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ABSTRACT

FACULTY OF ENGINEERING AND APPLIED SCIENCE

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A NUMERICAL INVESTIGATION OF SELF-SUSTAINED CAVITY FLOW OSCILLATIONS

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Two-dimensional (2-*D*) cavity flow physics and oscillation control were investigated through solutions of the Reynolds-Averaged Navier-Stokes equations coupled with a two-equation k-ω turbulence model. Effects of the leading edge modifications including compression ramps, expansion surfaces and mass injection on supersonic cavity flow oscillation were investigated. Different flow mechanisms were observed at Mach 1.5 and 2.5. The study proposed a different explanation of the flow control mechanism when mass injection was used. An optimal mass injection rate was identified. A further improvement on the 2-*D* model was made by considering the effect of the turbulent viscous sub-layer using the Integration-to-the-wall boundary condition. The results confirmed that the shear layer instability reduced gradually from Mach 1.5 to 3.5. An improvement in *SPL* prediction was achieved. Dominant modes were also correctly predicted.

The capability of the model was extended for the investigation of the 3-*D* compressible unsteady turbulent flow physics. It was validated against a hypersonic symmetric corner flow. The turbulent effect was modelled by a two-equation k-ω turbulence model. A laminar cavity flow oscillation at Mach 1.5 was predicted. The result showed a self-sustained pressure oscillation. The predicted pressure oscillation was dominated by the second mode and its frequency was 5702Hz which was close to the measured value of 5900Hz. The *SPL* discrepancies with the measurements were within 2.3dB. A secondary symmetric flow pattern inside the cavity displayed a 3-*D* effect and showed the effect of the side wall within a spanwise distance of 2*D*. Further simulation of the turbulent cavity flow at Mach 1.5 showed a weak pressure oscillation, which indicated the *RANS* is sensitive to the choice of turbulence model. However, the surface flow pattern and surface pressure distribution were consistent with the measurements. The strongest surface pressure oscillation was observed near the rear corner on the centre plane. A secondary symmetric flow pattern also existed. A spanwise wave was found in the cavity. At the trailing plate, a flow separation was formed in the laminar boundary layer but was not observed in the turbulent boundary layer.