Noise generation by cylinders in turbulent flow

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Introduction

An important part of future electrified aircraft engines will be the thermal management system, responsible for removing the heat generated by the electric components such as the electric motor, power electronics and the power source (for example a fuel cell) [1]. Some possible topologies for electric engines use a fan that sucks air through the heat exchanger, located at the core of the thermal management system, which leads to a downstream interaction of turbulent flow with the cooling fan or other structural elements like struts. This interaction is a strong source of aerodynamic noise, which is often investigated by simplified blunt geometries like cylinders or airfoils, as for example done in [2,3,4]. In the present study, the effect of inflow turbulence on the noise generated by a set of circular cylinders was investigated experimentally.

Setup

The experiments took part in a small aeroacoustic open jet wind tunnel [5]. Cylinder with a length of 0.28 m and diameters *d* from 3 mm to 20 mm were used. The required inflow turbulence was generated by a set of different passive grids, which generated turbulence with intensities between 5 % and 8 % and streamwise integral length scales between 4 mm and 6 mm. Acoustic measurements were performed with a planar microphone located outside of the flow, although most analyses were simply done using one of the array microphones that was located at approximately 90° to the flow in a distance of 0.7 m from the cylinder axis. Fig. 1 shows a photograph of the experimental setup inside the wind tunnel.

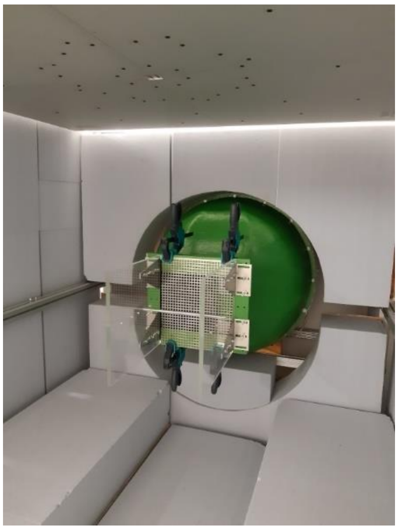

Fig. 1: Photograph of the experimental setup.

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Results

As an example result, Fig. 2 shows sound pressure level spectra measured for three different cylinders (diameters of 3 mm, 6 mm and 15.6 mm) at a flow velocity of approximately 20 m/s. It is visible that the inflow turbulence generated by the different grids (PPS – perforated plates with square holes of different mesh sizes and bar widths) mostly affects the broadband noise compared to the clean inflow (no grid). In addition, both the frequency and the magnitude of the vortex shedding tonal peak can be seen to depend on the inflow turbulence. Fig. 3 shows the resulting Strouhal number (based on cylinder diameter) of the vortex shedding peak as a function of Reynolds number. The turbulence can be seen to have a notable effect on the resulting periodicity of the vortex shedding.

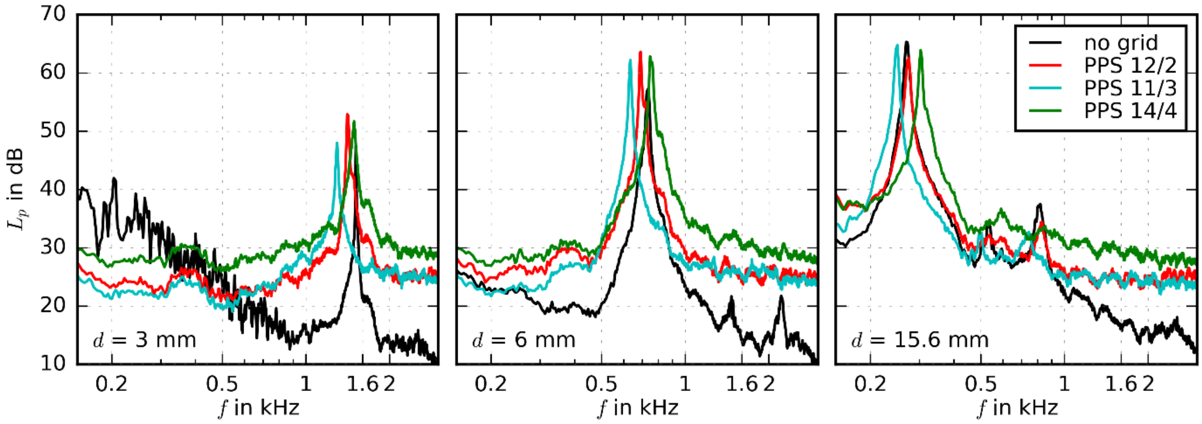

Fig. 2: Example sound pressure level spectra obtained for three different cylinders in clean (no grid) and turbulent inflow at a flow Mach number of approximately 0.06

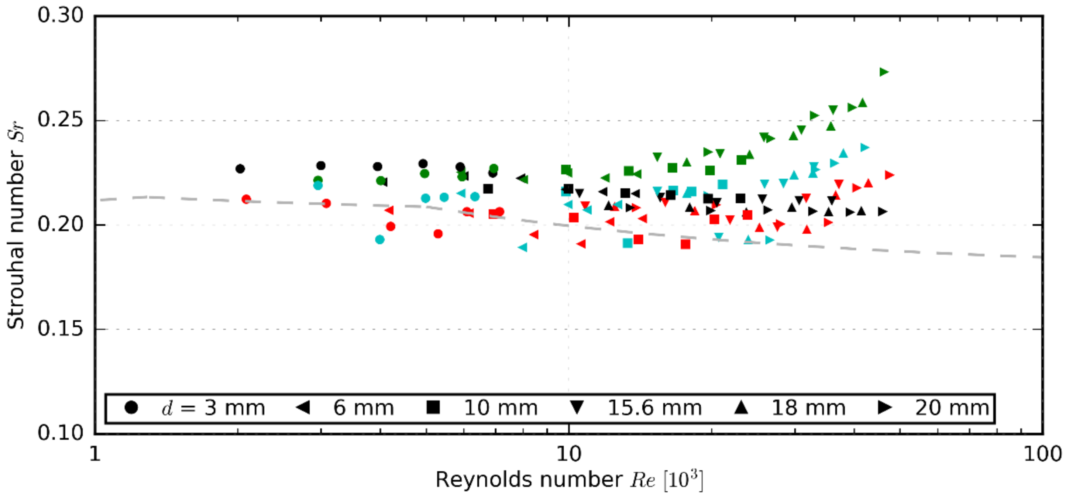

Fig. 3: Vortex shedding Strouhal numbers as a function of Reynolds number for the different cylinders in clean (black markers) and turbulent (colored markers, see **Fig. 2**) inflow

References

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