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低雷诺数下小展弦比机翼绕流的实验研究

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Experiments on Viscous Flows around Low-Aspect-Ratio Wing at Low Reynolds Numbers

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摘要

应用粒子图像速度场仪（PIV）和烟线两种流动显示技术，测量低雷诺数下小展弦比机翼粘性绕流的流场.风洞实验结果表明，弦长雷诺数为1.8×10^4，机翼处于5.0°攻角时，展向中间截面出现了层流分离，翼型后缘产生“驻留涡”.随着机翼攻角的增大，分离涡向翼型前缘迁移.当攻角增大至12.5°时，分离涡覆盖整个翼型上表面，翼型完全失速.此外，2种流动显示技术在同一工况下得到的实验结果较一致.将2种流动显示技术相结合，丰富了流场信息，能够更好地反映低雷诺数下小展弦比机翼粘性绕流的流动现象.

关键词： 低雷诺数；小展弦比机翼；粒子图像速度场仪；烟线；分离涡

Abstract:

To investigate viscous flows around low-aspect-ratio wings of a micro-aerial vehicle (MAV) at low Reynolds numbers, experiments are conducted in a wind tunnel using particle image velocimetry (PIV) and a smoke wire technique. The chord Reynolds number is 0.8×10^4. The results show that flow on the upper surface begins to separate, and primary vortex is generated at the trailing edge when the angle of attack is 5.0° . As the angle of attack gradually increases, separated vortex moves to the leading airfoil. Separated vortex dominates the whole upper surface of airfoil to make the airfoil stalls when the angle of attack reaches 12.5° . In addition, experimental results of two flow visualiztion techniques agree well with each other. Combination of the two techniques reveals more physical phenomena of the flow field, and better reflects the separation of the flow filed on the airfoil surface at low Reynolds numbers.

Keywords: low Reynolds number; low aspect ratio wing; particle image velocimetry (PIV); smoke wire; separated vortex

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