

AN EXPERIMENTAL APPROACH OF AN AIRFOIL AND ITS PERFORMANCE THROUGH SIMULATION

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Abstract:

Airfoil plays an important role in any aircraft because it has to generate adequate lift to hold the aircraft in the air with less drag. The design of an airfoil with desired aerodynamic characteristics is not so easy till date. In early days the design was random and it was tested in a flow section, then Wright Brothers come with cambered section. NACA has given a proper definition for airfoil which help us to create airfoil using formulas and not randomly. In this work a detailed study of NACA 2312 airfoil, at various angle of attack and different free stream velocity in the wind tunnel. This work is divided into two phase one is numerical analysis and another one is experimental verification by fabricating the airfoil and testing in wind tunnel. The aerodynamic characteristics are plotted against AOA and the comparison between the numerical and experimental is also performed.

Keywords: Airfoil, Ansys, Computational fluid dynamics, Wind Tunnel.

1.0 Introduction:

In the past days, when human being was yet residing in the part of creation, the main method for velocity was his legs. Subsequently, we have established faster and more plentiful methods for voyaging, most recent comprising the air conveyance. Since, its innovation planes have been adopting more fame as it is the quickest method of conveyance accessible. It has additionally picked up fame as a war machine since World War II. This prominence of air transport has prompted numerous innovations and exploration to grow quicker and more conservative planes. This work is an attempt to adjudicate how we can deduce most extreme execution from an aerofoil segment.

An aerofoil is a cross section of wing of the aircraft. Its fundamental occupation is to give lift to a plane amid departure keeping in mind of trajectory. Yet, it has a component

of resultant force called pressure –form drag which restricts the movement of the plane. The measure of coefficient of lift and its force required by an aircraft relies on upon configuration and assembly of various parts to the concerned aircraft. Heavier one accommodate more lift while lighter oblige less compared to heavier ones. Accordingly, contingent on the utilization of plane, aerofoil area is resolved. Lift however exert additional prediction to the uplift raising speed of the aircraft, which in turns depends on upon the plane with respect to flat speed. Hence, the coefficient of lift and coefficient of pressure is the deciding factor to ascertain how the lift responds as per the velocity and various parameters.

Aircraft wings which are horizontal and vertical stabilizers, helicopter rotor blades, propellers, fans, compressors turbines all have aerofoil designs. Even sails, swimming and flying creatures employ aerofoils. An airfoil-shaped ribs is sufficient to get down the force on an automotive parts or other motor conveying device so to improve the adhesive friction that is traction.

A wing following the laminar flow has a greatest affinity of thickness in the centre part of camber line. It demonstrates a negative weight inclination along the flow has the same impact as decreasing the rate when we dissect the Navier–Stokes mathematical statements in the straight administration. So on the off chance that we keep up greatest camber in the centre, a laminar flow over a bigger rate of the wing at a higher velocity can be attained to. Nonetheless, with particles on the wing, this does not work. Since such a wing slows down more effectively than others.

Types of flow on Airfoils

Laminar stream is portrayed by layers, or laminas, of air moving at the same rate and in the same course. No fluid is traded between the laminas and the stream require not be in a straight line. The closer the laminas are to the airfoil surface the slower they move. For a perfect liquid the stream takes after the bended surface easily, in laminas. In turbulent stream, the streamlines or stream examples are muddled and there is a exchange of liquid between these ranges. Momentum is likewise traded such that slow moving liquid particles accelerate and quick moving particles surrender their energy to the slower moving particles and ease off themselves. All or about all liquid stream shows some level of turbulence.

OBJECTIVE AND SCOPE OF PRESENT WORK

The objective of this project is to understand the phenomena of the uniqueness of aerofoil shape. Aerofoil shapes are employed in aircraft sectors as well as in automobile and production sectors e.g. wind turbines, wing of an automobile etc. It can generate lift as well as downforce when used in a specific manner. So it is quite important to decode the phenomena behind its shape and the process by which it produces necessary lift and downforce

2.0 Literature review

This section explains some previous literature on aerofoil sections and their analysis procedure.

Rana et al. [1] studied the flutter characteristics of an airfoil in a 2-D subsonic flow by using RANS based CFD solver with a structural code in time domain. strategy for fluxes makes conceivable the utilization of a cell-focused network in which speed and pressure questions have the same location, while going around the event of spurious pressure modes.

Gultop[2] contemplated the effect of viewpoint degree on Airfoil execution. The explanation behind this study was to center the swell conditions not to be kept up all through wind passage tests.

Goel[3] formulated a technique for advancement of Turbine Airfoil utilizing Quansi – 3D examination codes. He understood the intricacy of 3D demonstrating by displaying numerous 2D air foil segments and joining their figure in spiral bearing utilizing second and first order polynomials that prompts no harshness in the radial direction.

Arvind [4] looked into on NACA 4412 aerofoil and investigated its profile for thought of a plane wing. The NACA 4412 aerofoil was made utilizing CATIA V5 And examination was completed utilizing business code ANSYS 13.0 FLUENT at a rate of 340.29 m/sec for angle of attacks of 0°, 6, 12 and 16°. k-ε turbulence model was accepted for Airflow. Changes of static weight and element weight are plotted in type of filled shape.

Fazil and Jayakumar [5] presumed that in spite of the way that it is less requesting to model and make an aerofoil profile in CAD environment using camber billow of concentrates, after the making of vane profile it is extraordinarily troublesome to change the condition of profile for dismemberment or change reason by using surge of core inter.

Kevadiya [6] concentrated on the NACA 4412 aerofoil profile and remembered its significance for examination of wind turbine edge. Geometry of the aerofoil is made using GAMBIT 2.4.6. Additionally CFD examination is done using FLUENT 6.3.26 at distinctive methodologies from 0° to 12°.

Guilmineau et al. [7] talked about the processing of the time-mean, turbulent, two-dimensional incompressible thick stream past an airfoil at settled rate. Another physically reliable technique is exhibited for the reproduction of speed fluxes which emerge from discrete mathematical statements for the mass and energy equalization. This conclusion

Kunz and Kroo [8] advanced aerofoils at ultra-low Reynolds numbers. These examinations are done to comprehend the aerodynamic issues identified with the low speed and miniaturized scale air vehicle

outline and execution. The enhancement strategy utilized is in view of concurrent pseudo-time venturing in which stationary states are acquired by fathoming the preconditioned pseudo-stationary arrangement of comparisons.

N. Ahmed et al. [9] contemplated the numerical reproduction of stream past aerofoils is vital in the flight optimized outline of air ship wings and turbo-hardware parts. These lifting gadgets regularly achieve ideal execution at the state of onset of partition. Hence, division phenomena must be incorporated if the examination is gone for pragmatic applications. Thus, in the present study, numerical recreation of relentless stream in a straight course of NACA 0012 aerofoils is expert with control volume approach.

Mittal et al. [10] performed the computational examination for two-dimensional stream past stationary NACA 0012 aerofoil is completed with dynamically expanding and diminishing approaches. The incompressible, Reynolds averaged Navier–Stokes mathematical statements in conjunction with the Baldwin–Lomax model, for turbulence conclusion, are explained utilizing settled limited element formulations.

3.0 METHODOLOGY:

The process of the numerical simulation of fluid flow using the above equation generally involves four different steps and the details are given below.

(a) Problem identification

1. Setting the modelling ends
2. Placing the model to domain.

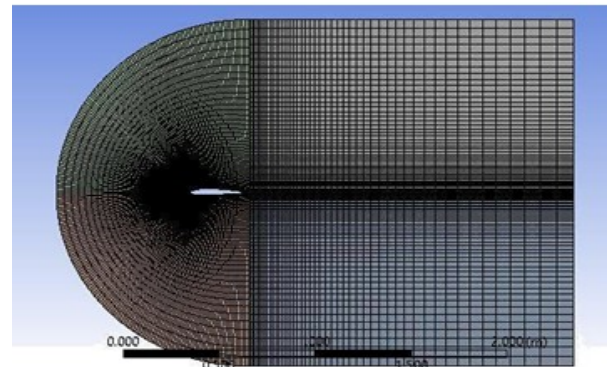
(b) Pre-working

1. Creating an airfoil model to represent the C-domain
2. Meshing configuration

PREPARING THE GEOMETRY MODEL



Model of the airfoil



Meshing model of the airfoil

Solver settings

The numerical strategy that CFD codes acquire is the finite volume method. The differential transport equations are then followed by integration throughout each of the computational cell, and subsequently Gauss and Leibnitz theorems are employed in this method. This comprises of several models used for flow analysis, the starting and boundary situations, the number of Eulerian levels, the holdings and properties of the materials, the physical and chemically development implication. Ultimately, the corresponding algebraic equations is figured out by iteration process and the corresponding centred values of the flow variables are calculated Experimentation

4.0 RESULTS

Experimental information useful for solving aerodynamics problems may be obtained in a number of ways: from flight test, water tables, flying scale models, subsonic transonic, supersonic and hypersonic wind tunnel. Each device has its own sphere of superiority. The nations of the world support research, of which wind tunnel testing is a major item, according to their desired and abilities. For the past some decades now, wind tunnels have been a pivot component in

scientific research area followed by hierarchical fields. Experimenting with the prototype of Mercedes Benz, Bugatti Veyron, various superfast cars followed by experimentation of air wings, complete aircraft, various weather patterns that is research on rain droplet, icing have been caused much ease because of its evolution. The structure of birds plays a vital role in aerodynamics to proposed a research on various wings that should be light weighted to identify the difference between nature and artificial. In the field of race the selective information accumulated from this research testing can mean the conclusion between winning and losing a race.



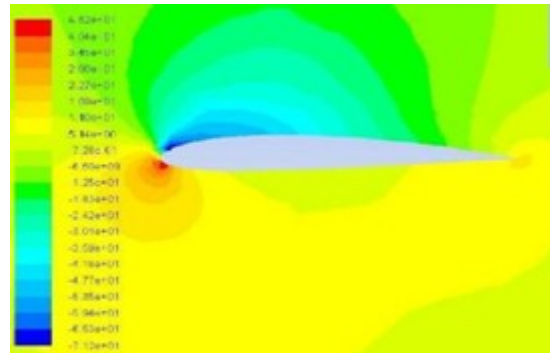
EXPERIMENTAL SETUP



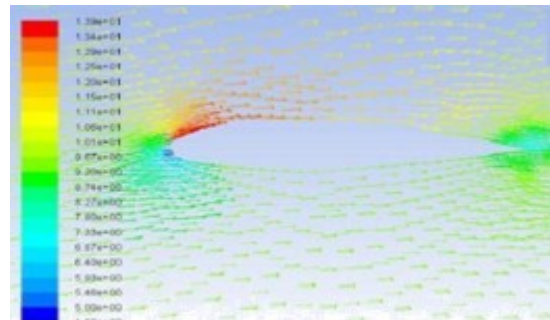
Wind tunnel



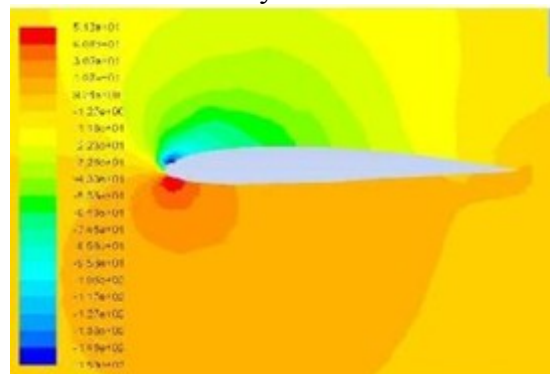
Multi tube manometer



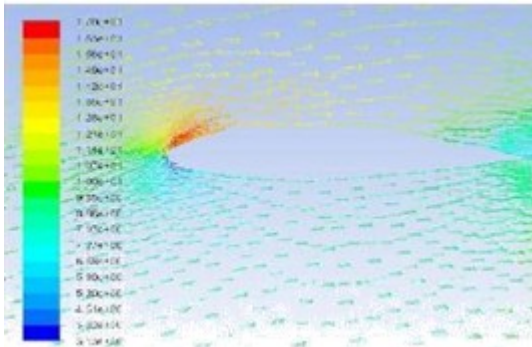
Pressure distribution



Velocity distribution



Static pressure counter flow



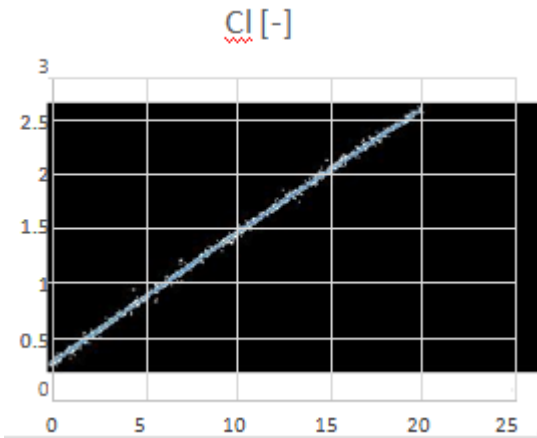
Static velocity counter flow

14.5 M/S AND VARIOUS ANGLES OF ATTACK

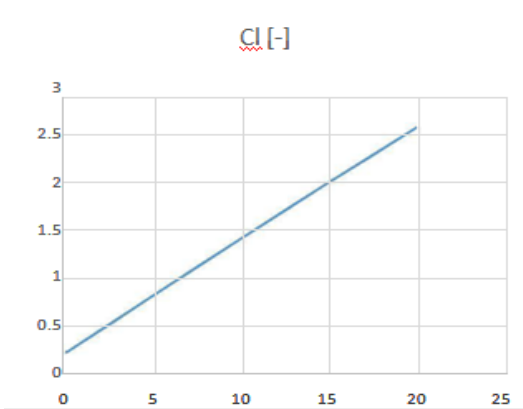
EXPERIMENT RESULTS:

Readings of an airfoil model tested in wind tunnel

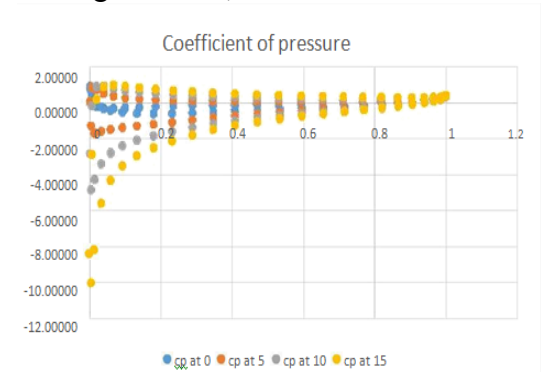
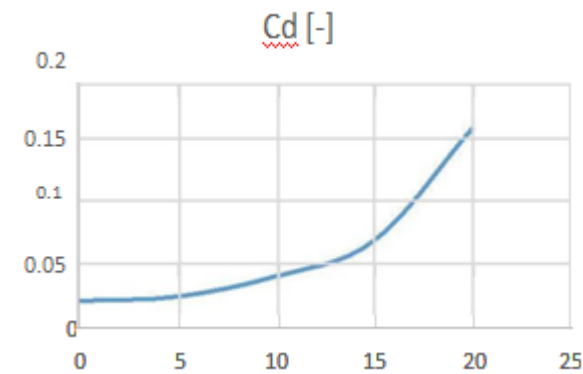
The readings have been proposed over an NACA 2312 airfoil model inside the test section of a wind tunnel at different air velocity 12m/s,13m/s,14.5m/s. Manometer reading at 12m/s,13m/s and 14.5 m/s



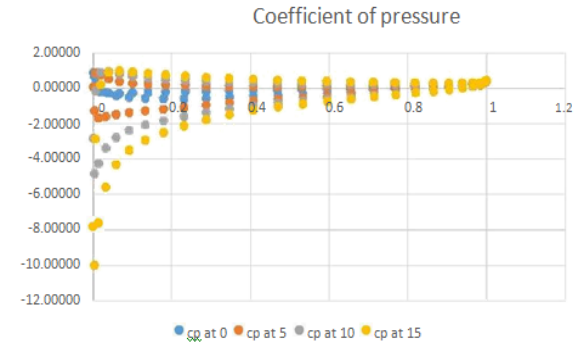
12 M/S AT DIFFERENT ANGLE OF ATTACK



13 M/S AND AT DIFFERENT ANGLE OF ATTACK

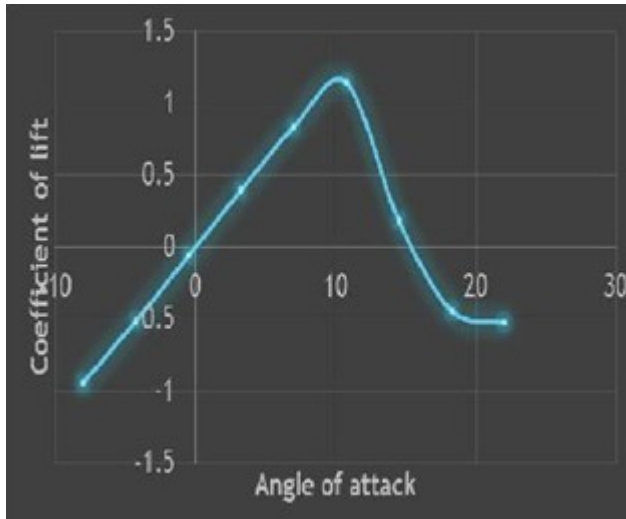


Coefficient of pressure against angle of attack

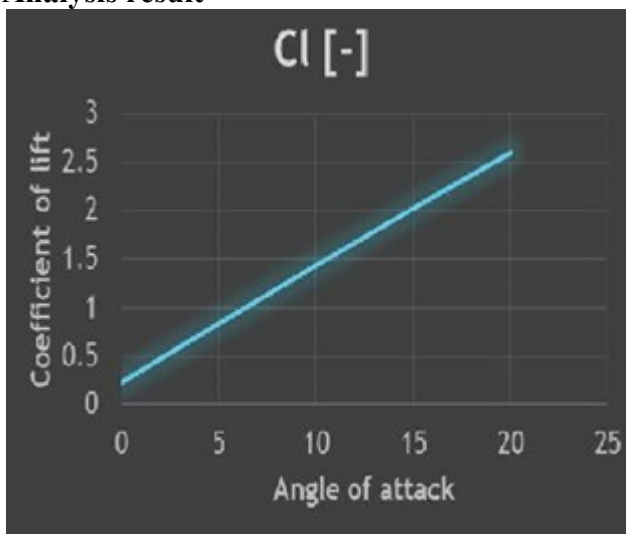


Coefficient of pressure against angle of attack for 13m/s

COMPARISON OF FLUENT DATA WITH EXPERIMENTATION:



Analysis result



Experimentation result

5.0 CONCLUSION:

- Coefficient of lift will be higher at an angle of 15 degree.
- As the angle of attack increase the amount of lift created by the airfoil also increases
- A lowering of pressure on the upper surface results in developing pressure gradient.
- Coefficient of pressure show better results at 14.5 m/s
- After comparing from the experimental data conclusion arise that stalling effect will occur after 20 degree angle of attack.

Future scope:

- Improve the modern airplane
- New configuration
- New rules and requirement

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