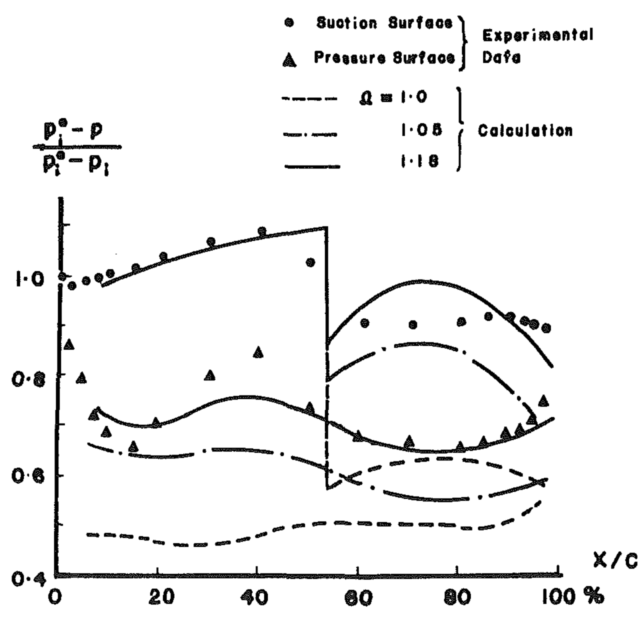

Fig. 15 Comparison between theoretical calculation and experimental data

[1] To the discussion by Dr. H. Starken of the paper "Transonic Cascade Flow Solved by Separate Supersonic and Subsonic Computations With Stock Fitting," by Wu Wenquan, Wu Chung-Hua, and Yu Dabang, Journal of Engineering for Gas Turbines and Power, Vol. 107, No. 2, April 1985, pp. 329–336.