How a jet flow interacting with a streamwise/spanwise corrugated surface causes an increase in turbulence kinetic energy

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19th May 2020

Abstract

Rapid-distortion theory (RDT) uses linear analysis to study the interaction of turbulence with solid surfaces. It applies whenever the turbulence intensity is small and the length (or time) scale over which the interaction takes place is short compared to the length (or time) scale over which the turbulent eddies evolve. The basic theory can be used to model the sound radiated by a turbulent flow interacting with a leading or trailing edge embedded in the flow (Goldstein *et al.* JFM, vol. 824, pp.477-512, 2017).

One way of reducing of possibly reducing the sound is to change the spatial morphology of the surface of the flat plate. While there are several ways one can achieve this, in this study we use CFD simulations to show what happens when to the local turbulence kinetic energy when the surface is morphed with streamwise or spanwise oscillations. In Figure 1 we show that a typical example of the surface meshed using Pointwise and solved in STAR CCM+. The acoustic Mach number of the jet flow is $Ma = U_J/c_\infty = 0.9$ and the temperature ratio, $TR = T_J/T_\infty = 1.0$. The streamwise surface corrugations effectively reduce the vertical stand-off distance between the jet and and the discontinuity. This has the effect of increasing the turbulence kinetic energy by almost a factor of 2. Assuming that the low frequency structure of the propagation of sound (determined by the Wiener-Hopf technique) after interacting with a wavy surface is similar to the flat plate solution, the sound will be proportional to the turbulence kinetic energy. The type of configuration shown in Figure 1 is therefore likely to result in an increase in radiated sound.

In the accompanying talk we present a full parametric study of the these results and discuss their implication for leading/trailing edge noise.

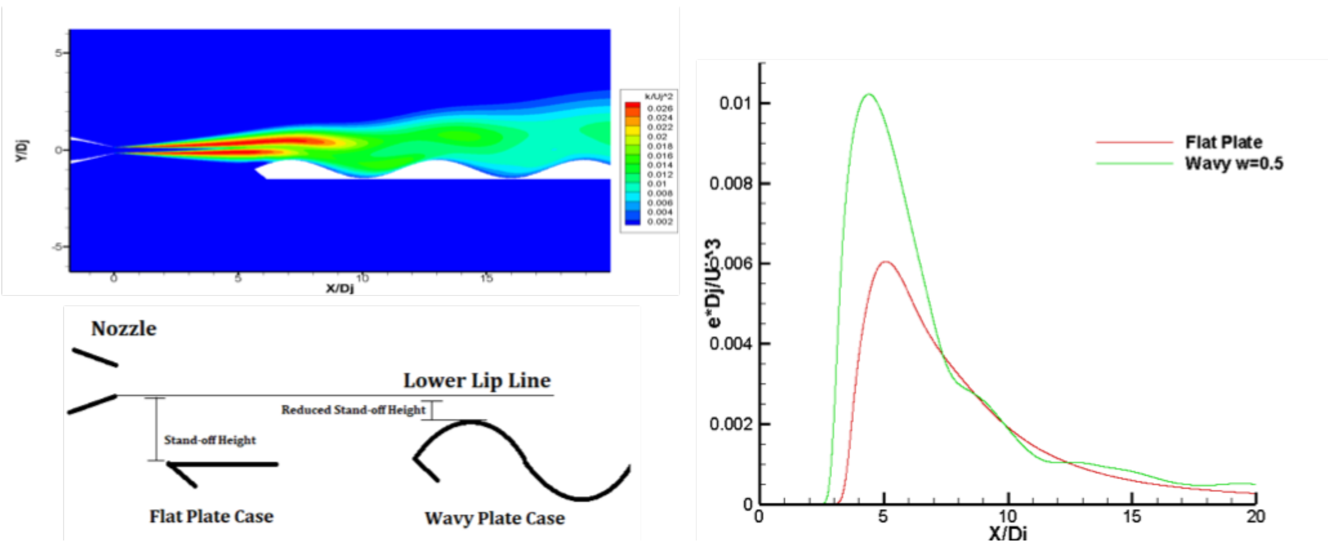

Figure 1: Normalized TKE using STAR-CCM+ as solver and $k - \varepsilon$ realizable turbulence model)

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