Volume 3, Issue 5, May – 2018
International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165

An Experimental Analysis on MAV Design by Means of Laminar Seperation Bubble at low Reynolds Numbers

Hafsa Shaikh, Shahid Khan
Acharya Institute of Technology

Abstract:- This paper is an investigation into the laminar LSB that frequently plagues airbone vehicles operating in the low reynolds number regime .

The specific application driving the pesent investigation is the fixed wing performance of unmand microairvehicles (MAV'S), defined by there maximum chord length of 10cm and crusing speed of 10-20 meter per sec .the goal of this study was to gain some insight into the boundary layer behavior through the use of dye injection for flow visualization , and hot wire expirements.

Application: The purpose of this research is to gain fundamental understanding of laminar bubble behavior and some insight into their control and its potential impact on the performance of the airfoil. Aplication of this study to design MAV to minimize the drag and increase the aerodynamics efficiency for potential military application.

***Keywords*:-** *flow visualization techniques, low Reynolds number, laminar seperation characterstticts, wind tunnel experiments.*

I. INTRODUCTION

Due to the advances in unmanned aerial vehicles (UAV), micro air vehicles (MAV) and wind turbines, aerodynamics researches concentrated on low Reynolds number aerodynamics, transition and laminar separation bubble (LSB) and its effects on aerodynamic performance. In order to improve endurance, range, efficiency and payload capacity of UAVs, MAVs and wind turbines, the aerodynamicbehaviorsofthesevehiclesmentionedshouldbeinvestigated

The overall performance of all model flying machine is emphatically tormented by Laminar Separation Bubbles (LSB), which may additionally show up at low Reynolds numbers. This kind of separation bubble is because of a strong negative pressure gradient (pressure upward thrust along the surface), which impacts the laminar boundary layer to split from the curved airfoil surface. The boost of pressure is identified with the decrease of velocity towards the trailing fringe of the airfoil, which can be found in the velocity promulgation of the airfoil via Bernoulli's condition. The boundary layer leaves the surface through a tangential route, bringing about a wedge shaped separation location. The separated, yet on the equal time laminar glide is largely sensitive to unsettling influences, which is lengthy, the final purpose is to alternate to the turbulent region. The transition region (now not precisely a transition factor) is located at a distance from the airfoil at the outside boundary of the separated flow perimeter. The thickness of the now turbulent boundary layer develops rather quickly, shaping itself as a turbulent wedge, which may additionally achieve the airfoil surface once more. Another point of interest may the zone wherein the turbulent waft touches the surface once more is known as reattachment point. The volume encased by means of the districts of isolated laminar drift and turbulent waft is called a laminar separation bubble.

II. TRANSITION

The separation of a laminar boundary layer occurs above the line marked "Separation Criterion". The separation may lead to a separated flow transition. The shaded region on Figure 2 corresponds to the transition Reynolds numbers for turbulence levels between 5% and 10%

Mayle (1991) presented a study of laminar to turbulent transition phenomena, types of transition and their effects on aerodynamics of gas turbine engines and he also reviewed both theoretical and experimental studies.

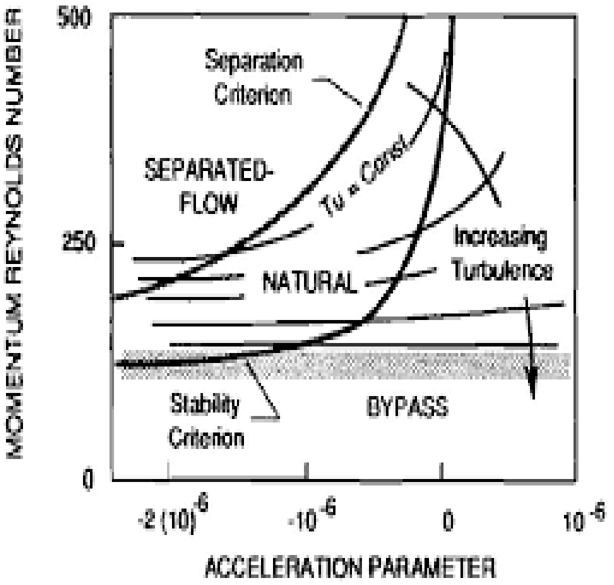

Fig 2:- Topology of the different types of transition in a Reynolds number-acceleration parameter plane (Mayle,1991)

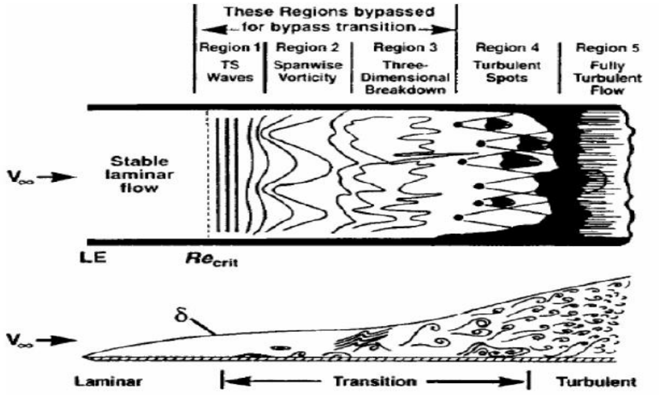

Fig 3:- The natural transition process (Schlichting, 1979)

A. *Natural transition*

The growth of the weak instabilities mentioned, results in nonlinear three-dimensional disturbances. After this certain point the three-dimensional disturbances transform into turbulent spots (Figure 4). The turbulent spots combine and so transition from laminar to turbulent is completed, from now on the flow is fully turbulent. Emmons (1951) and Emmons & Bryson (1951) stated that the turbulent spots within the boundary layer grew and propagated downstream until the flow was fully turbulent. They also presented amodel of growth mechanism of turbulent spots, whic hindicated the time and location dependent random production of the spots

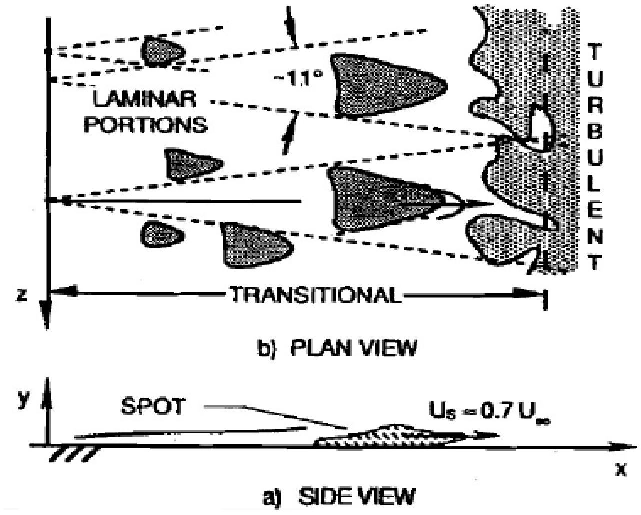

Fig 4:- Turbulent spot geometry and emergence of a turbulent boundary layertrough the growth and propagationof turbulent spots (Mayle,1991)

B. Separated flow transition -

Figure 1 shows the laminar separation bubble, this laminar separation bubble may occur on aerodynamic bodies working at Re ≤ 106. The laminar separation bubble may occur in few conditions that are briefly depicted: The presence of the laminar separation flow of the laminar boundary layer because of an adverse pressure gradient; a turbulent flow change the separation layer inside; a turbulent reattachment. Under these conditions a separation area described by a moderate recycling flow and by a practically consistent pressure is framed. The presence of laminar separation bubble may raise two classes of issues: (i) The airfoil efficiency decreases, because of the airfoil drag increases; (ii) Due to the presence of extensive pressure fluctuations on account of laminar separation bubble bursting

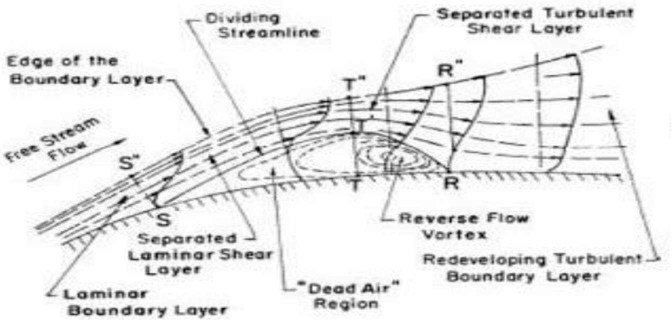

Fig 6:- Laminar separation bubble

III. MATERIALS AND METHODS

A search was made on the Google Scholar database on 3rd July, using specific key words (Laminar Separation Bubble over airfoil and experimental investigation on LSB over Airfoil). The key word “Laminar Separation Bubble and Experimental Investigation on LSB over airfoil” generated about more than 1000 results. The results generated included all other publications that had the words “Laminar Separation Bubble” or “Experimental Investigation on LSB over airfoil” in them. Searches were also made on other databases such as Scopus Indexed Journals. Other key words, such as ‘Wind Tunnel Experiment’ or ‘Flow Visualization over an airfoil’, were also used. The search and re-search in all database yielded near-similar results. Selection criteria for inclusion were made to eliminate all non-related or irrelevant publications. The main criteria for inclusion in phase one was that the publications had to be an original research paper and International Conferences specifically written on English, with at least one of the specific sub-criteria, as below:

- Laminar Separation Bubble (LSB) traits (height and duration) and flow characteristics at separation, transition, and reattachment region over low Reynolds range airfoil.
- Measurement of LSB over low Reynolds number airfoil.
- Experimental Technique: Surface Oil Flow Technique, Particle Image Velocimetry (PIV), Infrared Thermograph (IT).

Low Speed Wind Tunnel: Force Measurement and Hotwire Experiments, Smoke-Wire Experiment, Multi-line Molecular Tagging Velocimetry, Oil Film Interferometer, Volumetric Three-Component Velocimetry (V3V), ESP (Electronically Scanned Pressure) Scanners, Embedded Laser Doppler Velocimetry (ELDV) and stereo-PIV, Fast Fourier Transform (FFT) etc

IV. RESULTS AND DISCUSSION

Airfoil (Characteristics) & Reynolds Number

NACA 4412,

C = 10 cm,

Span = 10 cm.

Re: 25000, 50000 and 75000

A. Experimental Technique and Characteristics investigated

Low speed wind tunnel: Force Measurement and Hot-Wire experiments, Smoke-Wire experiment. Flow separation and vortex shedding

Outcomes/Conclusions

Low speed wind tunnel:

Re = 25000, Stall angle = 12°, CL,max = 0.9

Re = 50000, Stall angle = 16°, CL,max = 1.25

Re = 75000, Stall angle = 18°, CL,max = 1.35

B. Smoke-wire experiment:

Re 25000: The laminar separation bubble moved towards LE over the airfoil when the AOA changed from 8^0 to 12^0

Re 50000: The flow separation occurs at 16^0 AOA but even though the laminar separation bubble is found at 12^0

Re 75000: The perspective of the laminar flow separation occurs at 19^0 and the main-part separation is like wise seen at a 19^0.

C. Hot wire anemometry machine:

Re 25000: The velocity at the wake region reduced from 1.034 to 0.6 at 160 AOA. The rate further decreased from 1.074 to 0.37 at 200. The same decreasing is discovered at Re variety of 50000 and 75000.

V. CONCLUSION

It ends up noticeably presumed that as Re range broadened, the slowdown edge extended. What's more, the partition bubble moved towards LE over the airfoil as the approach expanded.In order to improve the aerodynamic performance of MAV, there are new methods being developed to reduced the effects of the LSB on airofoil, besides the high lift devices. these methods are called flow control methods and could be classified as active and passive.

REFERENCES

[1]. Hafsa shaikh , Shahid khan,"Experimental Study on Laminar Separation Bubble by Means of Surface Oil Flow Over an Airfoil", Volume. 3 Issue. 5, May- 2018, International Journal of Innovative Science and Research Technology (IJISRT) ,www.ijisrt.com , ISSN - 2456-2165, PP:-106-109.
[2]. Katz, J. & Plotkin, A. (1991). Low-Speed Aerodynamics from Wing Theory to Panel Methods, McGraw-Hill, Inc.
[3]. Lang, M., Rist, U., Wagner, S. (2004). Investigations on controlled transition development in a laminar separation bubble by means of LDA and PIV. Experiments in Fluids, Vol. 36, pp. 43-52.
[4]. Howard R, Alam M, Sandham ND. Two-equation turbulence modelling of a transitional separation bubble flow. Flow Turbulence Combustion. 2000 Jan; 63(1-4):175–91. Crossref.
[5]. Genc MS, Karasu I, Acıkel HH. An experimental study on aerodynamics of NACA2415 aerofoil at low Re numbers. Experimental Thermal and Fluid Science. 2012 May; 39:252–64. Crossref.
[6]. Jones BM. Stalling. Journal of the Royal Aeronautical Society. 1934 Sep; 38:753–70. crossref
[7]. Menter, F. (1994). Two-equation Eddy Viscosity Turbulence Models for Engineering Applications, AIAA Journal, Vol.32, pp. 1598-1605.
[8]. Nakano,T.,Fujisawa,N.,Oguma,Y.,Takagi,Y.,Lee,S.(2007).Experimentalstudyonflowand noise characteristics of NACA0018 airfoil. Journal of Wind Engineering and Industrial Aerodynamics, Vol. 95, pp. 511-531.
[9]. Wahidi R, Bridges DH. Experimental investigation of the boundary layer and pressure measurements on airfoils with laminar separation bubbles. 39th AIAA Fluid Dynamics Conference; 2009 Jun. Crossref.