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Effect of Inlet Velocity Distribution on Diffuser Flow

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In centrifugal compressors and turbines, non-uniformity of the free stream velocity distribution is commonly seen because of the existence of centrifugal force or the separation of the boundary layer.

Non-uniformity of the free stream velocity distribution at inlet may affect not only the performance of the diffuser but also the outlet flow condition. The latter one is important when one considers the downstream component.

To examine the effect of such non-uniformity on the performance of two-dimensional straight walled diffusers and the change of velocity distribution between two parallel walls of them is the main object of this work.

Before undertaking the main part of the experiment, tedious trials were made to generate linear velocity profiles having required velocity gradients. Using resistance plates which were placed parallel to the axis of a rectangular duct, five kinds of velocity gradients were produced.

Applying this method, the main part of this experiments was performed. Two kinds of diffusers were tested, both having the same 64×28 mm inlet cross section and 4° and 8° total diverging angles respectively. Nine velocity traverse stations were set up in them, at which velocity profiles between two parallel walls and centerline static pressure distributions were measured with 1 mm outer diameter total and static tubes.

These experiments showed that pressure loss coefficient of a diffuser increases with free stream velocity gradient at inlet. But the results did not agree with those of similar experiment with a duct of constant cross section. Hence it may be seen that free stream velocity gradient affects the secondary flow condition as well as the boundary layer growth. These effects may change the diffuser loss coefficient indirectly.

Generally, non-uniformities in the velocity of an incompressible inviscid fluid flowing through a diffuser become accentuated. Recently Horlock gave an analytical solution for two dimensional straight walled diffuser. We applied this method to our problem and showed that free stream velocity gradient between two parallel walls of a two dimensional diffuser changed proportionaly to the radial distance from the point at which two walls meet. This result agreed with experiments when radius ratio and velocity gradient were small. When radius ratio

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becomes larger, boundary layer growth can not be ignored and such inviscid analysis is insufficient.

After all, in a diffuser of small radius ratio such as of conventional turbo-machinery, the effect of the process of diffusing a fluid flow on the velocity profile can be ignored comparing with the boundary layer growth.