48th AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition
4 - 7 January 2010, Orlando, Florida

AIAA 2010-376

Effect of Three-Dimensional Surface Perturbations on Boundary Layer Transitional Characteristics

J.M. Early[1]

School of Mechanical and Aerospace Engineering,
Queens University, Belfast, BT9 5AG, Northern Ireland

H. Medina[2]

School of Mechanical and Automotive Engineering,
Coventry University, Coventry, CV1 5FB, United Kingdom

R. McRoberts[3]

School of Mechanical and Aerospace Engineering,
Queens University, Belfast, BT9 5AG, Northern Ireland

The influence of a three-dimensional surface perturbation on the transitional boundary layer has been investigated experimentally. The perturbation height and longitudinal location relative to the leading edge have been varied to represent the effects of moving the location of a rivetted joint on a typical aerodynamic surface. A single hot wire probe was used survey the flow at a freestream turbulence intensity of 0.08% ($Re=1.4x10^6$) to 0.12% ($Re=1.7x10^6$). The experimental results indicate that while, for most configurations tested, the presence of a surface perturbation reduces the transitional Reynolds number, there are potential benefits to be realised with careful positioning of the rivet joint, promoting an increase in the transition onset location of up to 5%. This has a series of implications with respect to manufacturing tolerance analysis, and the manner in which tolerances are assigned to joints.

I. Introduction

The adoption of Laminar Flow Control (LFC) techniques has continued to attract a great deal of interest within the aviation community due to the increasing need for more effective drag and emissions reduction techniques (ACARE, 2001). However, in order to fully exploit the benefits on offer from LFC, a thorough understanding of the range of influences which affect boundary layer transition is first required (ranging from manufacturing tolerances, in-flight surface degradation and ice accretion through to noise, temperature and pressure gradient), combined with an ability to accurately predict transitional characteristics across this wide range of variables. The introduction of new materials and joining techniques has also led to a heightened awareness of the linkage between surface finish and aerodynamic performance, with innovations such as new generation composite materials having implications for the achievable surface finishes.

There has been a large quantity of work undertaken in the past number of decades devoted to furthering the understanding of the physics of transition (Atkin, 2008, Crouch, 1997, Reshotko, 1994, Joslin, 1998,

[1] Lecturer, School of Mechanical and Aerospace Engineering, AIAA Senior Member
[2] Senior Lecturer, School of Mechanical and Automotive Engineering
[3] Research Student, School of Mechanical and Aerospace Engineering, AIAA Student Member