Journal of Wind Engineering and Industrial Aerodynamics, 26 (1987) 275-277
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

Short Communication

EFFECTS OF WALL CURVATURE ON THE PERFORMANCE OF TRANSITION DUCTS

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(Received June 26, 1986)

In 1980 Atilgan and Calvert studied the geometry of transition pipe sections between square and rectangular ducts of the same cross-sectional area [1]. The transition pipes studied were designed to have straight walls as shown in Fig. 1. They had an area variation of parabolic form with the maximum occurring at the mid-point. The present authors have investigated the pressure loss in this type of transition [2–4], and discussed the design of transitions with constant cross-sectional area [5]. "Constant-area" transitions may be designed with one pair of flat walls and one pair of curved walls (Fig. 2). (Wall curvature is one of the methods which has been used to improve diffuser efficiency, for example see ref. 6.) From Fig. 2, the width of the transition between the curved side walls is given by

$$b_x = \frac{A^{1/2}}{1-(x/L)[1-g^{1/2}]}$$

where $A = D^2 = (a.b)$ and $g = a/b$
which represents an equation for the side wall curvature.

Using the same rig and procedure described in previous references [2–4], the authors have tested and compared the performance of a "straight-walled" transition and of a "constant-area" transition of length $L/D = 1$ and an aspect ratio $g = 0.4$.

Figure 3 shows static pressure variation along the centre-lines of the constant-area and the equivalent straight-walled transitions for approximately fully-developed flow at the entry, where the Reynolds number $Re = 5\times10^4$ approximately. In the constant-area transition the static pressure decreases gradually along the duct to reach a minimum value of $C = -0.280$ at $x/L = 0.76$ approximately. After this point, the pressure rises along the rest of the transition length. On the other hand, the static pressure distribution along the straight-walled transition has two turning points: minimum and maximum

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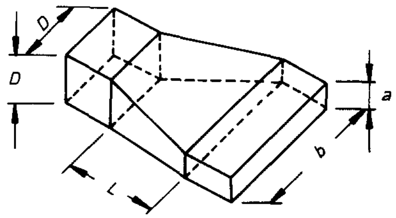

Fig. 1. Straight-walled transition between square and rectangular ducts of the same cross-sectional area.

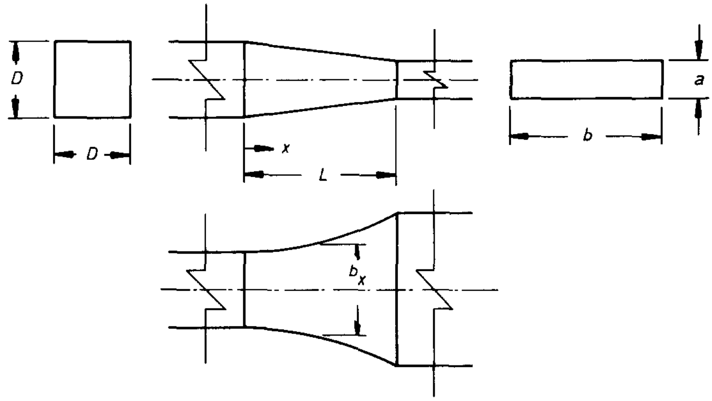

Fig. 2. Constant-area transition between square and rectangular ducts of the same cross-sectional area.

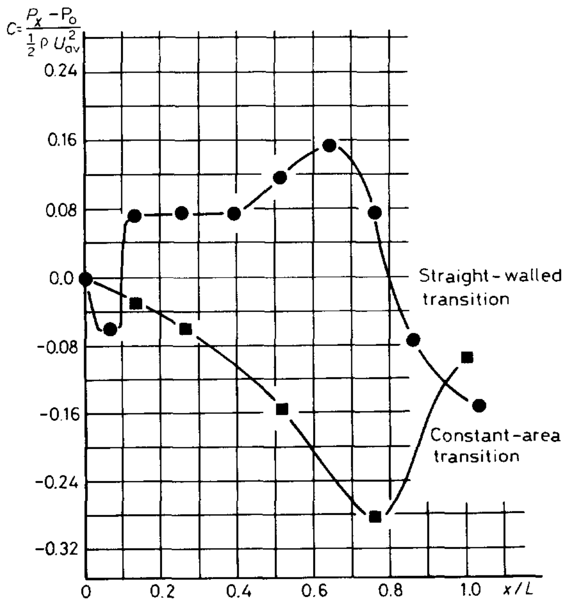

Fig. 3. Static pressure distributions along transition centre lines.

values as indicated in Fig. 3. The pressure falls rapidly to attain the minimum value of -0.060 at $x/L=0.06$ approximately and then rises sharply to remain almost constant to approximately $x/L=0.4$. After that the pressure rises to the maximum value of 0.150 at $x/L=0.63$ approximately and then falls to the end of the transition.

The overall pressure loss coefficient for the constant-area transition is approximately 0.156; a reduction of 28% compared to that in the equivalent straight-walled transition.

The effect of wall curvature is a function of the transition length and aspect ratio. Therefore, for constant-area transitions of higher aspect ratio ($g>0.4$) and with the same length ($L/D=1$) the benefit from curving the side walls would be smaller than the present result. However, for transitions with lower aspect ratios the improvement would be expected to be higher for the same length.

References

1 M. Atilgan and J.R. Calvert, Geometry of transition sections between ducts of equal area, J. Wind Eng. Ind. Aerodyn., 6 (1980) 25–37.

2 E.I. Dekam and J.R. Calvert, Pressure losses in transitions between square and rectangular ducts of the same cross-sectional area, Int. J. Heat Fluid Flow, 6(3) (1985) 212–216.

3 E.I. Dekam and J.R. Calvert, Effects of inlet conditions and surface roughness on the performance of transitions between square and rectangular ducts of the same cross-sectional area, The University of Southampton, Department of Mechanical Engineering, Report No. ME/85/22, Nov. 1985, Int. J. Heat Fluid Flow, to be published.

4 E.I. Dekam and J.R. Calvert, Pressure losses in sudden transitions between square and rectangular ducts of the same cross-sectional area, The University of Southampton, Department of Mechanical Engineering, Report No. ME/86/7, March 1986, Int. J. Heat Fluid Flow, to be published.

5 E.I. Dekam and J.R. Calvert, Design of transition sections between ducts of equal area, J. Wind Eng. Ind. Aerodyn., 24 (1986) 117–127.

6 Introduction to design and performance data for diffusers, Engineering Sciences Data Unit, Item No. 76027, Nov. 1977.