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SMALL SLENDER PIECES ATTACHED AT END OF THE NOZZLE FOR DECREASING THE LOW VELOCITY JET-NOISE

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1. INTRODUCTION

It is an important subject to abate aerodynamic noise for developing comfortable high-speed vehicles, ventilation systems and etc.. Low-noise acoustic wind-tunnels which have the quietter air-flow to measure aerodynamic sounds are important and very useful for developing quiet and agreeable vehicles or air-conditioning systems. In the measuring section of an acoustic wind-tunnel, noise from the fan as an air-source are reduced enough by sound-absorbing systems and many kinds of aerodynamic soun radiated from the test-object in the flow can be directly measured[1]. It is more expected to decrease flow noise without any test objects in the measuring section of acoustic wind-tunnels. Contribution analysises with respect to aerodynamic sound-sources in the measuring section had been examined with refering to the text[2] as presented before[3]. Following to those results, sound-

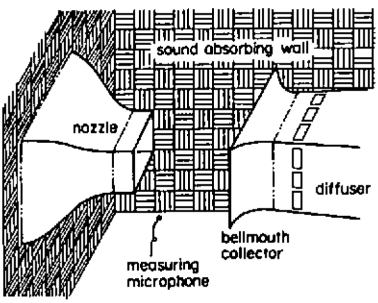

Fig.1 Outline of a measuring section of semi-open type acoustic wind-tunnels

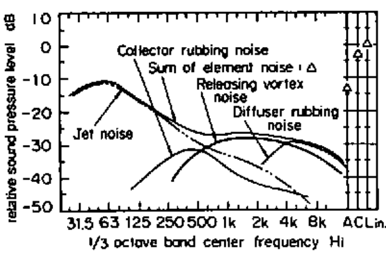

Fig.2 Contribution analysis about back ground flow-noise in measuring section.

sources in the measuring section without the floor of a wind-tunel as like figure 1 are analyzed as shown in figure 2. Dominant aerodynamic noise are the jet-noise in the lowwer frequency region and the releasing vortexes sound in middle and higher frequency region. Both noise-sources are induced by the low velocity blowing flow from 20m/s to 80m/s. Then we experimentally have studied some methods for decreasing aerodynamic noise from nozzle blowing flow.

2. NOISE SOURCE OF BLOWING FLOW

Characteristics of aerodynamic noise from blowing-flow itself of nozzle outlets were investigated by using the very low noise flow[4]. Ordinary speaking, acoustic powers of jet-noise are proportional to the 8th power of blowing velocity and the 3rd power of nozzle-diameter with basing on past studies[2]. But these characteristics are obtained on conditions of high flow-velocity in very far-field. Therefor it is impossible to apply directly those to the present study as the flow-velocity is lowwer than 100m/s and observation areas are nearer to a nozzle-outlet. The structure of a nozzle blowing flow is generally indicated as shown in figure 3. The jet noise is generated in shear-flow regions and in jet-mixing regions. The second component measured in this study might be generated at outlet-edges of nozzle with considerations of results obtained by sound-intencity vectors. Origins of shear flows are the releasing vortexes at edge of the nozzle and these releasing vortexes would generate sounds corresponding with the second component. There are optimal lenght of straight ducts connected to contractive nozzle with reference to the low noise[4]. The length of duct affects on thicknesses of boundary layers at nozzle-edge and these boudary layers have influence on the shear-flow noise and the releasing-vortex noise.

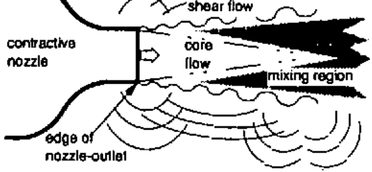

Fig.3 Outline structure of blowing flow from nozzle outlets.

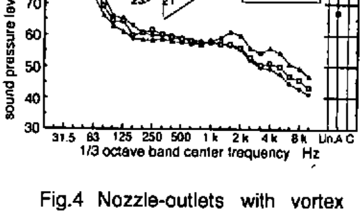

Fig.4 Nozzle-outlets with vortex breakers at the edge decrease low frequency components of these noise. (500×500, 50m/s)

3. FORMER METHOD AGAINST JET-NOISE

Methods for reducing these aerodynamic noise have been studied experimentally by using the small acoustic wind-tunnel. Attaching vortex breakers at the nozzle-edge reduces low-frequency components of these noise as shown in figure 4. It would be probably the cause of this reduction that breakers change constructions of the shear flow and decrease the spanwise coherence of fluctuations in the shear flow. While, high frequency components increase as vortex-breakers generate some aerodynamic noise by separated flows around breakers itself. These methods had been applied for stabilizing the shear flow in a measuring section of some open-type wind-tunnels[5].

And more, we had studied and presented the method for reducing higher frequency components of noise from nozzle blowing flow by an inclined flanges at the edge of nozzle[4]. But this method induces unstable shear flow layer and increases lowwer frequency components although this is effective on abating the noise from releasing vortexes.

4. INSTALLING SMALL SLENDER PIECES

On this study we have investigated other new methods for abating both lowwer and higher frequency components of aerodynamic noise from nozzle blowing flow. Firstly we tried to install many thin rods around the inside edge of nozzle outlet for breaking the spanwise coherence of releasing vortexes without any noise of separated flow. About 2dB noise reduction are recognised by installing many thin rods and this result proves that small slender pieces on the inside edge is effective to abate both the shear-flow noise and the noise from releasing vortexes.

Installing many small slender pyramids on the inside edge as shown in figure 5, velocity turbulences in shear-flow region become decrease more than 20% of those without any pieces as shown in figure 6. This

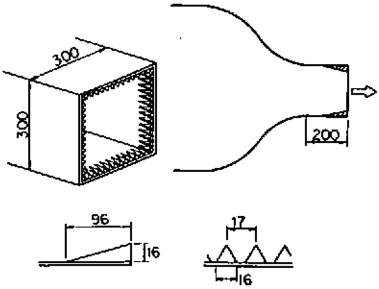

Fig.5 Installing many small slender pyramids on inner edge of nozzle(dia. 0.3m×0.3m) for controling releasing vortexes and shear flow.

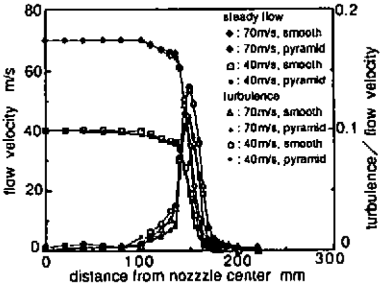

Fig.6 Comparing distributions of steady velocity and turbulence in nozzle fllow at 150mm downstream from the outlet with small pyramids.

phenomenon is induced by small pieces which may make spanwise characteristics of shear flows ununiform. In this condition noise by nozzle flow decrease about 6dB on the lowwer frequency region and about 4dB on the higher frequency region from those without any pieces as shown in figure 8. In this figure, square marks indicate noise spectra with installing other type slender pieces as shown in figure 7. Installing many small semi-cones on the inner edge, noise from blowing flow are decreased about 6dB on both lowwer and higher frequency regions.

5. CONCLUSION

Some methods for making the back ground flow-noise in acoustic wind-tunnels quietter has been experimentally investigated on the flow-velocity from 20m/s to 80m/s and it has been made clear as follows.

(a) Dominant components of aerodynamic noise in the measuring section are jet-flow noise and releasing vortexes noise.

(b) It is effective on decreasing the noise from nozzle blowing flow to install many small slender pieces on inside nozzle-edge.

(c) On the small acoustic wind-tunnel, the back ground flow-noise at the measuring section are decreased as about 4dB by attaching many small slender pyramids and as about 6dB by many semi-cones.

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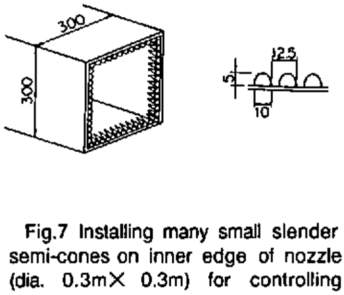

Fig.7 Installing many small slender semi-cones on inner edge of nozzle (dia. 0.3m× 0.3m) for controlling releasing vortexes and shear flow.

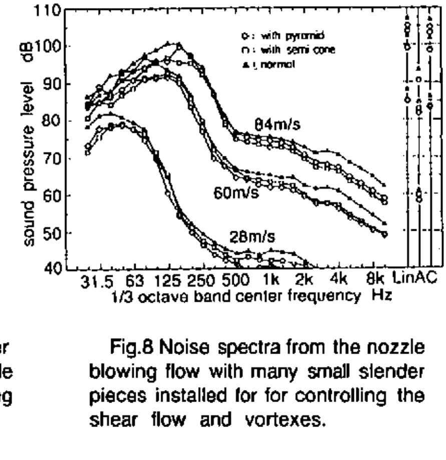

Fig.8 Noise spectra from the nozzle blowing flow with many small slender pieces installed for for controlling the shear flow and vortexes.