In the transonic and high subsonic range the vortex shedding affects almost equally the static pressures (trailing edge and side wall) and the total pressure (probe at mid-blade height). However, in the low subsonic range, up to $M_{2,is} \approx 0.5$, the tests did not indicate any measurable effect on the static pressures.

Figures 8a and 8b present the Strouhal numbers (vortex shedding frequency x trailing edge thickness/free stream velocity) in function of the isentropic downstream Mach number $M_{2,is}$, Fig. 8a, and the isentropic Mach number at the trailing edge just before separation $M_{TE,is}$ (mean value between suction side and pressure side Mach numbers), Fig. 8b. Except for the lowest Mach number ($M \approx 0.3$) for which the total pressure probe indicates a Stouhal number of $S \approx 0.3$, all other values lie in the range $0.2 \leq S \leq 0.15$ with a slight decrease in S with increasing Mach number.

So far the tests did not yet allow to draw definite conclusions as to the pressure variations involved in this type of flow unsteadiness.

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A new technique for controlling the exit flow periodicity of supersonic cascades

by
H. Starken

Upstream and downstream flow periodicity are two of the important conditions to be observed in all cascade test. This periodicity condition is directly connected to the boundaries of the cascade in the circumferential direction. Considerable efforts have been directed in the last years to this problem especially in the transonic and supersonic flow region, because only the solution of this problem justifies the application of the simple two dimensional cascade model. If such a solution is not found, only the annular and rotating cascades could be used.

The inlet flow problems have been solved in the past, but we had still difficulties in the exit flow region. As has been shown by LICHTFUSS [1], neither solid walls (Fig. 1) nor free jet boundaries (Fig. 2) do give periodic exit flow at supersonic velocities having an axial subsonic component.

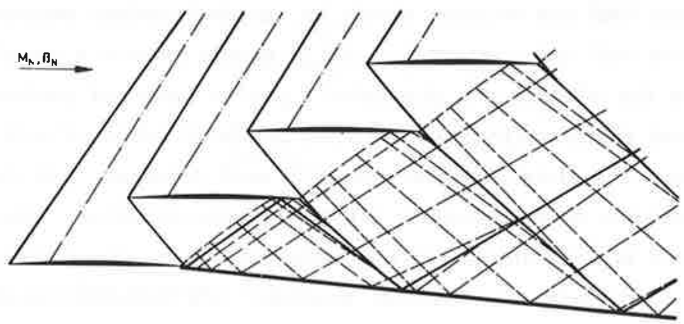

Fig. 1 Solid wall boundary (Ref. [1])

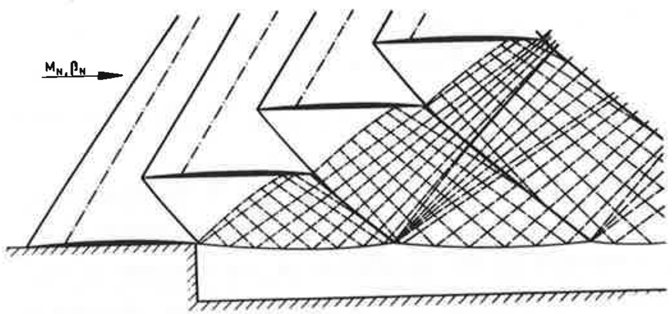

Fig. 2 Free jet boundary (Ref. [1])

Lichtfuss proposed a theoretically exact solution for the loss free exit flow, which, however, requires a completely new cascade wind tunnel design (Fig. 3). In many cases it is not possible to build a new wind tunnel. Apart from that the Lichtfuss-solution requires also special efforts to cover the transonic velocity range $0.9 < M_2 < 1.2$. This velocity range, however, is the most important one in compressor cascade work. Therefore, we were looking for a modified technique.

Keeping in mind that this solution should be, in its boundary behaviour, in between solid wall and free jet and that it should provide a variable pressure along the boundary we developed a porous tailboard combined with an attached chamber (Fig. 4). We used a slotted tailboard with 30 % open area. The slots could be closed in such a manner that the open area increases or decreases in the streamwise direction. This slotted tailboard is very similar to the walls used in normal transonic wind tunnels. In cascade wind tunnels, however, this tailboard has also

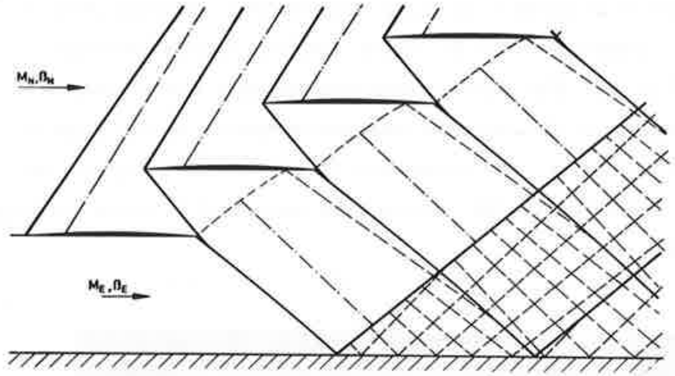

Fig. 3 Lichtfuss solution (Ref. [1])

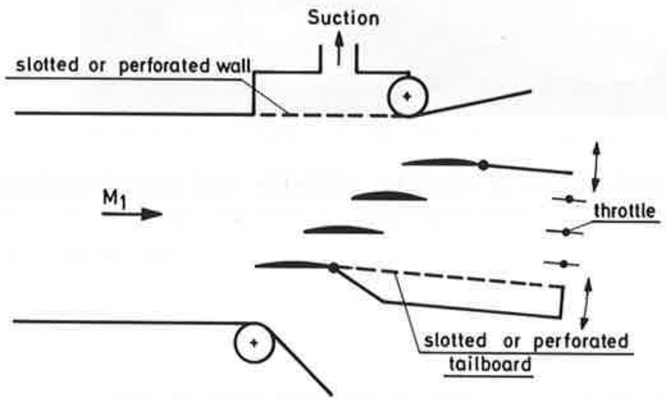

Fig. 4 New porous tailboard system

to provide the necessary back pressure. This is done by feeding the pressure just upstream of the throttle through the chamber to the open slots. With this method we have successfully obtained periodic back pressure conditions even for blade sections having internal contractions (Fig. 5). The experiments showed that the measured exit flow conditions of the cascade are not sensitive to the angular position of the tailboard. The same exit flow could be obtained by using either the throttle or by rotating the tailboard in order to vary the back pressure.

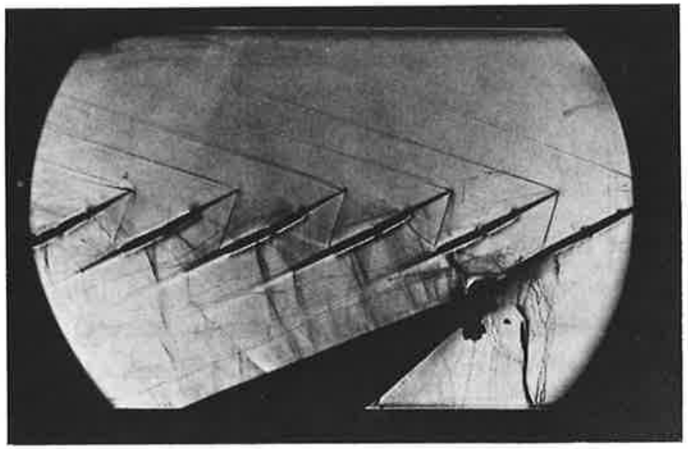

Fig. 5 Schlieren picture of cascade, throttled with porous tailboard

Reference

[1] Lichtfuss, H. J., Starken, H.: Supersonic Exit Flow of Two-Dimensional Cascades. ASME paper 72-GT-49 (1972).

A new configuration of wind tunnel and some experience with an annular cascade for transonic flow conditions

by

A. Bölcs and T. Fransson

Summary:

To investigate experimentally the transonic flow in annular cascades, a new type of wind tunnel was developed. The testrig enables variations of the medium velocities and flowangles in the test section, as well as of the velocity- and flowangle-distributions over the channel height.

Flow-measurements were made in a transonic turbine-cascade with a small aspect ratio (H/S = 0.19). A comparison between the profile Mach numbers measured on the outer wall of the test section and in the middle of the channel shows a fairly good agreement on the pressure side, but a greater deviation is found on the suction side of the blade. This is due to the clearance-flow.

By attaching end-plates on the tip of the blades, the clearance-flow was reduced. In this case, the difference between the measured profile Mach numbers in the middle of the channel and on the outer wall was also reduced. The flow-velocity in the cascade with end-plates, compared to the case without end-plates, increases in the case of identical up-stream-conditions.