

The research of micro riblets drag reduction mechanism of laminar airfoil

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Abstract With the decreasing of non-renewable energy, how to use energy effectively attracts more and more attention. Reducing the skin friction of various transport vehicles is one of the main ways to save energy. For civil aviation aircraft, skin friction accounts for about half of the total resistance, and drag reduction is not only directly related to the performance of civil aviation aircraft, but also affects the flight cost and environmental protection. In recent years, with the development of experimental and turbulence simulation technology, it has been recognized that the appropriate groove surface shape has a significant inhibitory effect on turbulent friction resistance. In this paper, PIV, fluorescence oil film and balance were adopted to study the drag reduction mechanism of micro riblets grooved surface in one laminar airfoil experiment. The experimental results show that the near wall region of turbulent boundary layer is greatly affected by micro riblets. Micro riblets groove is conducive to maintaining the motion of low speed stripe in the near wall region, reducing the intensity of ejection and sweep motion in the near wall region of turbulent boundary layer and inhibiting the turbulence intensity. Micro riblets can reduce the friction velocity and surface friction, improve the average velocity of the near-wall region, and enlarge the correlation scale along the longitudinal direction. Due to the reduction of friction velocity and skin friction, high speed scope above the surface of airfoil is enlarged, and lift was also increased.

Keywords: drag reduction, micro riblets, turbulence, PIV, fluorescence oil film

1 Introduction

For a typical long-haul aircraft, fuel consumption accounts for about 22% of direct cost. Reducing drag would directly reduce operating costs, and 1% reduction in drag could reduce the cost of long-haul aircraft by about 0.2%, adding 1.6 tons of payload or 10 passengers. During cruising, most of the surface flow of civil aircraft is in turbulent state, so it is of great significance to study turbulent boundary layer drag reduction, which has been listed as one of key aviation technologies in the 21st century by NASA.

In recent years, with the development of experimental and turbulence simulation technology, it has been recognized that the appropriate groove surface shape has a significant inhibitory effect on turbulent friction resistance. In this paper, PIV, fluorescence oil film and balance were adopted to study the drag reduction mechanism of micro riblets grooved surface in one laminar airfoil experiment.

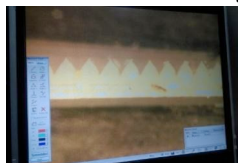


Fig. 1 Microscopic image of micro riblets film

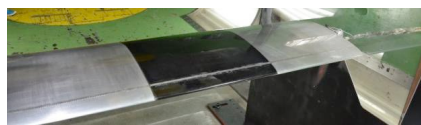


Fig. 1 Experiment model and trigger wire.

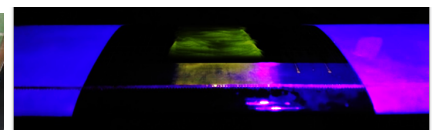


Fig. 3 Fluorescence oil film (excited by UV-light)

2 Scheme of experiment and test methods

By means of hub hot-pressing process, micro riblets film can be manufactured with regular groove surface. PVC film was used as the basic material, which is composed of three parts: the surface layer of PVC film, the middle layer of rubber and the release backing paper. The wind tunnel experiment was carried out in the fd-07 wind tunnel, the size of the experiment section was 3m×3m. The experimental model is NLF0415 airfoil, with a chord length of 0.4m and a span length of 1.2m.

PIV, fluorescence oil film and balance were utilized to study the drag reduction mechanism of micro riblets grooved surface in one laminar airfoil experiment. By PIV, Flow structure of near wall region can be obtained. By fluorescence oil film, the distribution of skin friction can be presented. By balance, the drag reduction effect of micro riblets can be measured.

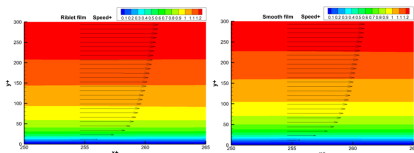


Fig. 4 Comparison of velocity distribution

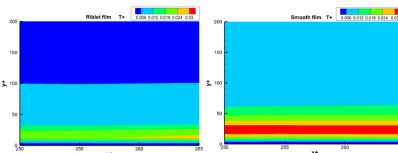


Fig. 2 Comparison of turbulent kinetic energy

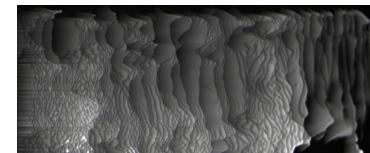


Fig. 3 Image of fluorescence oil film (20m/s, 1°)

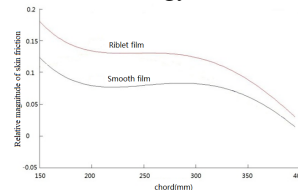


Fig. 4 Comparison of relative magnitude of skin friction

3 Experimental results

The experiments show that micro riblets have certain influence on the near wall region of turbulent boundary layer. Micro riblets groove is helpful to keep the motion of low speed stripe in the near wall region, reduce the motion intensity of ejection and sweep in the near wall region of turbulent boundary layer and suppress the turbulence intensity. Micro riblets can reduce friction velocity and skin friction, and increase the average speed of near wall region, and enlarge the correlation scale along longitudinal direction.

4 Conclusion

In this paper, PIV, fluorescence oil film and balance were adopted to study the drag reduction mechanism of micro riblets grooved surface in one laminar airfoil experiment. The experimental results show that the near wall region of turbulent boundary layer is greatly affected by micro riblets. Micro riblets groove is conducive to maintaining the motion of low speed stripe in the near wall region, reducing the intensity of ejection and sweep motion in the near wall region of turbulent boundary layer and inhibiting the turbulence intensity. Micro riblets can reduce the friction velocity and surface friction, improve the average velocity of the near-wall region, and enlarge the correlation scale along the longitudinal direction. Due to the reduction of friction velocity and skin friction, high speed scope above the surface of airfoil is enlarged, and lift was also increased.

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