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抽吸控制对低雷诺数下翼型分离流动的影响

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Effect of Suction Control on Separation Flow Around an Airfoil at Low Reynolds Numbers

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摘要

为了系统研究抽吸区域相对于分离点的作用位置、孔间距和孔径对抽吸控制翼型分离流动效果的影响，以NACA0012翼型表面分离流动为基准状态，在其吸力面设计了局部多孔抽吸结构，采用AUSM$^+$-up格式、大涡模拟方法和双时间步长（LU-SGS）隐式算法，对低雷诺数下多孔分布式抽吸结构对流动分离的控制效果进行了数值研究。研究结果表明：当抽吸区域位于分离点之后时，抽吸控制效果最好；抽吸系数不仅存在一个下限值以达到快速、有效的控制效果，而且有一个上限值以保证抽吸控制品质因数（FOM）大于1；孔间距和孔径对翼型气动性能的影响较小，但对FOM分布的影响较大。

关键词： 流动控制 附面层抽吸 低雷诺数 翼型绕流 流动分离

Abstract:

In order to research the effects of suction zone locations with respect to separation point, hole spacings and diameters on separated flow suppression under suction control, some local porous suction distributions are designed on the NACA0012 airfoil upper surface, where the flow separation often happens at low Reynolds numbers. The effectiveness of the designed suction distributions is numerically investigated, by using AUSM$^+$-up scheme, large eddy simulation method and lower-upper symmetric Gause-seidel (LU-SGS) implicit scheme with dual-time-stepping technique. The computational results show that when the suction zone is located behind the separation point, the control effect is best. The suction coefficient should be limited by a minimum value to obtain fast and effective control effect, also must be limited by a maximum value to ensure the figure-of-merit (FOM) of suction control is larger than one. The hole spacings and diameters have smaller effects on airfoil aerodynamics performance, but larger influences on FOM distributions.

Keywords: flow control boundary layer suction low Reynolds numbers flow around airfoil flow separation

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