On the Effects of Micro-Vortex-Generators on a Finite Wing in Subsonic Flow
על ההשפעות של מחוללי מערבולו זעירים
על כנף אינסופית בזרימה תת-קולית

A Master's Thesis Proposal
by
Anton Ronis
Principle Advisor
Prof. Daniella Raveh
Secondary Advisor
Prof. Rimon Arieli
March 19, 2013
Faculty of Aerospace Engineering
Technion - Israel Institute of Technology
Technion City, Haifa 32000, Israel

1 Introduction

The quest of improving ones desired aerodynamic flow design parameters has been initiated since the beginning of human flight. In order to try and accomplish this ~~quest~~goal, the concept of flow-control devices has been established.

A flow-control device affects the original flow field, thus enabling controlling flow characteristics such as reduction of drag by delaying and/or eliminating separation zones. The flow-control devices fall into two main categories:

1. Active devices.
2. Passive devices.

The difference between the two categories is the usage of external energy source to control the desired flow characteristics (e.g. pumps, bleeds etc.). Practical requirements of flow-control techniques such as robustness, light weight and ease of implementation, tend to favor passive devices such as vortex generators (VGs).

The concept of using VGs, first introduced by Taylor [1] in the late 1940s, is based on increasing the near-wall momentum through the momentum transfer from the free-stream flow. He arranged a row of small plates/airfoils that projected normal to the surface at an angle of incidence, β, to the local flow which produced streamwise trailing vortices.

Further investigations were conducted, considering the effect on pitch-up and wing-dropping problems, buffet boundary, aileron effectiveness and airplane drag for a swept-wing fighter airplane at transonic speeds, via flight tests [2] showing positive results while noting no noticeable drag increase due to lift.
A newer approach suggests the usage of micro vortex generators (MVGs), whose height, h, is less than the boundary-layer thickness, δ, placed ahead of a region with adverse flow conditions. In addition to the effects on subsonic flows, MVGs have been also proposed as being able to improve the adverse effects caused by shock/boundary layer interactions (SBLIs) over transonic wings [3].

2 Research Objectives

In the proposed research, the effects of an array of MVGs, placed on an infinite wing, subjected to subsonic flow will be investigated. The tested MVGs will be of co~~unter~~-rotating vanes type, as were shown to be effective for a high energy flow [1, 2]. A vanes type MVGs are shown in Figure 1.

The research will focus on the following subjects:
1. Drag: Drag will be calculated for both controlled and uncontrolled solutions. A comparison of the drag due to lift for the two cases will be analyzed, and an attempt to evaluate the compressibility effect ~~controlled and the uncontrolled cases~~ will be made.
2. Sweepback: The effect of the MVGs on ~~a~~ swe~~e~~pt ~~back~~ wings will be studied. Accounting for the spanwise flow and assessing the influence of the MVGs on 3D separation regions (or process)~~Expecting spanwise flow induction due to the finite wing geometry~~.
3. Flow regions: In both the 2002 review [1] as well as in the 2011 review [2] the majority of experimental studies used a bump type model placed on a flat surface. The effect of the interaction between the lower and upper streams ~~part flow domains of~~around the wing might be interesting since in this case ~~on~~ the separation bubble, if exists, is "open"will be compared to that of a flow over an upper section of the wing (single domain). Expecting an "open" separation bubble at the trailing ~~leading~~ edge ~~area~~region.

The study will be conducted by solving numerically the flow equations (NS), of an infinite wing section (chunk) with periodic boundary conditions; using the freesource program SU2 and/or the proprietary program EZNSS. In

Comment [RA1]: Since there is an unresolved debate whether CFD (RANS) can predict stall, I prefer to omit that goal altogether.

Comment [RA2]: This item should be rephrased.

order to eliminate turbulent-model dependence on the results, the solution will be solved using one turbulent model (SA), and the results will include ~~while supplying~~ an uncertainty factor (percentage) for the calculated flow characteristics for several ~~well established~~commonly used turbulence models.

Figure 1: Vane configuration [3], co-rotating and counter-rotating.
2

References

[1] John C. Lin, \Review of Research on Low-Pro_le Vortex Generators to Control Boundary-Layer Separation\. Progress in Aerospace Sciences Volume 38, Pages 389-420. November, 2002.
Add the AIAA review of 2011
[2] Norman M. McFadden,George A. Rathert,Jr. and Richard S. Bray, \The E_ectiveness of Wing Vortex Generators in Improving the Maneuvering Characteristics of a Swept-Wing Airplane at Transonic Speeds\. National Advisory Committee for Aeronautics, Technical Note 3523, Ames Aeronautical Laboratory. Mo_ett Field, California. September, 1955.
[3] Frank K. Lu, Qin Li, Yusi Shih, Adam J. Pierce and Chaoqun Liu, \Review of Micro Vortex Generators in High-Speed Flow\. 49th AIAA Aerospace Sciences Meeting. Orlando, Florida. 4 - 7 January, 2011.

3