Effects of Nozzle Shapes and Compressibility on Formation of Synthetic Jets

Jihyeon Park[a], Junsung Choi[a], Ji Hun Song[a] and Minsuk Choi[a,b]

A synthetic jet is induced by the rapid flow moving back and forth through a small nozzle. An actuator for generating the synthetic jet consists of a chamber with a nozzle and a thin oscillating membrane, which is initially suggested to suppress the flow separation on an airfoil. Depending on the volume change induced by the membrane oscillation, the actuator inhales air around the nozzle exit and ejects a synthetic jet downstream. Although most of the research on synthetic jets was conducted using experiments, recently many papers have been published to analyse synthetic jets numerically in an aid of the development of numerical methods and computational facilities.[1,2] Due to the limitations of the computational cost and time, most of numerical studies are still based on the incompressibility of air and simple pressure or velocity boundaries instead of implementing the real motion of the membrane. However, the compressibility of air and the motion of the membrane could affect the formation of synthetic jets significantly.[3] In this work, the nozzle shape has been changed to be straight(ST), convergent(CT), divergent(DT), convergent-divergent(CD) and Laval(LV) nozzles with keeping the throat area constant. Figure 1 shows the mass flux change at the nozzle exit during a cycle. With the assumption of the incompressibility, the mass flux change is the same independent of the nozzle shapes. With the consideration of the compressibility, however, there is a big difference in the maximum and minimum of the mass flux and a time-lag occurs depending on the nozzle shapes. An attempt has been made to figure out why the mass flux changes depending on the nozzle shapes only when the compressibility is considered.

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[a] Dep. Mechanical Engineering, Myongji University, Yongin 17058, South Korea

[b] Dep. Semiconductor Engineering, Myongji University, Yongin 17058, South Korea

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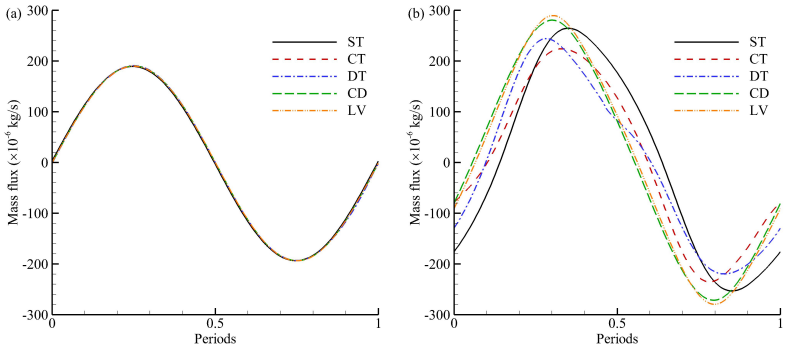

Figure 1: Mass flux at the nozzle exit (a) Incompressible (b) Compressible.