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PROCEEDINGS

Understanding of Airfoil Characteristics at High Mach-Low Reynolds Numbers

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ABSTRACT

A computational study has been conducted on various airfoils to simulate flows at low Reynolds numbers 17,000 and 21,000 with Mach number changes from 0.25 to 0.85 to provide understanding and guidance for Mars rotory wing designs. The computational fluid dynamics tool used in this study is a Reynolds-averaged Navier–Stokes solver with a transition model (k-ω SST γ-Reθ). The airfoils investigated in this study include NACA airfoils (4, 5, and 6% camber), UltraThin airfoils, and thin cambered plates (3% camber, but various maximum camber locations). Airfoils were examined for lift and drag performance as well as surface pressure and flow field characteristics. The influence of Reynolds and Mach number effects on the flow past airfoils was analyzed and significant impact on flow separation and subsequent wake patterns was demonstrated. In general, the Mach number shows a significant impact on the flow past airfoils, including of flow separation, trailing-edge wake patterns, and shock wave types. A stretched trailing-edge separation pattern is clearly observed from NACA and Ultra-thin airfoils. In addition, NACA airfoil shows a trailing edge separation, and a shock wave starts to appear at moderate to high incidences. By contrast, UT airfoil shows a leading-edge separation as incidence increases. As angles of attack rise at moderate, an "A-type" shock appears on the up-airfoil's surface, which alters the response of the outer flow pressure to displacement surface perturbations, including the influence on the growth, curvature, and even unsteadiness of the separated shear layer.

KEYWORDS

Low reynolds number aerodynamics; airfoil aerodynamic optimization; shock-separation region interaction; Mars rotor design

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