© July 2019 | IJIRT | Volume 6 Issue 2 | ISSN: 2349-6002

Study of shock formation around various wing shapes in supersonic flow using col-our schlieren method

Pavan Kumar Mekala[1], Naga Manikanta Kommanaboina[2], Sai Krishna Pabba[3], Akash Chanda[4], Adithya Reddy Ettireddy[5], Veeranjaneyulu Latchiboyina[6]

[1,2,3,4,5]*Kaunas University of Technology, Studentų g. 56, Kaunas, Lithuania*

[6]*Qis college of Engineering and Technology, Assistant Professor, Ongole, India*

Abstract- **Summary of the project is to be finding the effects of different wing shapes and size in supersonic flight. The wing shapes include delta, double delta and other some shapes. By using schlieren method and BOS method in softwares Ansys and designed in Catia. Using common fuselage size and shape according to blockage ratio of supersonic wind tunnel test section and various wing shapes.**

Index terms- Shock wave, supersonic wind tunnel, computer aided design, schlieren method, BOS method, stainless steel, sweep angle, straight angle

I. INTRODUCTION

A shock wave is a kind of disturbance. The waves move quicker than the nearby speed of sound in a fluid it is called shock wave. Shock wave spreads energy and grow through a medium change in pressure, temperature and density of the medium. In supersonic stream extension is accomplished through a development fan otherwise called Prandtl Meyer development fan. Schlieren Photograph of a shock on a sharp-nosed supersonic body. When shock wave passes through matter energy is pre-served but entropy increases.it will changes in the matter properties shows itself as a decrease in the energy which can be extracted as working as a drag force on supersonic objects shockwaves are strongly irreversible processes [6].

The main focus is to determine the effect of different wing shapes and size in supersonic flight. The wing shapes include delta, double delta, circular, elliptical, oval, straight etc. A common fuselage size and shape will be selected according to the blockage ratio of test section supersonic wind tunnel and according to blockage ratio of test section of supersonic wind tunnel and different types of wing shapes will be analyzed by joining with fuselage at zero angle of attack. Contemporary methods such as BOS can be employed to know the change in flow properties at different stations. Colour schlieren gives visual clue about the presence of shock and expansion waves. This project involves testing of models (preferably made of stainless steel) at Mach 2, which exerts high pressure on the mod-el and surroundings. The involvement of very high pressure dictates high level of accuracy, high strength and fatigue strength on model making.[7]

New experiments aimed at exploring the results of three dimensionality presenting in the supersonic tunnel with Mach number M =1.5 and 2. this wind tunnel has a rectangular closed type test section of 100mm times 100mm size. Apparatus required Mach, Convergent Diver-gent Nozzle, Supersonic wind tunnel, Schlie-ren set up, Digital camera. Consider as the four basic interactions between a shockwave and a two-dimensional flow are the impinging reflecting shock the ramp flow the normal shock and the pressure jump [4].

The normal shock wave is opposite to the course it is known as an ordinary shock and it happens before a supersonic item it the stream is turned by a vast sum and the shock is absent on the body [5].

II. MATERIAL SELECTION

Be that as it may, in the primary piece of this audit the exchange is limited to circumstances in which the material might be portrayed to a de-cent estimate by the model of a compressible, heat directing, Newtonian continuum. The extra suspicions that a material component is exposed just to such moderate changes that it can keep up thermodynamic balance wherever prompts a basic articulation for the thickness of stuns in term of the mass and shear viscosities, thermal conductivity, thickness, and speed of sound of the material.

In the event that these properties are swapped by relating values for a genuine gas of discrete particles, at that point the thickness of adequately solid stuns sums just to a couple of mean freeways. Density =7.85 kg/m^3, Bulk modulus = 134 GPa, Hardness = 1700 Map, Shear modulus = 74 GPa, Tensile strength =510 Map, Youngs modulus = 190 GPa.

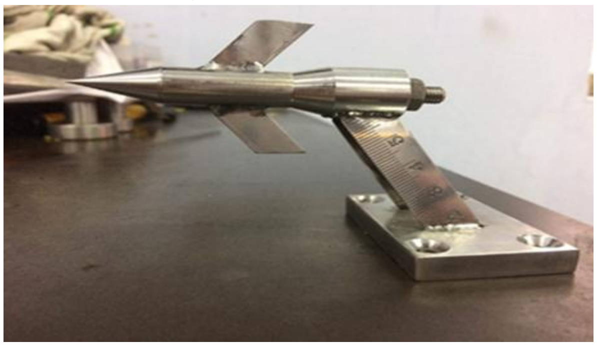


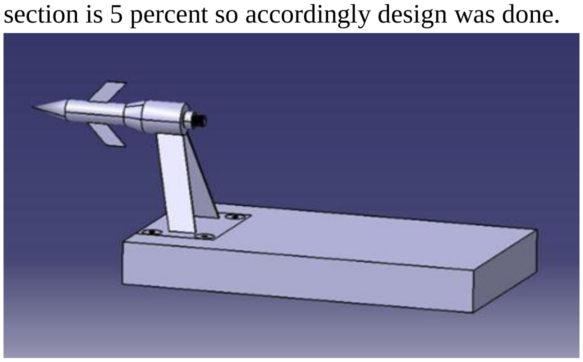
Fig.1 Fabrication of desgined model of wing

III. DESIGN AND METHODOLOGY

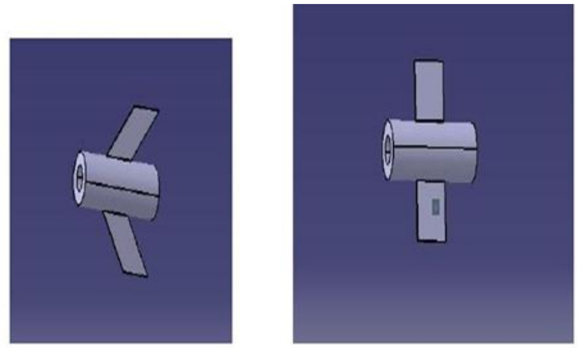
Table.1 Design parameters of the model

Parameters	Front cone	Wing shape	Wedge model	Bed
Total length(mm)	78.4	30	30	180
Thickness(mm)	5	10	15	20
Wedge angle (deg)	75	-	5	-
Wing angle (deg)	-	45 and 90	-	-

The complete design of model done by using the software CATIA (In Fig 2) and finally drafted with appropriate dimensions. The design has been tak-en with the constraints in the test section of the supersonic wind tunnel. Blockage ratio of the test section is 5 percent so accordingly design was done.



(a) Total model



(b) 45 and 90 degree wing

Fig.2 Computer aided design of the model(a), 45 degree and 90 degree (b).

IV. EXPERIMENTAL ANALYSIS

The formation of the shock wave around the model is a normal shock wake with Mach number 1.5 to 2 by using schlieren method. the shock wave is passing through the model when it is in 0 degree. We observed by using supersonic wind tunnel. In this straight wing the shock-waves will not affect on the wings and no vortices will form.

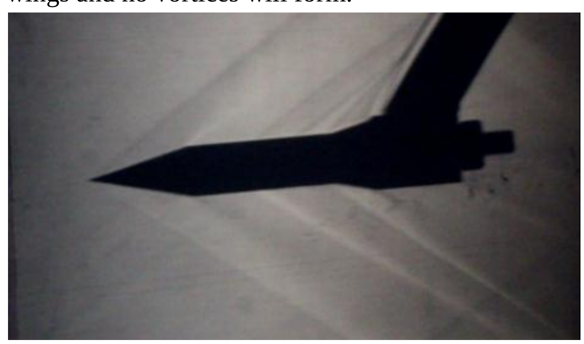


Fig.3 Testing of 90 degree wing in the supersonic wind tunnel

Fig.4 Testing of 45 degree wing in the supersonic wind tunnel

The formation of the shock wave around the model is a normal shock wake with Mach number 1.5 to 2 by using schlieren method. the shock wave is passing through the model when it is in 90 degree. When it is in 90 degree the wing impact will be there the second wave will form around the wing area which divide the flow at nose area and wing area. We observed by using supersonic wind tunnel.

V. NUMERICAL ANALYSIS

First, we must make the Catia file in wedge shape model and save it in a its file. Start all programs Ansys 16.0 workbench 16.0. select the Ansys cox and drag into workspace. Click the geometry and import geometry. Right click geometry and edit geometry and we must update and select units in millimeter. using sketcher option draw a rectangle and give appropriate dimensions. Select on sketch and click on extrude optionless both asymmetric options give dimensions according to length of test section. Using Boolean option remove the wedge model 12 click update and click mesh and edit select face selecting tool select faces one by one right click select named selection enter specific name and select mesh right click and up-date sizing use advance size function.
Mesh insert sizing select entire body by using body selecting tool apply update. Go to work bench right click setup and edit. Double click solution and wait until solution is converged and select result and right click create a plane and select contours of velocity/Mach number/pressure/density and display. Default domain in the outline section and domain type is fluid and material is air ideal gas and reference pressure is 1atm and fluid models is heat transfer option total energy and turbulence factor is k epsilon. normal speed and pressure, relative static pressure - 7.2 atm, normal speed - 694 m/s, high intensity - 10, static temperature -303 k. Flow regime – supersonic as an outlet. Mass and momentum - free slip condition, Heat transfer – adiabatic as a wall.

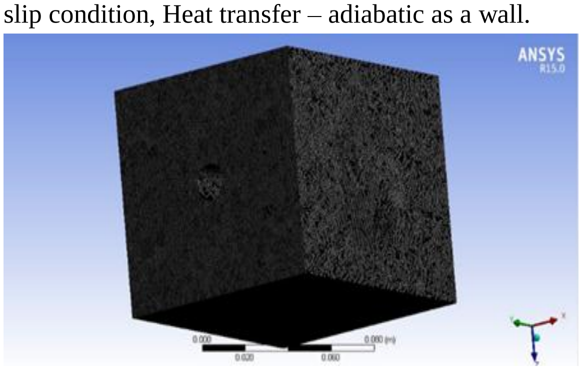


Fig.5 Meshing of the model in ansys softwear

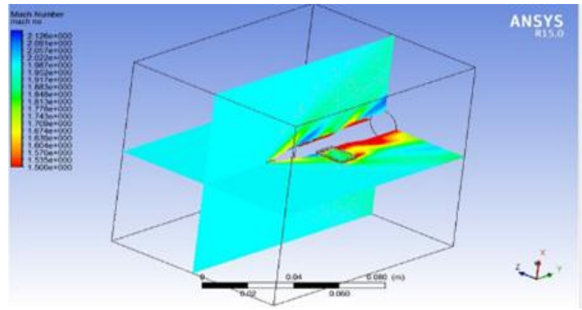


Fig.6 Isometric view of Mach no in 3d analysis

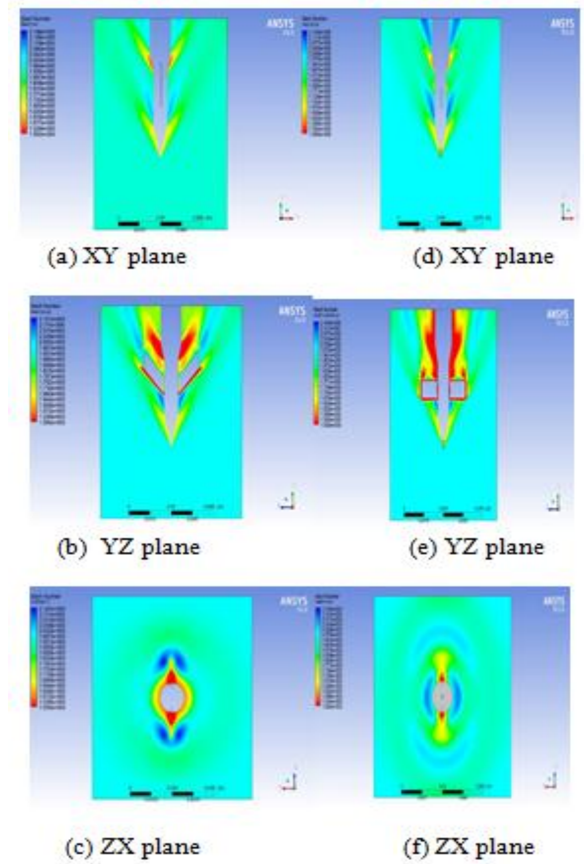


Fig .7 Flow visualisation of Sweep angle 45 degree (a, b, c) and Straight angle (d, e, f)

In above figure7 shows that flow visualisation of the 3-d model in the 2-d view using Ansys software.so the 2-d views can be shown through XY, YZ and ZX plane. The difference between the sweep angle 45 degrees and straight angle is the sweep angle 45 degree will get vortices after the wing. The shock wave is passing normally through it. In the straight angle case, the vortices are forming after the wing position after passing shock wave through it because the wing is in straight and there are no wingtips on it. The vortices are formed due to skin friction drag and parasite drag.

VI. CONCLUSION

The study of shock formation around various wing shapes in supersonic flow using colour schlieren method was done and we absorbed it in the different planes at different directions in numerical analysis how Mach number is impacting the creation of the shock wave around the model. In experimental model we have done in two different angles to observe the flow around the model how the shock wave is forming and how Mach number is impacting on the model.

REFERENCES

[1] Jones, R.T. Theoretical determination of the minimum drag of aero-foils at supersonic speeds journal of the aeronautical sciences.
[2] Jones, R.T. The minimum drags of thin wings in frictionless flow, journal of the aeronautical sciences.
[3] Al-Obaidi, A.S.M. (2005). The influence of configuration design on the aerodynamics and stability of SSM at supersonic speeds.
[4] Kermode, A.C. (2006). Mechanics of flight person prentice hall, new jersey
[5] Lebedev, A.A.; and Chernobrovkin, L.S. (1973). Dinamika poletabezpi-lotnykh letatelykh apparatov. Flight dynamics of un-manned vehicles. Mashinostroenie, Moscow.
[6] Peixue jiang, Zhiyuan, Zheng huang. Influence of shock waves on supersonic transpiration cooling.
[7] K. Ananth Krishna and M. Govardhan influence of fillet shape on secondary flow field in a transonic axial flow turbine stage.
[8] Jonaitis M.; Kamaitis P.; Rimaitis E. 1999. Determining J-R curves of steam pipeline Du-630 welded joint materials in Ignalina NPP, Mechaninė technologija t.XXVII: 182-199 (in Russian).
[9] Anderson, T.L. 1991. Fracture Mechanics. Fundamentals and Applications. Boca Raton, Ana Arbor: CRC Press. 793 p.
[10] Dickey, H.; Watson, V.; Zangelidis, A. 2009. Job satisfaction and quit intentions of offshore workers in the UK North Sea oil and gas industry.