Acoustical characteristics of the noise radiated from supersonic multi-jets

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Abstract: The acoustical characteristics of the noise radiated from combined jets issuing from one main nozzle and 1, 2, 4 or 8 sub nozzles which were placed closely to the main nozzle were investigated experimentally. From the frequency characteristics of the screech tone, it is found that in almost all cases, two oscillation modes appear, but when 8 sub jets with diameter of a/d=0.6 were used, the screech tone was disappeared completely. From variations of the SPL of screech tone, it is observed that although the total cross sectional area of the multiple nozzles was larger than that of the single jet, the SPL radiated from multi-jets becomes the same or lower than that from the single jet.

INTRODUCTION

It is well known that the acoustic emission from a supersonic jet has a broad frequency band component and a few discrete ones in its spectrum. The latter components of sound spectrum are called screech tones. Powell proposed a feedback mechanism for the radiation of the tone. It consists of downstream-convecting coherent vortical structure and the upstream-propagating sound waves in the ambient. In recent years, the reduction of noise radiated from the supersonic jets becomes very important theme in conjunction with the development of the supersonic passenger airplane of next generation. So far, the noise and coupling process between two and four closely spaced jets have been studied by a few researchers.

EXPERIMENT

The schematic views of the nozzles used in this experiment are shown in Fig. 1. The diameter d of the main nozzle was 5mm and the diameter a of sub nozzle was 1 or 3mm (a/d=0.2 or 0.6). The center-to-center spacing b between the main and sub nozzles was fixed to 5mm (b/d=1.0). In this experiment, the pressure ratio R of the jets was varied from 2.00 to 6.33. One microphone, B&K 4135, was rotated at a radius of 1m in the horizontal plane. Signal outputs were analyzed on an Ono Sokki CF-5210 FFT Analyzer.

The variations of the screech frequencies with pressure ratio measured at right angles to the main nozzle axis are presented in Fig. 2 for various nozzle configurations as shown in Fig. 1. The solid circles indicate the dominant tone, the level exceeding the local broadband noise by at least 10dB. The data points marked by open circles indicate secondary tones exceeding the broadband noise by 5-10dB. From these results, it is observed that in almost all cases, two oscillation modes were appeared, but when sub jets were exhausted from 8 sub nozzles with diameter of a/d= 0.6, the screech tone was disappeared completely. The variations of SPL of the screech tones with pressure ratio of the jet measured in the backward arc of α-30° from the jet axis are shown in Fig. 3 for various nozzle configurations. The solid and open circles and open triangles indicate the SPL for the multi-jets and the crosses indicate the SPL for the single jet. From these results, it is observed that although the total cross sectional area of the multiple nozzles was larger than that of single jet, the SPL radiated from multi-jets becomes almost the same with that from single jet when the sub jets were issued in the perpendicular plane where a microphone was located, whereas the SPL becomes lower than that from the single jet when the sub jets were issued in the same plane where the microphone was placed.
ACKNOWLEDGEMENT

This work was supported by the Ministry of Education and Culture of Japan (Grant No.C2-09650187).

REFERENCES


Fig. 1 Nozzle configurations.

Fig. 2 Frequency characteristics of screech tone radiated from different nozzle configurations (at $\alpha=90^\circ$).

Fig. 3 Variations of SPL with the pressure ratio of jets emitted from different nozzle configurations (at $\alpha=30^\circ$).