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PSEUDO-ACTIVE SOUND ATTENUATION IN A DUCT

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ABSTRACT

The possibility of attenuating the noise propagating in a duct flow by a "sound barrier" consists in a strong tranverse acoustic field generated by the flow itself, the so-called Parker β-mode . This mode is obtained when the vortex shedding of a flat plate inserted in the duct couples with transverse acoustic waves . The experiments have been carried out in a subsonic open circuit wind tunnel . First, the sound level has been measured at the wind tunnel exit when no β-mode was excited . Then, the plate was inserted in the wind tunnel test section so as to excite the β-mode . It was found that, at the same wind tunnel velocity, the sound level was decreased by as much as 10 dB over all the frequency spectrum above 200 Hz when the β-mode was excited , confirming the possibility of using it as a pseudo-active sound absorber .

1. INTRODUCTION

Sound attenuation in flows is in important area of research . Two ways are usually investigated to decrease the sound level : passive means and active means . Here, a third possibility is proposed which we suggest to call "pseudo-active" sound suppression .

The idea is to create a sound barrier across the duct, the barrier consisting in a strong acoustic field, the latter field being produced by the flow itself . If the idea can be materialized, no microphone, no loudspeaker, no electronic equipment would be needed, as is the case of active sound absorbers . One mean of creating a strong transverse acoustic field is to insert a flat plate in the duct. Welsh et al (1984), Stokes and Welsh (1986), have shown that by properly choosing the shape of the plate (leading edge, trailing edge, thickness, chord) the vortex shedding frequency at the trailing edge may be locked on the transverse acoustic mode of the duct . This phenomena is called β-mode by Parker (1967) and occurs over a certain flow velocity range which depends on the plate shape . The transverse mode can reach intensities as high as 160 dB near the plate location but is evanescent, so that it attenuates very quickly with increasing distance from the plate .

The experiments described in this paper were aimed at investigating wether downstream propagating sound waves were attenuated while crossing this transverse acoustic field .

2. EXPERIMENTAL SET-UP

The experiments were carried out in a subsonic wind tunnel of the I.M.F.M. (Fig. 1) in which stable flow velocities ranging from 10 to 80 m/s are achievable .

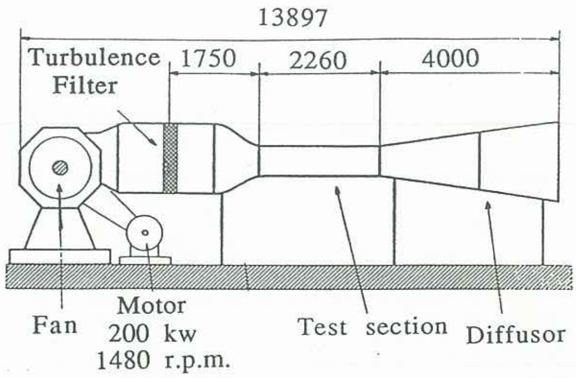


Fig. 1 Subsonic wind tunnel (dimensions in mm)

The measuring system is shown on Fig. 2 . Two microphones Bruel and Kjaer Type 4138 (1/8 '') with a sensitivity of 1 mv/Pa and a dynamic range of 55 to 168 dB (ref 20 μPa) were used . They were fit out with a preamplifier 2639 T and an adapter UA 0036 . The measurable frequency band went approximately from 6.5 Hz to 140 KHz . An

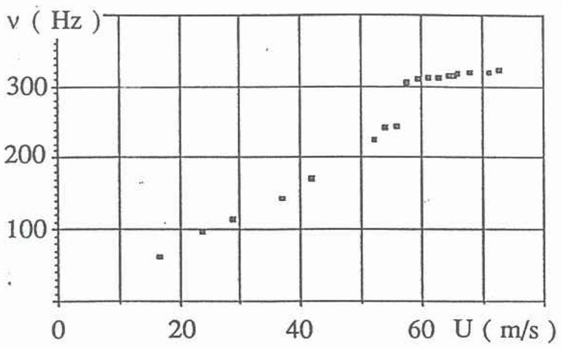
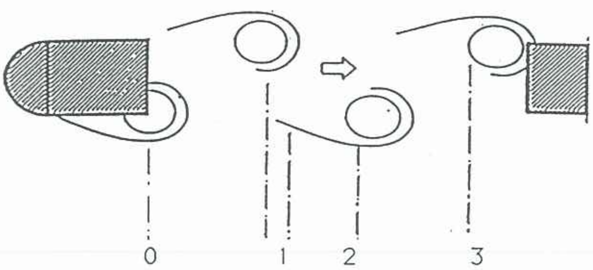


Fig. 5 Vortex shedding frequency ν as a function of flow velocity U

3.3 <u>Noise measurements with upstream and downstream parts of the model</u>

The most efficient "sound barrier" should be the one which gives the strongest transverse mode near the model with the most rapidly decreasing intensity as a function of distance from the model . In an attempt to optimise the sound barrier, experiments were run with the 2 parts model in order to determine the configuration giving the most evanescent acoustic field . Measurements have been carried out at 4 separation distances (0, 105, 180, 264 mm) between the upstream and downstream parts . These 4 distances correspond to an even or odd number of vortices in the gap separating the 2 model parts (Fig. 6) .



Upstream Microphone	258	324	250	324	332	Hz
	108	112	130	138	129	dB
Downstream Microphone	258	324	247	324	330	Hz
	120	108	130	132	122	dB

Fig. 6 Intensities and frequencies of β-mode as a function of separation distance between upstream and downstream parts of the model .

The microphones were located 450 mm upstream and 1600 mm downstream of the model and the flow velocity was 60 m/s . As can be seen from the data reported on the figure, intensity of the β-mode is strongly dependent on the number of fully developed vortices present in the gap . It was also found that the configuration giving the most evanescent mode is when the separation distance is large, when the downstream part does not influence the flow on the upstream part any more. In other words, the most efficient sound barrier should be realised when only the upstream part is used .

3.4 <u>Influence of β-mode on noise at wind tunnel exit</u>

Noise measurements have been made at the downstream end of the wind tunnel diffusor with and without the β-mode being excited, both measurements being made at the same flow velocity . This comparison is illustrated by Fig. 7 . It is seen that when the β-mode is

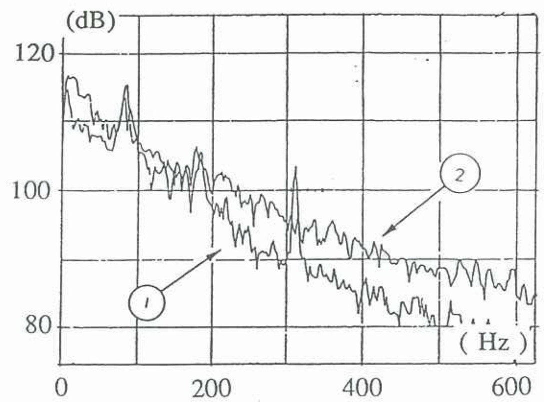


Fig. 7 Noise spectrum at windtunnel exit

1) with upstream part of model in test section (β-mode excited)
2) no model in test section

excited the noise level is decreased by about 10 dB for frequencies above 200 Hz, except at the β-mode frequency which is very clearly visible on the spectrum (315 Hz) .

4. CONCLUSION

It has been experimentally demonstrated that a strong transverse acoustic field can constitute a " sound barrier" and decrease significantly the noise level downstream of this barrier . Further experiments are presently carried out at the I.M.F.M. to further optimise the configuration of the model that generates the β-mode . On the theoretical side, absorbtion of sound by sound will be investigated in order to understand the mechanism which leads to the observed noise attenuation .

REFERENCES

PARKER,R (1967) Resonance effects in wake shedding from parallel plates : calculation of resonant frequencies . J. Sound Vib. 5(2), 330-343 .