A thermographic method to evaluate laminar bubble phenomena on airfoil operating at low Reynolds number

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Abstract

Aim of this research is the study of laminar boundary layer separation phenomena on aerodynamic bodies by infrared thermography. The presence and the size of laminar bubble are mainly observed. This phenomenon may occur on airfoils operating at low Reynolds numbers, typically below 500000; in this range the laminar boundary layer may separate itself from the airfoil’s surface. At this point, if the flow reaches a turbulent condition, it may attach again downward, because of the higher level of mixing energy associated to the turbulent flow. This creates a localized zone of re-circulating flow called “bubble”. The presence of this one changes the drag and lift coefficients of the aerodynamic body, decreasing its efficiency; this problem can be observed mainly on small wind turbines or sailplanes wing tips when these operate at low Reynolds numbers.

A thermographic method is adjusted to detect the presence and the longitudinal dimension of the laminar bubble. In this region the convective heat transfer coefficient is lower than in the surroundings, because of the re-circulating flow. Heating the airfoil surface, the laminar bubble will appear warmer than the other zones and so it is possible to know its presence and position. The separation and re-attachment points and, consequently, the bubble longitudinal dimension, can be carried out by the derivative of the temperature profile.

Three different airfoils have been used for the tests. They have been coated with a sheet of electrical conductor material and supplied by high-current/low-voltage device, to obtain Joule heating. These wing sections have been put in the testing chamber of the low-speed wind tunnel available at the Department of Energica, University of Ancona (Italy). The upper wing surfaces were observed with a new-generation thermographic scanner, equipped with a 320x240 array of IR QWIP sensors. At the same time typical aerodynamic tests have been performed by using a load balance, in order to obtain the airfoil polars.

A comparison between the thermographic and the dynamometric balance results have been carried out in order to obtain a validation of the thermographic method and a better understanding of the bubble behavior.

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