EXPERIMENTAL INVESTIGATION OF FLOW SEPERATION OVER AN AIRFOIL AT SUBSONIC MACH NUMBER

Karthick B

2. Hemnath

3. Shanmuga sundaram K

1. Assistant Professor – Department of Aeronautical engineering

2.3 Assistant Professor Department of Mechanical Engineering

Dhanalakshmi Srinivasan College of Engineering and Technology

[2]hemnath.mech@dscet.ac.in

[1.] karthickb@gmail.com

[3.]shannusundaram@gmail.com

ABSTRACT;

Airfoil Extensively depend on lift and drag geometry. To design the NACA 0021 airfoil and to be experimentally analysis with help of low speed wind tunnel. To be calculated the pressure distribution over an airfoil and velocity of flow to change the angle of attack of the airfoil to be calculated the pressure distribution and velocity of flow. To be required angle of airfoil (1,5,10,15).to be created the golf ball surface above the airfoil surface to be analysis the flow separation and to be calculated to be calculate the Reynolds number because of Reynolds number to be decide the flow .analyze the lift and drag on airfoil model.

Keywords: Airfoil, NACA, Reynolds number,drag

INTRODUCTION;

Wind tunnel large tube with air blowing through them which are used to replicate the interaction the air and na object flying through the air or moving along the ground. Researchers use wind tunnels to learn more about how an aircraft will fly. NASA uses wind tunnels to test the scale models of aircraft and spacecraft .some wind tunnels are large enough to contain full size versions of vehicles.Experimentalinvestigations were carried out to study the wake profile of a supercritical airfoil at Mach numbers of 0.4 and 0.6 in a pitching motion. Both static and dynamic tests were conducted in a tri-sonic wind tunnel. Flow fi eld inside the wake was measured by hot wire anemometry at downstream distances of 0.25 and 0.5 times the chord length from trailing edge. All data were taken at mean incidence angle of 3°; the amplitude of oscillation was 3° and the oscillation frequencies were 3 and 6 Hz. Moreover, numerical study was applied for the same airfoil under similar experimental test conditions; finally, wake profiles obtained from both numerical and experimental methods were compared.The NREL phase 1V airfoil to numerically analysis to find the pitching moment aerodynamics force and integrated from surface pressure measurements. multiple hot film sensor f Reynold number (1.35*10^5).Are studied experimental and numerical investigation of lift and drag coefficients measured two dimensional subsonic stream over NACA 0012 symmetric airfoil to low and high Reynolds number. The result presented every two degree angle of attack from 20°to 20° at 45m/s . The computational \domain was made 80000 elements for NACA 0012. Numerically analysis used CFD program in Ansys 15 software.Experiments are carried out of study static pressure distribution and drag variations over naca0018 airfoil and over an automobile dome. Static pressure coefficient are calculated both test models and result are compared further the relationship between coefficient drag and Reynolds number has been arrived for different angle of incidence and coefficient drag decrease and Reynolds number Increase and coefficients drag high at high angle of incidence.In this work we experimental investigation was carried out to enhance the performances of airfoil NACA4311 by surface modification initially the aerodynamic performance of three different shapes of airfoil symmetric. Flat. Cambered airfoil was checked experimentally. Based on these investigation it was concluded the symmetrical airfoil gave quite better than performance than other shapes of airfoil. After surface modification by placing dimples of different sizes and shapes at suction surface of symmetrical and cambered and flat**.**An experimental investigation was conducted to study the transient behavior of the flow separation on a NASA low-speed GA (W)-1 airfoil at the chord Reynolds numbers of 68,000. A high-resolution PIV system was used to make detailed flow field measurements in addition to the surface static pressure distribution mapping around the airfoil. The measurement results visualized clearly that a separation bubble would be generated on the airfoil upper surface if the adverse pressure gradient is adequate. The length of the separation bubble could be up to 20% of airfoil chord length and its height only about 1% of the cord length. The transient behavior of the flow separation on the airfoil, which includes the “taking-off” of the laminar boundary layer from the airfoil surface at the separation point, the generation of unsteady Kelvin-Helmholtz vortex in the separated boundary layer, the rapid transition of the separated laminar boundary layer to turbulent flow, the reattachment of theturbulent flow to the airfoil surface to form separation bubble, and the burst of the separation bubble to cause airfoil stall, were elucidated clearly and quantitatively from the detailed flow field measurements.The lift coefficient and drag coefficients for S9023 airfoil are obtained by measuring the pressure distribution from the pressure ports which is situated over the airfoil surface. The aerodynamics parameters at different Reynolds number is plotted i.e. Cp vs. x/c, Cp vs. y/c, Cl vs. α. Cd vs. α and L/D vs. α. The non-dimensional aerodynamics characteristics for S9023 2D airfoil described in details for different Reynolds number

1.1Measurement Of Aerodynamic Forces

Air velocity through the test section is determined by bernoulli's principle, measurement of the dynamic pressure , the static pressure , and (for compressible flow only)the temperature rise in the airflow .the direction airflow around the model can be determined by tuffs of yarn attached to the aerodynamic surfaces.

1.2 Flow Visualization

Some of the flow visualization methods are use in wind tunnel these are

- Smoke flow visualization
- Carbon dioxide injection
- Tuffs, mini tuffs, or floe cones can be applied to a model and remain attached during testing.
- Oil: when oil applied to the model surfaces it can clearly show the transition from laminar to turbulent flow as well as flow separation

METHEDOLOGY;

The tunnel are used to copy the action of an object in flight researchers use wind tunnel to learn more about how aircraft will fly . NASA uses wind tunnel to test scale model of the aircraft and spacecraft . The wind tunnel moves air around an object making it seem like the object is really flying.

Stainless Steel

Stainless steel is essentially a low carbon steel which contains chromium at 10%or more by weight it is addition of chromium that gives the steel its unique stainless corrosion resisting properties. the chromium content of the steel allows the formation of a though adherent, invisible ,corrosion-resisting chromium oxide film on the steel surface. If damaged mechanically or chemically , this film is self – healing provided that oxygen even in very small amounts is present .

Wood

They have to be a tall and straight and their wood must be srong and light . The dark bands contain many fibers , whereas the light bands contain much more 'resin' . Thus the wider the dark bands , the stronger and heavier the wood , if the dark bands are very narrow and the light bands quite wide , the wood is light but not strong Today good airfoil wood is very hard to come by. Instead of using one good board for our spars we have it use laminations because of large price of wood are practically unavailable and we no longer can trust the wood quality.

TERMS AND CALCULATION;

Drag

A drag force resistance force caused by the motion of a body through a fluid such as water or air. A drag force acts opposite to the direction of the oncoming flow velocity. This is a relative velocity between the body and the fluid. In a fluid dynamics drag coefficient is a dimensionless quantity that is used to quantify the drag or resistance of an object in a fluid environment such as air or water. The drag coefficient is always associated with particular surface area.

$$Cd=2Fd/\rho.V^2.A$$

Where

Fd =drag force

P=density of air

V=velocity of the object relative to the fluid

A=is a reference area

Lift

Lift is defined as the component of the aerodynamic force that perpendicular to the flow direction. The lift coefficient is a dimensionless coefficient that relates the lift generated by a lifting body to the fluid density around the body. The fluid velocity and an associated reference area

$C_l=2L/\rho.V^2.A$

L =Lift force

P=density of air

V=velocity of the object relative to t

A=is a reference area

Pressure distribution

This is used for studying pressure distribution across various model such as airfoil, cylinder, special purpose shapes. Bottom of all tubes are interconnected and in turn to the balancing reservoir filled with coloured water. While the last tube is left open to atmosphere reference. All other 12 tubes are connected at their top to pipe /tube bundies of the model

Pt =Ps+Pd

Where

Pt=Total pressure

Ps= Static Pressure

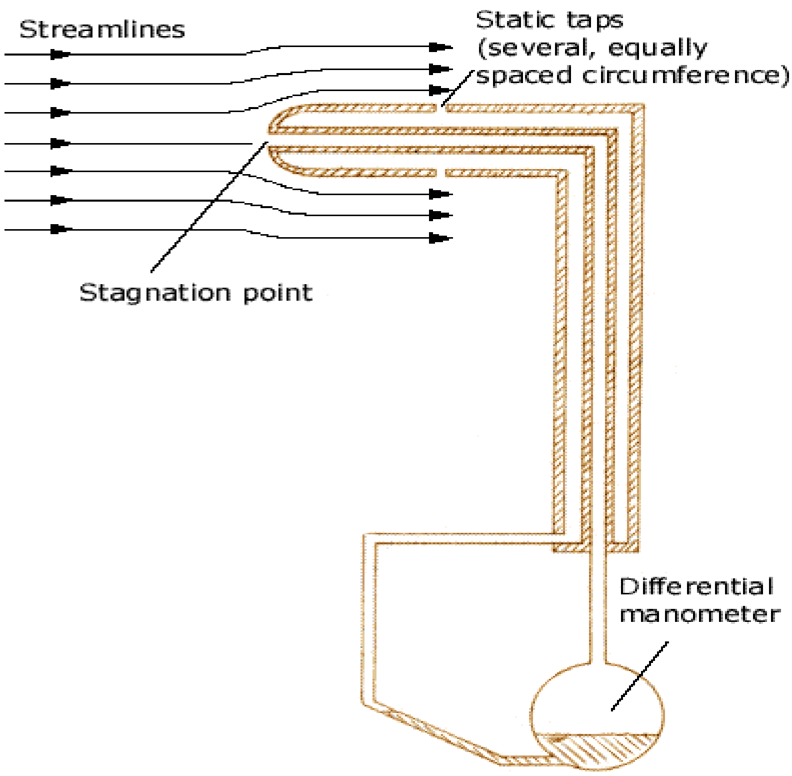
Pd=dynamic pressure

VELOCITY MEASUREMENT ;

One very important use of wind tunnel is to visualise flow patterns and measure the pressure at a selected point in the flow field and compute the corresponding speed of air

$$V=\sqrt{2(p_o-p)/\rho}$$

Pitot tube image



REYNOLDS NUMBER;

It defined as ratio between inertial force and viscous force

$Re = \rho\ v\ l\ /\mu$

Where

V=velocity of fluid

μ = dynamic viscosity

ρ = density of air
l=the characteristic length , the chord width of an airfoil

• Reynolds number plays on important part in the calculationof the friction factor in a few of the equation of fluid mechanics including the Darcy weisbach equation.

CALCULATIONS ;

5.2.1 (CL V/s Angle of attack)

- 1 angle of attack

Cl= (2 *19.013)/(0.1*1.225*31.67*31.67)

Cl=0.314

- 5 angle of attack

Cl=0.687

- 10 angle of attack

Cl=0.8854

- 15 angle of attack

Cl=0.8214

Angle of attack	Lift	Coefficient of lift
1	19.013	0.314
5	42.21	0.687
10	54.3946	0.8854
15	50.4641	0.8214

Table 5.2.1 angle of attack &lift &lift coefficient

(Cd v/s Angle of attack)

- 1 angle of attack

Cd= (2*0.846)/(1.225*0.1*31.37*31.37)

Cd = 0.013

- 5 angle of attack

Cd=0.0293

- 10 angle of attack

Cd=0.07909

- 15 angle of attack

Cd=0.2358

Angle of attack	Drag	Drag coefficient
1	0.846	0.013
5	1.80454	0.0293
10	4.859	0.07909
15	15.489	0.2358

Table 5.2.2 angle of attack &drag &drag coefficient

Pressure acting on the airfoil model

$$P + 1/2\ \rho\ v^2 = P_o$$

Where

P = static pressure

ρ =density of air

v= velocity of flow field

Po =Total Pressure

Angle of attack V/s pressure

- 1Angle of attack
  P=(101*10^3)-(1/2*1.225*31.367*31.367)
  P=100.795 N/m^2

- 5 angle of attack

  P= 100.233 N / m^2

- 10 angle of attack

  P = 100.001 N/m^2

- 15 angle of attack
  P = 99.774 N/m^2

Reynolds Number Calculation

$$Re = \rho\ u\ l / \mu$$

Re = 1.225 *20.87* 0.15/1.802*10^-5

Re = 212811.459489

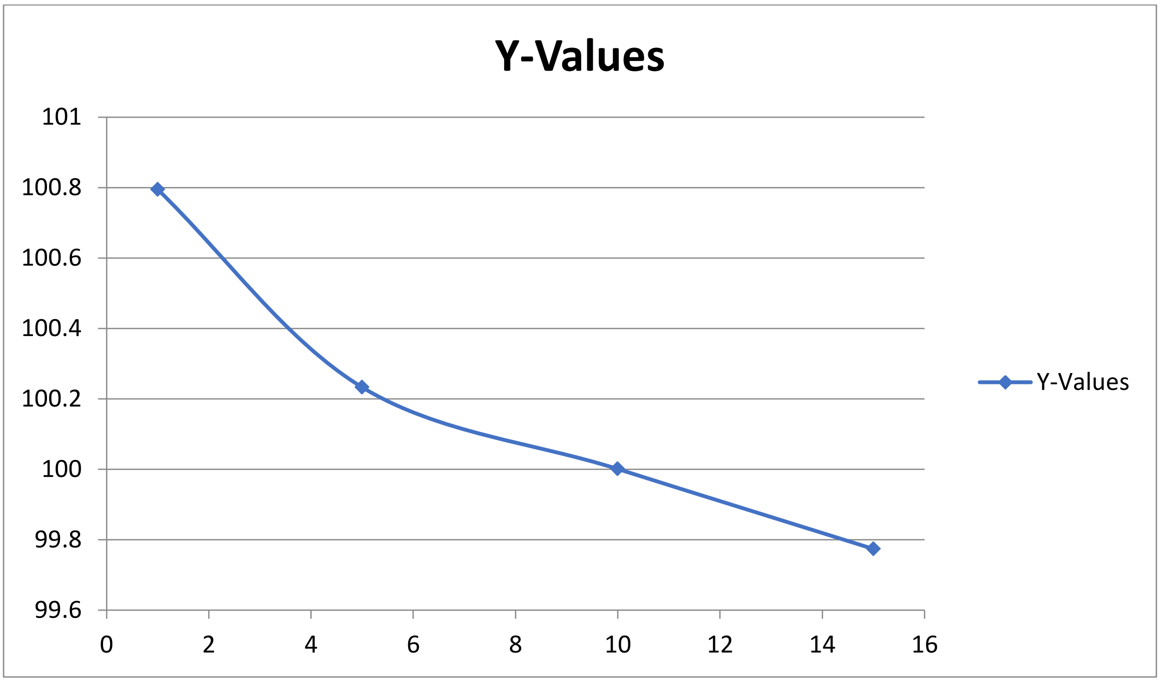
Laminar flow <2000

Transition flow 2000<Re>4000

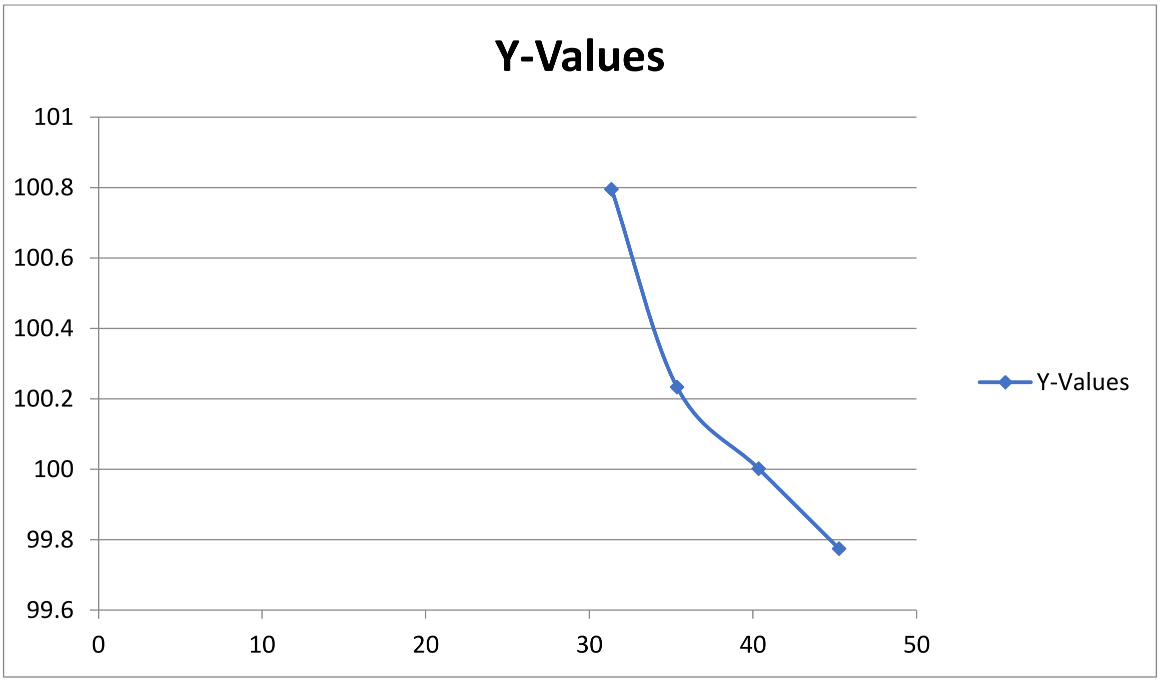
Turbulent flow >4000

RESULT;

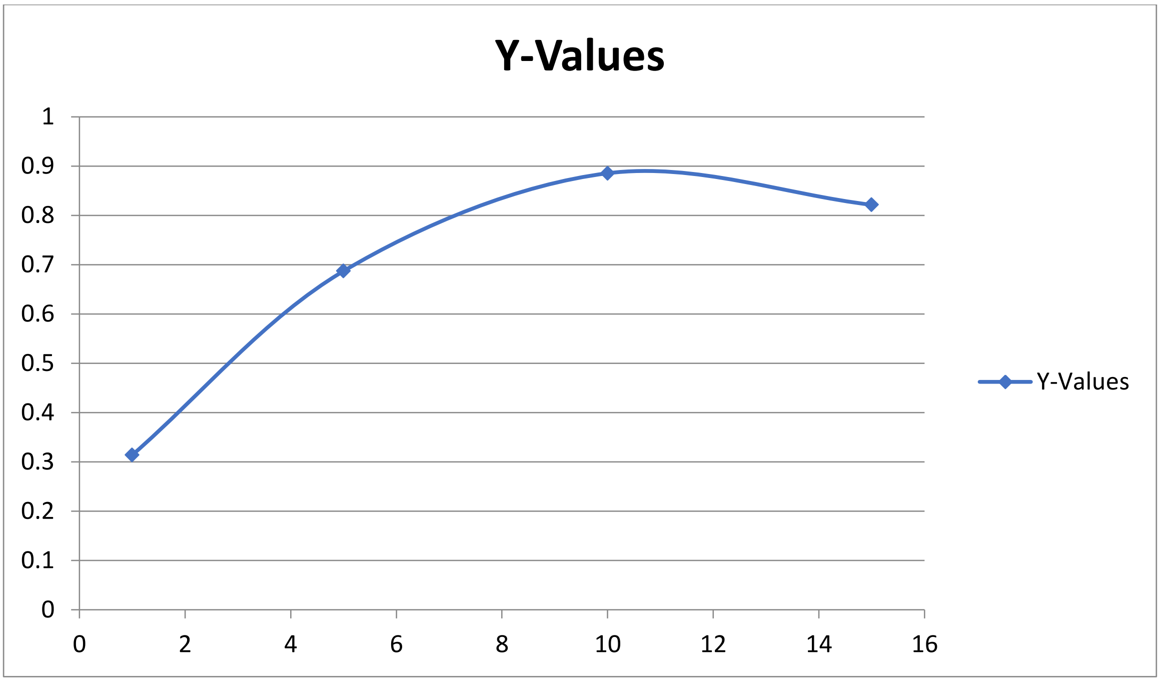
Experimental investigation of flow separation over an AIRFOIL at subsonic Mach can be tested in wind tunnel and take the reading can be calculate with help of the formula and to draw graph with respect value



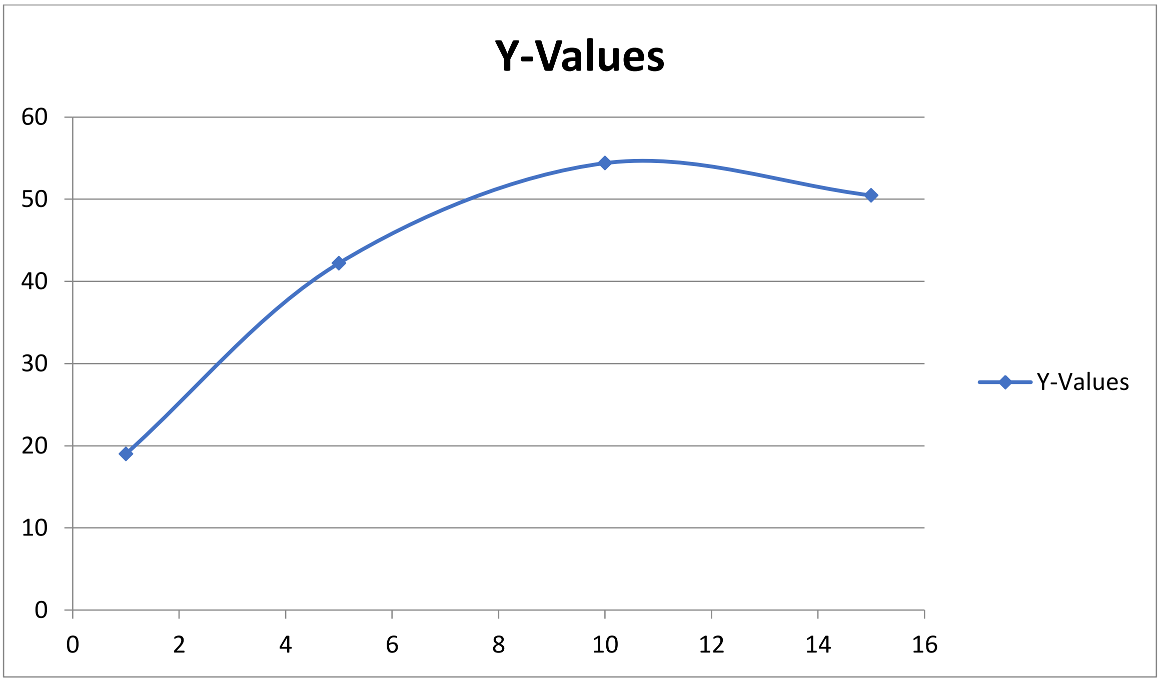
Graph 6.1 Angle of attack V/ s pressure



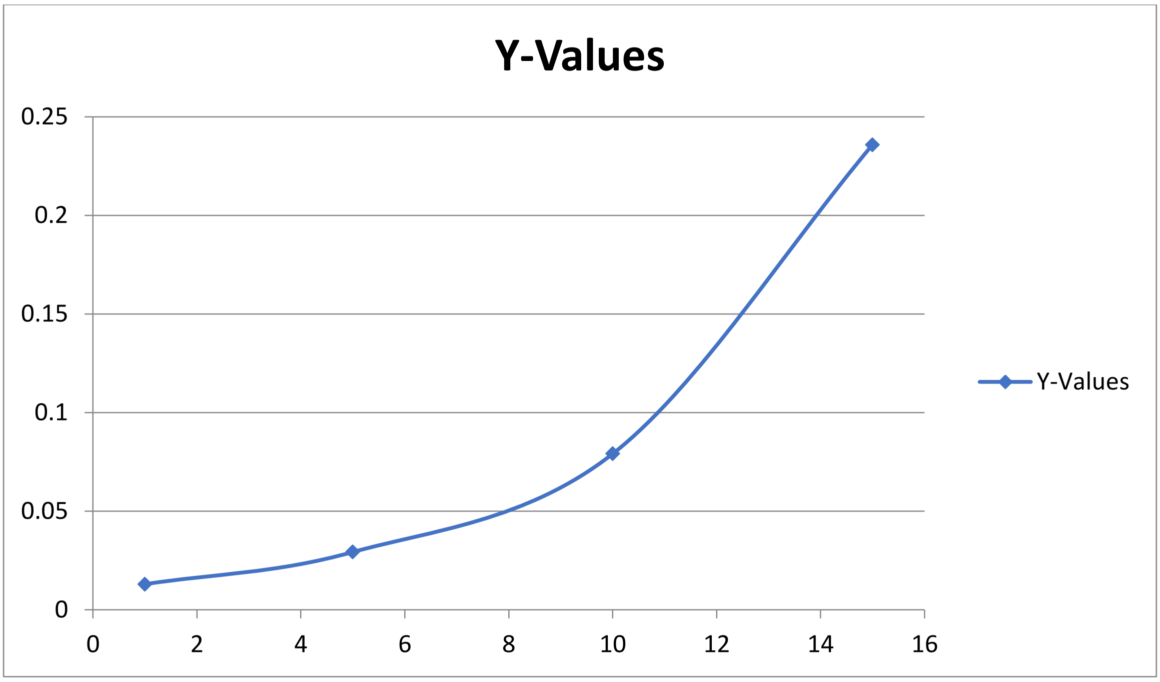
Graph 6.2 Velocity V/s pressure



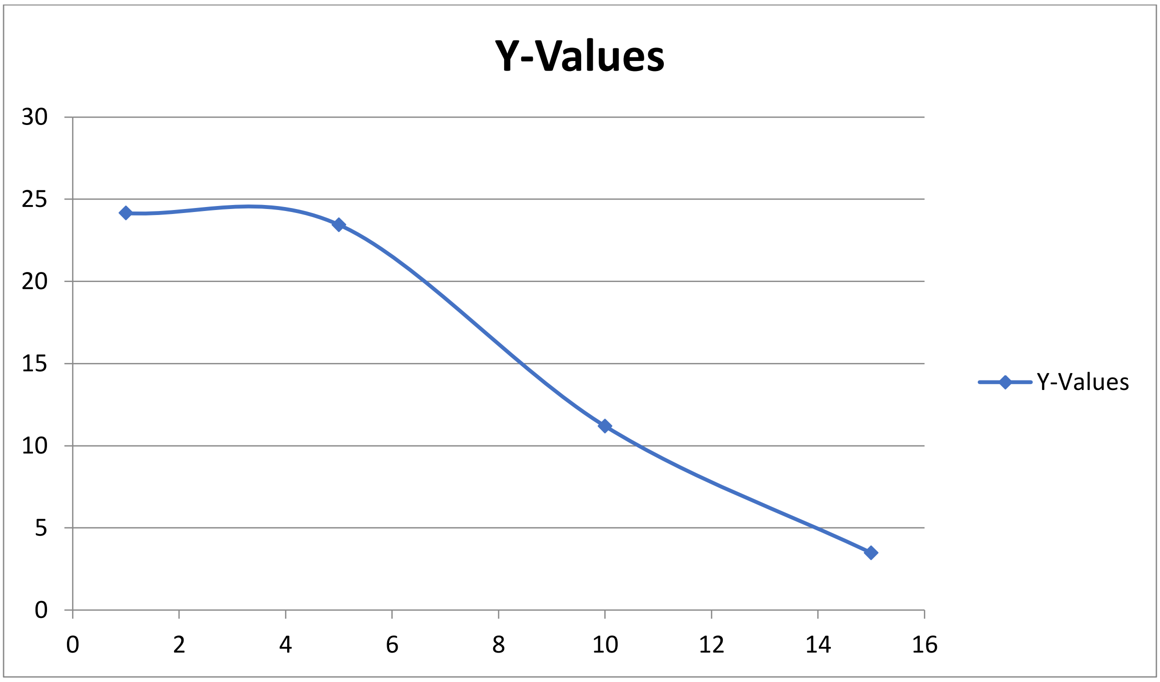
Graph 6.3angle Of Attack Vs Coefficient Of Lift



Graph 6.4 Angle Of Attack Vs Lift Force



Graph 6.5angle Of Attack Vs Drag Coeeficient



Graph 6.7 Angle of attack V/s Cl/Cd

CONCLUSION;

A wind tunnel test was conducted on NACA 0021 AIRFOIL were at angle of attack. The conclusion of the experiment based on the objective set out in from point

- The angle of attack of the AIRFOIL were found by forcing the calculated pressure distribution of the AIRFOIL with multi tube manometer that had water as the working fluid. The pressure weregiven initially as height changes in the manometer and were thereafter converted into the pressure distribution reading by a number of calculation. The pressure reading require information about the working of the fluid in AIRFOIL The far field properties were measured directly while the air flow properties inside the wind tunnel were found by measurement taken with a pitot tube upstream of the AIRFOIL

- Modify the AIRFOIL surface to be analyse the flow separation over an AIRFOIL and to be measured the laminar or turbulent or transition flow of the AIRFOIL
- To be cut the small portion of the AIRFOIL to be hopefully to be analyse and the lift coefficient and drag coefficient , drag force , lift force can be measured the various angle of attack (1 , 5 , 10 ,15)

REFERENCE;

1 Mahamoudmani ,Behnazboroumoundbehastii**"Experimental and Numerical Study of unsteady wake of supercritical airfoil"**(2018)

2 T. Lee **"Numerical Investigation flow NREL phase iv AIRFOIL "**(2016)

3 B. RaghavaRao ,Ranginenisahitya**"Numerical and Experimental investigation the flow field around NACA 0021 AIRFOIL"**(2015)

4 M .Sri Ramamurthy , A.SV.S.S.K.S Gupta **"Experimental investigation study the flow characteristics over a NACA AIRFOIL and automobile dome"**(2013)

5 Dikshasingh ,radheshyam h , gajghar , mrinalkandimanik**"Experimental investigation examine the effect of shape and size of dimple at suction surface of AIRFOIL"**(2019)

6 M.M. Zhang , G.F Wang **"experimental study of flow separation control a low –Re AIRFOIL using leading edge protuberance method"**(2007)

7 Fred L Haan ,zifeng yang "**An experimental investigation on the flow separation on a low Renold's number AIRFOIL"**(2018)

8 Jianhuichen ,Gongnanxie , Di zhang , Mohammad Moshfeg**hi "Numerical and experimental investigation control of S809 AIRFOIL with slot"**(2013)

9 Nandhini KS , Subhashini KN , Somasekar "**Experimental investigation of aerodynamic performance of S9023AIRFOIL "**(2018)

10 Yang zhang ,zhouzhou **" Aerodynamic characteristic of different**

Airfoils under varied turbulence intensities at lowReynold's number"

(2019)