EXPERIMENTAL INVESTIGATION OF EFFECT OF HIGH TURBULENCE ON THE AERODYNAMICS OF LOW RE AIRFOIL

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Abstract

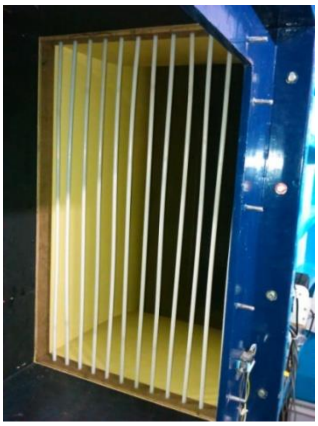
Turbulence pertaining to low Re flows is a subject of interest due to its considerable effect on the aerodynamics of high-lift low Re airfoils. The formation of laminar separation bubble (LSB) on the upper surface differentiates low Re airfoils from the conventional airfoils. The LSB has several detrimental effects on the airfoil performance such as, high drag[1], drastic change in the pressure distribution with varying bubble length[2], losing control on the pitching moment stability[2] etc. The dynamics of the LSB is also depends largely on the freestream turbulence level present in the flow.

In the present study, high turbulence is created inside a low speed wind tunnel by inserting passive grid at the entry of the test section. The grid is designed based on the empirical relation given by Roach [3] and the turbulence level is varied from 4 % to 10 % by varying the mesh size and the rod dimensions. The grid is made in the form of parallel rods and two grid configurations; parallel horizontal and parallel vertical grid are derived by changing the orientation of the rods as shown in Fig.1. NACA 4415 airfoil is chosen in the present study to explore the influence of turbulence on the dynamics of LSB at various angles of attack and at Reynolds number of 120000 based on chord length and freestream velocity. The orientation of vorticity production in both the grid configurations will be orthogonal and subsequently it will be interesting to see their interaction with the vorticity present in the LSB. Fig. 2 shows the decay in turbulence level from 16 % at the exit of the grid to 4 % downstream of the grid at mid of the test section measured using hot-wire by traversing it along tunnel centerline. ESP scanner is used for the measurement of surface pressure distribution over pressure tapped NACA-4415 airfoil model. Fig. 3 shows typical C_p distribution plot for 4^0 angle of attack for the case of flow without grid turbulence. The extent of LSB from x/c = 0.4 to 0.7 is also marked on the plot. The influence of the grid turbulence on the C_p distribution is currently underway. However, Surface oil flow visualization over the airfoil is carried out with and without grid. Fig. 4 (a) shows clearly, the separation and reattachment lines indicating the presence of LSB on the upper surface of the airfoil for the nominally smooth flow (turbulence level less than 0.1 %). Fig 4 (b) shows remarkable change in the flow pattern due to presence of high turbulence in the flow due to grid. No distinct separation and reattachment lines are observed and spots of the oil flow are seen along the span of the airfoil as shown in Fig 4 (b).

Detailed characterization of the grid turbulence based on hot-wire measurements and study of its effect on the pressure distribution through ESP measurements are underway and the flow physics associated with interaction of LSB with high turbulence will be elucidated in the full length paper.

(a)

Parallel horizontal rod mesh



(b)

Parallel vertical rod mesh

Fig.1: Mono-planar grid configuration of mesh size = 60 mm, rod dia = 14 mm

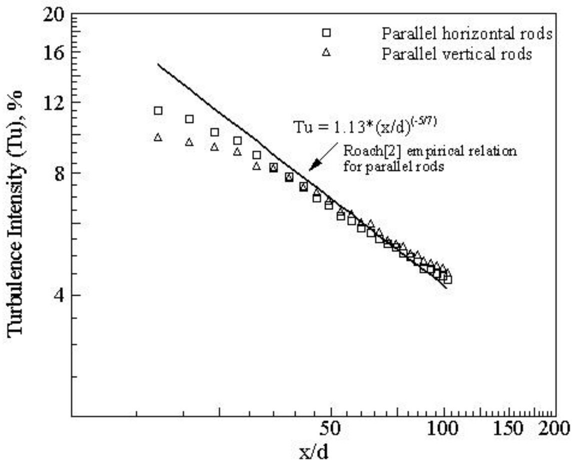


Fig. 2: Turbulence Intensity decay for the Parallel Horizontal and Parallel Vertical rod grids

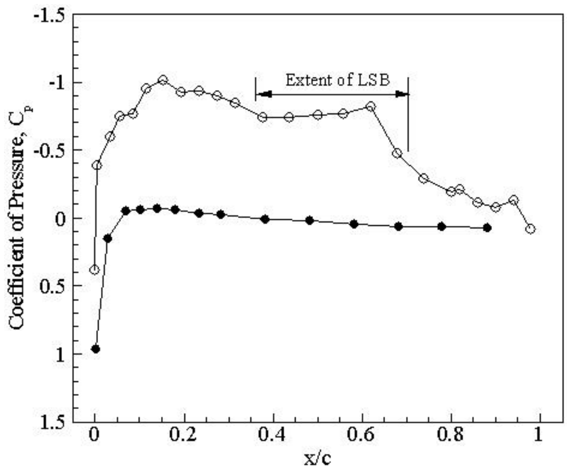
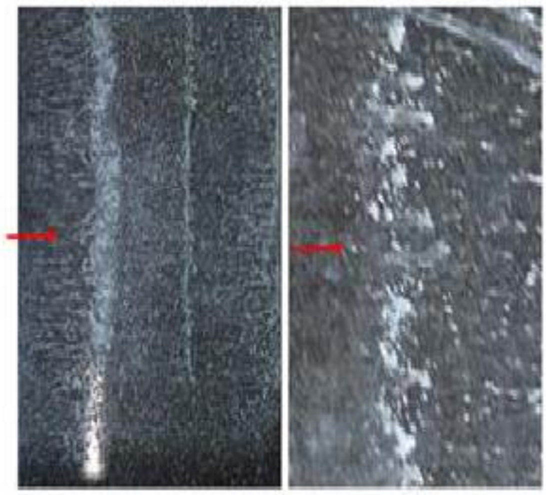


Fig.3: Surface pressure distribution over NACA-4415 at 4^o AOA



(a) **(b)**

Fig. 4: Surface oil flow visualization (a) without grid (b) with grid

References

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