SCREECH SUPPRESSION OF SUPERSONIC JET NOISE

Ramani Ramakrishnan[1,2], Sergio Raimondo[2], Anant Grewal[3] and Gary Elfstrom[2]
[1]Department of Architectural Science, Ryerson University, Toronto, ON, Canada rramakri@ryerson.ca
[2]Aiolos Engineering, Toronto, ON, Canada
[3]Institute for Aerospace Research, NRC, Ottawa, On, Canada

1. INTRODUCTION

Screech tones are a common by-product of supersonic jets. The screech tones are seen to get amplified due to the effect of solid surfaces. The amplification is clearly seen in V/STOL aircrafts and in particular during landing. Different techniques have been applied to reduce and/or eliminate the screech tones altogether. A detailed test programme was conducted to evaluate the noise generating potential of supersonic jets. Screech tone removal was one subset of the test programme conducted at the at the National Research Council Canada's Acoustic Reverberant Chamber in Ottawa. The results of the measurement programme are presented in this paper. In particular, the results of two techniques utilized for screech removal will be the focus of the presentation.

2. BACKGROUND

Ganesh Raman[1], in a review paper, described the mechanism of the shock wave periodicity-acoustic feedback loop with the nozzle lip as the main source of screeches. The intensity of the screech seems to be related to the stabilization of the above feedback loop by the impinging plate. Complete details of supersonic screech are also found in the references listed in Raman[1].

A large test programme was conducted at the National Research Council of Canada's Acoustic Reverberant Chamber in Ottawa in early 2009 to understand the noise output of supersonic jets. The results of the programme were summarized and presented at the Inter-Noise 2009 conference[2]. The results of the test programme that pertain to jet screech removal are discussed below.

3. SCREECH REMOVAL

Different techniques have been applied to remove the screech from supersonic jet noise. Khan et. al.[3] used a hemispherical reflector to remove screech. Another mechanism for screech removal is the use of small tabs (rectangular or chevron shaped) attached to the nozzle at the exit[4]. The application of the tabs, called vortex generators, and the relevant details of the tabs can be found in Reference 4. Choi et al.[5] have demonstrated the application of pulsed micro-jets to remove screech tones.

Reflectors and tabs will be used for the current investigation of screech tone removal.

4. THE EXPERIMENT

A jet rig, as shown in Figure 1, was installed in a 540 m^3 reverberation chamber. Different converging nozzles of sizes varying from 1” to 3.5” were used and the supply pressure ranged from 10 psi to 100 psi. The diffused sound pressure levels inside the chamber were measured using eight microphones.

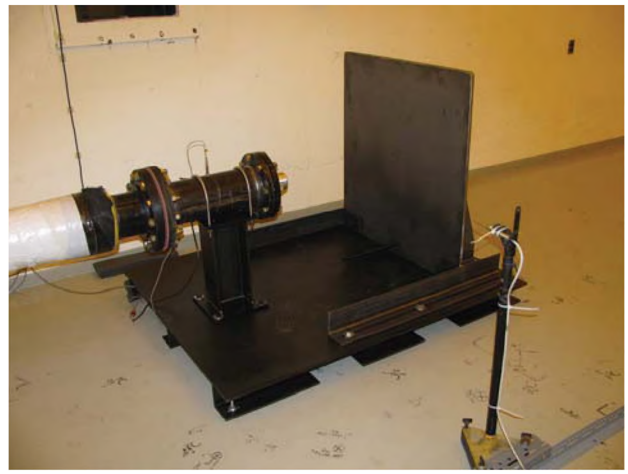

Figure. 1. Jet rig to produce supersonic jet noise.

Various reflectors whose sizes were proportional to the nozzle diameters were used in the current test programme. In addition, rectangular or chevron shaped tabs, either one or three, were applied as the second mechanism for screech tone removal.

5. RESULTS AND DISCUSSION

A sample set of results from more than 50 runs are presented in this section. The effect of using spherical reflectors and/or tabs is also discussed in this section. The use of a spherical reflector is shown in Figure 2 below.

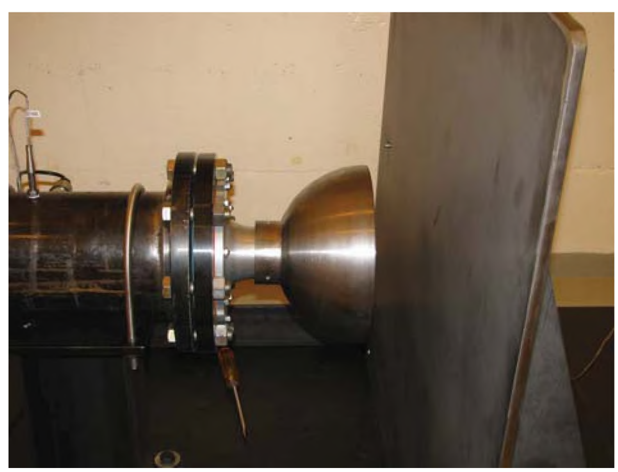

Figure. 2. Jet Nozzle with bell mouth.

As mentioned earlier, different size reflectors were used for each nozzle size. The results for a 2” nozzle with four different reflector sizes are shown in Figures 3 and 4. The supply pressure for these tests was 35 psi.

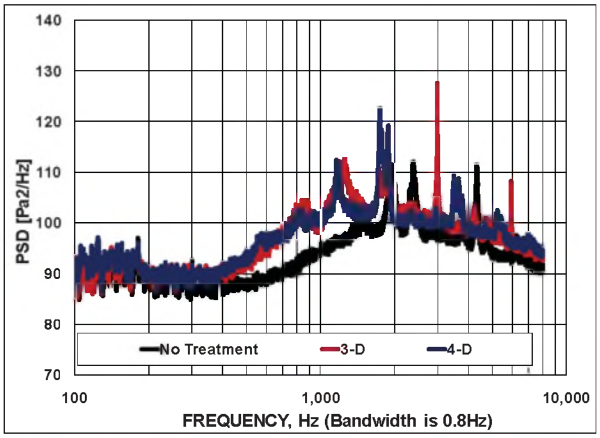

Figure. 3. The effect of spherical reflectors.

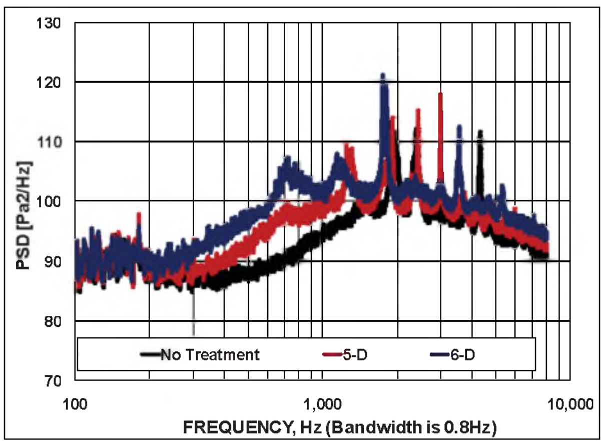

Figure. 4. The effect of spherical reflectors.

The results of Figures 3 and 4 clearly show that the spherical reflectors are not useful as screech tone removal. In some instances, the reflectors actually produce screech tones as the reflectors are seen to stabilize the shock-wave patterns[1].

The nozzle with three chevron shaped tabs is shown in Figure 5.

Figure. 5. Jet Nozzle with three chevrons.

The results for a 2” nozzle with one or three chevrons are shown in Figure 6. The Single tab was effective in attenuating the dominant tone by about 10 dB, but the tone is still present. The three chevrons are seen to remove the screech tones completely. Similar results were seen for other nozzles and across all supply pressures.

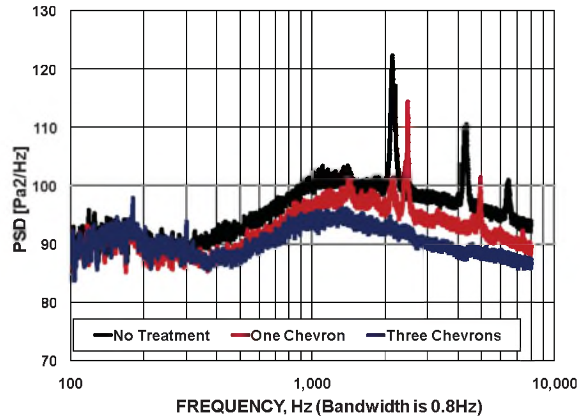

Figure. 6. The effect of chevrons.

6. CONCLUSIONS

The impact of screech tones from V/STOL jet during landing can be considerable. Two methods were applied to remove the screech tones. The spherical reflectors were seen to be not useful mechanism of tone removal. The tabs, rectangular or chevron shaped, were successful in removing the screech tones completely.

REFERENCES

1. Ganesh Raman, “Advances in understanding supersonic jet screech.” *AIAA Paper* 98-0279, 55 pages (1998).
2. R. Ramakrishnan, S. Raimondo, A. Grewal and G. Elfstorm, “High frequency noise generation by impinging jets.” Proceedings of Inter-Noise 2009, Ottawa, Ontario. Institute of Noise Control Engineering, Poughkeepsie, NY, USA, August 2009
3. T. I. Khan, K. Seto, Z. Xu and H. Ohta, “An approach to noise reduction of a supersonic jet with a spherical reflector,” *Acoust. Sci. & Tech.* **25**(2) 136-143 (2004).
4. M. Samimy, K. B. M. Q. Zaman and M. F. Reeder, “Effect of tabs on the flow and noise filed of an axisymmetric jet,” *AIAA Journal*, 31(4), 609-619 (1993).
5. J. J. Choi, A.M. Annaswamy, H. Lou and F. S. Alvi, “Active control of supersonic impingement tones using steady and pulsed microjets,” *Exp. Fluids* DOI 10.1007/s00348-006-0189-7 (2006).