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Modeling and CFD Analysis of RC Aircraft Wing

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Abstract

In this paper, Computational fluid dynamics (CFD) analysis of an aircraft plays a vital role in providing an ideal design of the aircraft. The qualitative and quantitative characterization of the wing provides useful information to verify the wing selection and design prior to the time-consuming fabrication of aircraft. CFD analysis was carried out at various velocities for each wing separately. The lift, drag, pressure and velocity of each wing were determined and the comparative study of these showed how minute changes to the wing improve its overall flow characteristics. Furthermore, the material aluminum alloy replaced with the aid of composite substances E Glass and carbon fiber. Static analysis is to be determine the stress and deformation with different materials.

1. INTRODUCTION

An air ship is a machine that can fly by picking up help from the air. It counters the power of gravity by utilizing either lifter by utilizing the dynamic lift of an airfoil, or in a couple of cases the descending push from fly motors. Basic instances of air ship incorporate planes, helicopters, aircrafts, lightweight planes, parameters, and tourist balloons. The human action that encompasses air ship is called avionics. The study of avionics, including structuring and assembling air ship, is called air transportation. Run flying machine are flown by a locally available pilot, however unmanned flying vehicles might be remotely controlled or self-constrained by installed PCs. Flying machine might be arranged by various criteria, for example, lift type, flying machine drive, utilization and others.

The airframe of a fixed-wing airplane comprises of the accompanying five noteworthy units:

1. Fuselage
2. Wings
3. Stabilizers
4. Flight controls surfaces
5. Landing gear

Aircraft wing

The wing might be considered as the most significant part of a flying machine, since a fixed wing flying machine can't fly without it. Since the wing geometry and its highlights are affecting all other air ship parts, we start the detail configuration process by wing structure. The essential capacity of the wing is to produce adequate lift power or just lift (L). Be that as it may, the wing has two different preparations, specifically drag power or drag (D) and nosedown pitching minute (M). While a wing architect is hoping to amplify the lift, the other two (drag and pitching minute) must be limited. Actually, wing is expected promotion a lifting surface that lift is created because of the weight distinction among lower and upper surfaces. Streamlined features course readings might be concentrated to revive your memory about numerical systems to figure the weight conveyance over the wing and how to decide the stream factors.

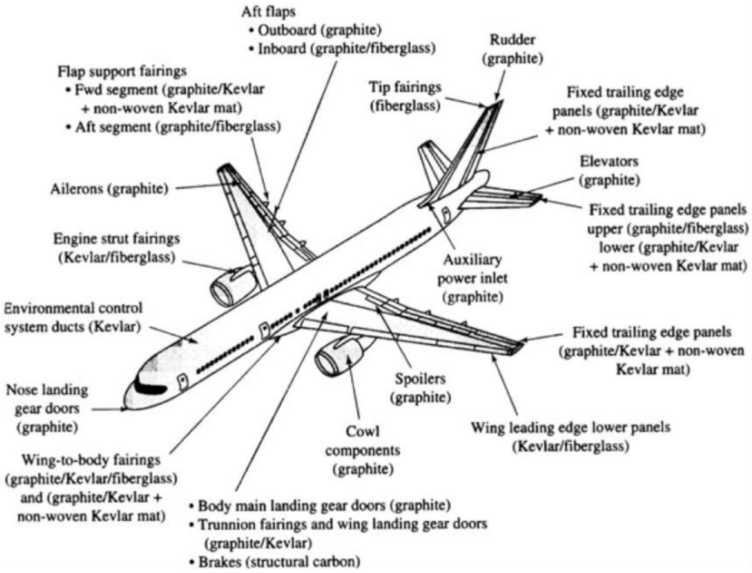

Fig. 1: aircraft.

2. LITERATURE REVIEW

Design and performance analysis of spiroid winglet with normal wing: this is focused on the modeling and analysis of winglet of aircraft. In aerodynamic engineering, drag reduction is a big challenge. To reduce drag a device called winglet which is placed vertically at set of angles on the end of aircraft wing. Winglet design will reduce the fuel consuming by reducing the aircraft drag and makes the aircraft more stable during flight, also it will give the aircraft engine longer life by reducing the load on the engine thrust. The aim is to design and simulate a model of winglet used to construct the winglet models and ANSYS is used to test and simulate the winglet model. With wing angles, results are compared and aircraft because it lowers the amount of drag and increases the fuel efficiency by using less energy by reducing wing improving the aircraft performance.

Design and analysis of spiroid winglet: wingtip vortices are strongly associated with induced drag for a three-dimensional wing. So, it is important to neglect the wingtip vortices in order to reduce the induced drag. The drag breakdown of a typical transport aircraft shows that the lift-induced drag can amount to as much as 40% of the total drag at cruise conditions and 80–90% of the total drag in take-off configuration. One way of reducing lift-induced drag is by using wingtip devices. By applying biomimetic abstraction of the principle behind a bird’s wingtip feathers, we study spiroid wingtips, which look like an extended blended wingtip that bends upward by 360 degrees to form a large rigid ribbon. In this paper a configuration of different winglets are studied. A model composed of wing of boeing-737 is designed using CATIA and also the spiroid winglet are designed and attached with a Boeing 737 wing using

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CATIA. Then the modelled wing is meshed using ICEM-CFD. The meshed model will be analyzed using ANSYS FLUENT. Finally, the percentage decrement of wingtip vortices is calculated using the analysis results.

Design of winglet device for aircraft: aircraft winglet is a device placed at set of angles on the end of aircraft wing. This device plays a very important role in improving aircraft performance. The economic raise of the aircraft flight make the aircraft designer and the airline management to find a new technology to reduce the cost. After many searches and study in this field the winglet design will be the best way to reduce cost. Winglet design will reduce the fuel consuming by reducing the aircraft drag and make the aircraft more stable during flight, also it will give the aircraft engine longer life by reducing the load on the engine thrust. The aim of this paper is to design and simulate a model of winglet for aircraft. Study about winglet contribution on aircraft performance in term of less fuel consumption and the stability of aircraft flying in continuation cruise flight or during take-off and landing. First author visited to Airbus Manufacturing Company to know the process and to understand how winglet devices are designed and how they contribute on aircraft drag reduction were discussed with the aircraft designing engineer. Study how winglet can reduce aircraft induced drag. Analyses about winglet effect on reducing wingtip vortex. This paper is also aimed to design a model of winglet device by using software such as CATIA -V5 and ANSYS. This software plays important role in time in use to make the designing, simulation and testing the designed model.

3. MODELING AND ANALYSIS

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation, or EDA. In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

CATIA is an acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products. CATIA provides the capability to visualize designs in 3D. When it was introduced, this concept was innovative. Since Dassault Systems did not have an expertise in marketing, they had revenue sharing tie-up with IBM which proved extremely fruitful to both the companies to market CATIA. In the early stages, CATIA was extensively used in the design of the Mirage aircrafts; however the potential of the software soon made it a popular choice in the automotive sector as well. As CATIA was accepted by more and more manufacturing companies, Dassault changed the product classification from CAD / CAM software to Project Lifecycle Management. The company also expanded the scope of the software.

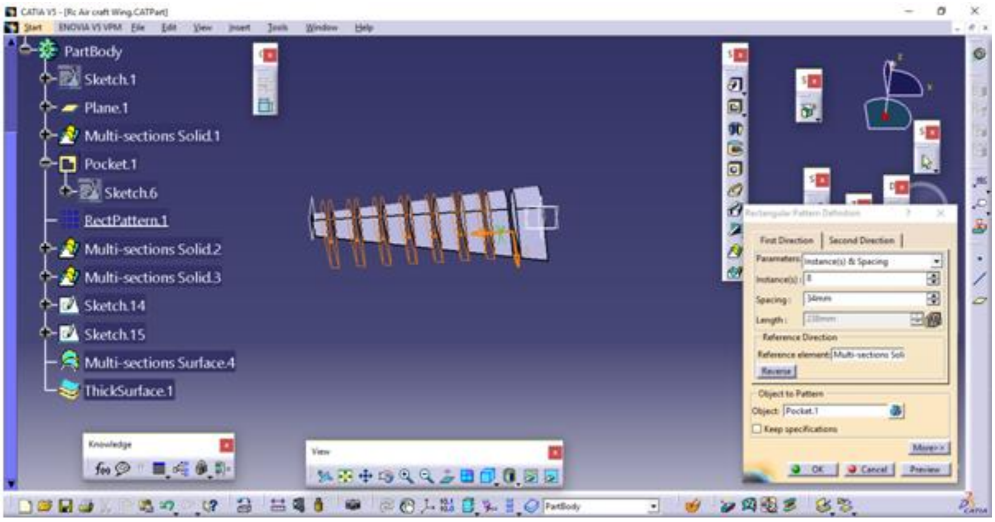

Fig. 2: 3D Model of ribs and spars

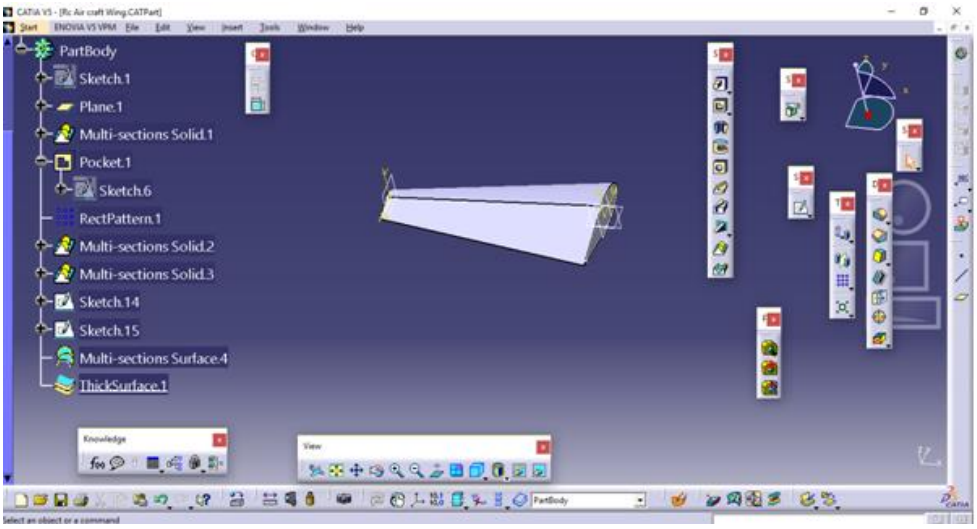

Fig. 3: Assembly model

Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in. Vibrational analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may act on the natural vibrational frequency of the material which, in turn, may cause resonance and subsequent failure. Fatigue analysis helps designers to predict the life of a material or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely to occur. Failure due to fatigue may also show the damage tolerance of the material.

CFD

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed

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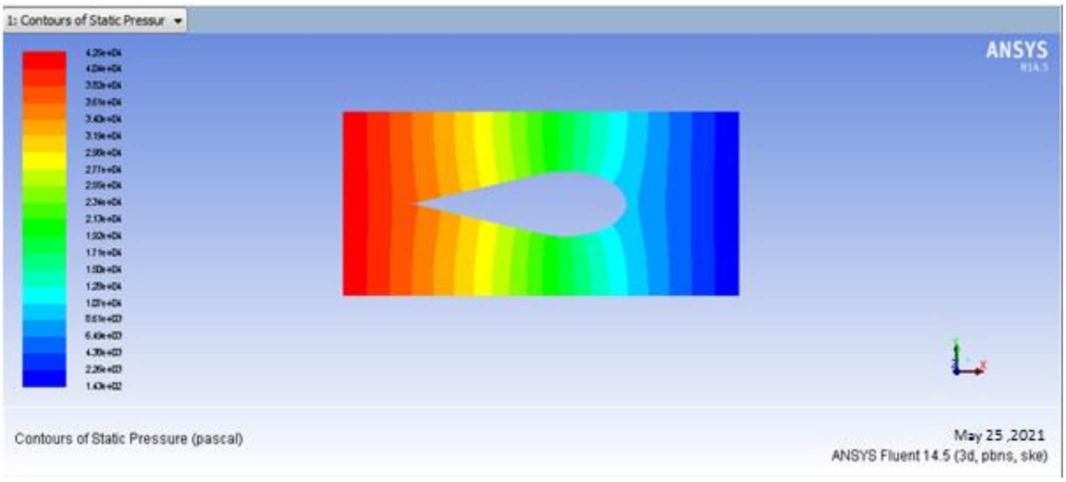
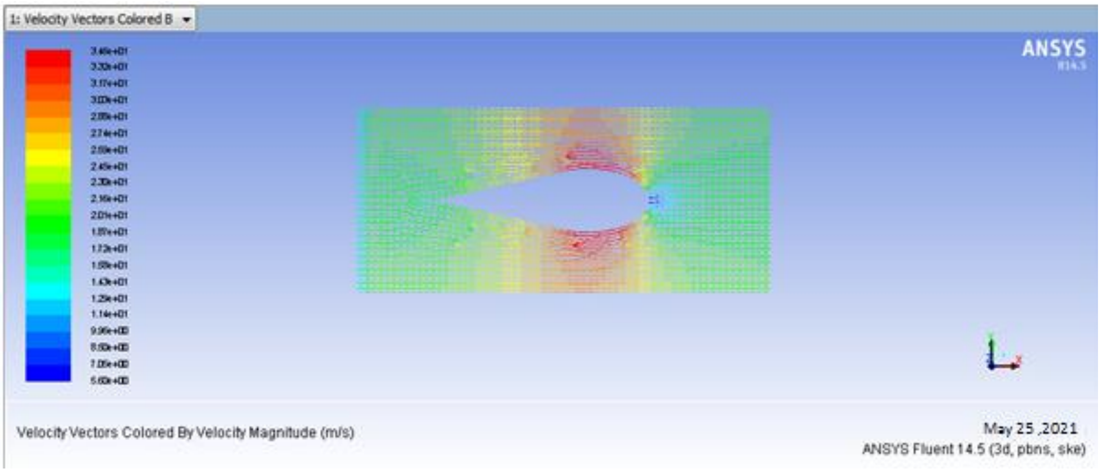
supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Initial experimental validation of such software is performed using a wind tunnel with the final validation coming in full-scale testing, e.g., flight tests.

CFD ANALYSIS OF RC AIRCRAFT WING

PRESSURE



VELOCITY



Drag Force

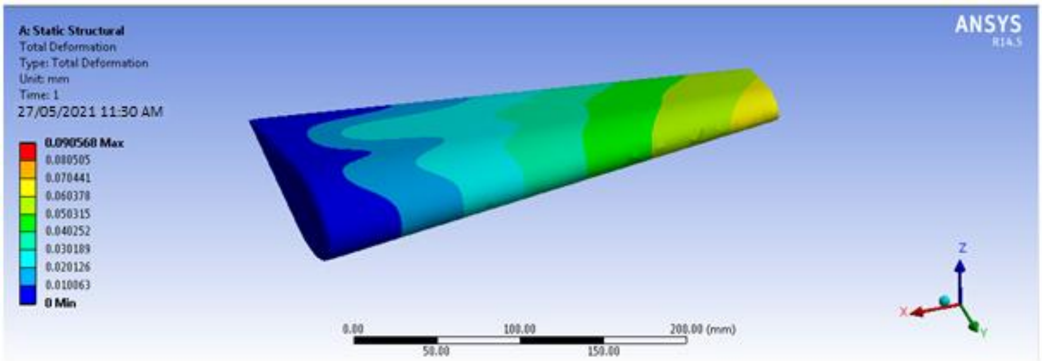
```
Forces - Direction Vector (1 0 0)
                                Forces (n)
Coefficients
Zone                            Pressure          Viscous           Total
Pressure          Viscous              Total
wall-partbody                   0.072853141       0.40213513        0.47498827
0.1189439         0.65654716           0.77549106
------------------------------  ----------------  ----------------  ----------------
----------------  ----------------   ----------------
Net                             0.072853141       0.40213513        0.47498827
0.1189439         0.65654716           0.77549106
```

Lift Force

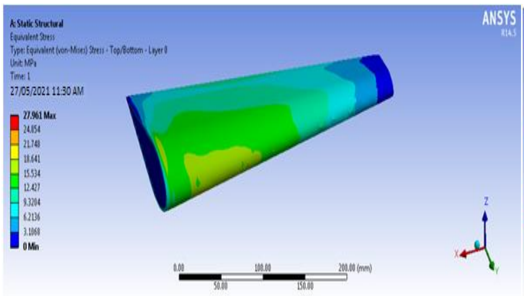
```
Forces - Direction Vector (0 1 0)
                          Forces (n)
Coefficients
Zone                      Pressure         Viscous          Total
Pressure        Viscous         Total
wall-partbody             2.870211e-05     -2.8620612e-05   8.1498001e-08
4.6860588e-05   -4.672753e-05   1.3305796e-07
-------------------------  ---------------  ---------------  ---------------
---------------  ---------------  ---------------
Net                       2.870211e-05     -2.8620612e-05   8.1498001e-08
4.6860588e-05   -4.672753e-05   1.3305796e-07
```

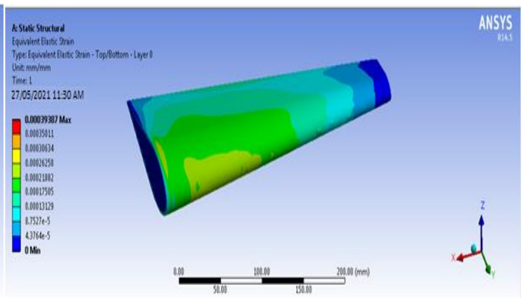
STATIC ANALYSIS OF COOLING TOWER

Deformation



Stress **strain**





4. RESULTS

CFD analysis

Inlet velocity (m/s)	Pressure (Pa)	Velocity (m/s)	Drag force (N)	Lift force (N)
20	4.25e+04	34.6	0.77	1.35e-07
30	6.78e+04	51.5	1.64	3.56e-06
40	8.66e+04	72.5	1.58	1.79e-05

Static analysis

Materials	Deformation (mm)	Stress (N/mm^2)	Strain
Aluminum alloy	0.14151	43.689	0.00061542
E-glass fiber	0.11462	35.388	0.00049849
Carbon fiber	0.09056	27.961	0.00039387

5. CONCLUSION

Computational fluid dynamics (CFD) analysis of an aircraft plays a vital role in providing an ideal design of the aircraft. The qualitative and quantitative characterization of the wing provides useful information to verify the wing selection and design prior to the time-consuming fabrication of aircraft. CFD analysis was carried out at various velocities for each wing separately. The lift, drag, pressure and velocity of each wing were determined and the comparative study of these showed how minute changes to the wing improve its overall flow characteristics. Furthermore, the material aluminum alloy replaced with the aid of composite substances E Glass and carbon fiber. Static analysis is to be determine the stress and deformation with different materials. By observing the CFD analysis results, increasing the inlet velocities increases pressure, velocity and lift force. By observing the static analysis results, the stress values less at carbon fiber material when we compared to other materials. So we can conclude the carbon fiber material is suitable for air craft wing model.

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