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MODELLING, ANALYSIS AND FABRICATION OF PARACHUTE AERIAL VEHICLE

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ABSTRACT

Parachute aerial Vehicle is a Para vehicle from which the human has been removed and is being controlled remotely from ground. For designing a PAV firstly, the size and dimensions are calculated according to the payload. Using CATIA software, a 3D model is constructed with calculated dimensions. This 3D model is then imported to ANSYS FLUENT in order to find out aerodynamic parameters i.e., lift and drag coefficients and other flow properties. Once the simulation part is over the physical model is constructed using aluminum extrusions and sheets which are then fitted together using screws and bolts. The avionics required for a PAV includes a motor with enough thrust generation to propel the PAV forward, and electronic speed controller to control the speed of motor according to the transmitter input, a receiver receives the signals from transmitter on ground and a battery to power up all the electronics. All the electronics are calibrated to work in sync with each other. Lastly, the parachute is connected via servo which helps in the directional control of the PAV.

Keywords: Aerial vehicle, Catia, ansys, Turbulence kinetic energy, pressure, velocity

I. INTRODUCTION

An **unmanned aerial vehicle (UAV)**, commonly known as a **drone** is an aircraft without a human pilot aboard. UAVs are a component of an unmanned aircraft system (UAS) which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy either under remote control by a human operator or autonomously by onboard computers. Compared to manned aircraft, UAVs were originally used for missions too "dull, dirty or dangerous" for humans. While they originated mostly in military applications, their use is rapidly expanding to commercial, scientific, recreational, agricultural, and other applications, policing, peacekeeping, and surveillance, aerial photography, agriculture, smuggling, and drone racing. Commercial application of autonomous things, to be followed by the autonomous car and home robots.

II. METHOD & MATERIAL

UAV Components Body:

The primary difference for planes is the absence of the cockpit area and its windows. Tailless quad copters are a common form factor for rotary wing UAVs while tailed mono- and bi-copters are common for manned platforms.



Fig.1.1. Frame of a PAV

Power supply and platform:

Small UAVs mostly use lithium-polymer batteries(Li-Po), while larger vehicles rely on conventional airplane engines. Battery elimination circuitry(BEC) is used to centralize power distribution and often harbors a microcontroller unit (MCU). Costlier switching BECs diminish heating on the platform.

*Fig.1.2. Li-Po Battery***Propeller:**

A **propeller** is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade.

*Fig.1.3. Propellers***Motor:**

The motors chosen will have a huge impact on the flight time and how heavy of a load the UAV can carry.

*Fig.1.4. Motor***Sensors:**

Position and movement sensors give information about the aircraft state

Parachute aerial vehicle

A powered vehicle that does not carry a human operator, can be operated remotely, autonomously, can be expendable or recoverable and can carry a lethal or non-lethal payload. Ballistic or semi ballistic vehicle, cruise missiles, artillery projectiles, torpedoes, mines, satellites and unattended sensors are not considered unmanned vehicles. Unmanned vehicles are the primary component of an unmanned system.

- remotely piloted aircraft
- remotely piloted helicopter aerial robotics

Different types of unmanned aerial vehicles (UAVs) have become available in recent years, namely, multi copters, gliders, and powered parachutes.



Fig.2.1 Parachute UAV type

Working of parachute aerial vehicle:

The powered parachute is an aircraft which derives lift from a ram-air inflated canopy, under which the fuselage is suspended. The parachute is inflated by the dynamic pressure of the air flowing into the canopy, which has a cross section in the shape of an airfoil. This process helps the vehicle to create lift.

The direction of a powered parachute is controlled by the pilot pushing on either a left or right steering bar that pulls down on a line attached to the trailing edge of the canopy. The increased drag causes the aircraft to turn. If the control lines connected to the canopy are pulled down together, both trailing ends of the canopy will drop at a time, causing a sudden increase in lift. This maneuver is similar to flaring, which is generally done during landing, when the pilot wants a smooth touchdown.

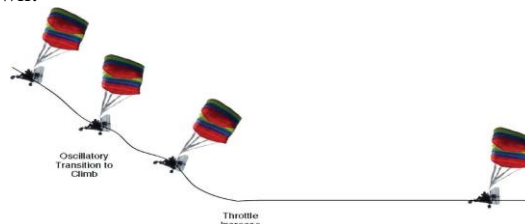


Fig.2.2 Oscillations in powered parachute during takeoff

III. AERODYNAMICS TERMS USED IN POWERED PARACHUTE AERIAL VEHICLE

The cross section of the parachute, which is used to produce lift, typically the canopy itself, is called an airfoil. The mean curvature of the wing is called camber. A parafoil has two chambers, namely, upper chamber and lower chamber. Leading edge refers to the forward edge of the parafoil. Trailing edge refers to the rear edge of the parafoil. Chord line is the imaginary line joining the trailing edge and the leading edge. Relative wind is the direction of airflow with respect to the wing, which is generally opposite and parallel to the flight path of the parachute. The angle between the relative wind and the chord line is known as angle of attack. Longitudinal axis is the axis passing through the nose of a powered parachute aerial vehicle it is also called roll axis. The angle between the chord line and the longitudinal axes is known as angle of incidence. Trim angle is the angle between the chord line and the horizontal plane of the powered parachute when the vehicle is in unpowered condition. Pitch angle is the angle between wing chord to the horizontal plane. The ratio of wing span by average chord line gives the aspect ratio. The more the aspect ratio the more the lift with less induced drag.

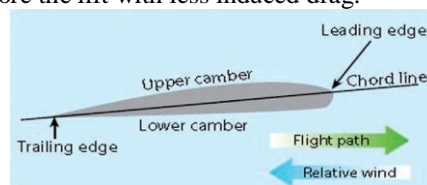


Fig.3.1 Terminology of Airfoil

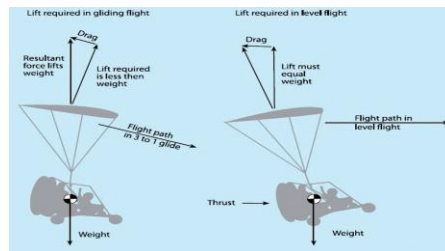


Fig.3.2 Different forces between gliding and level flight

This is the final CAD model after all the operations.

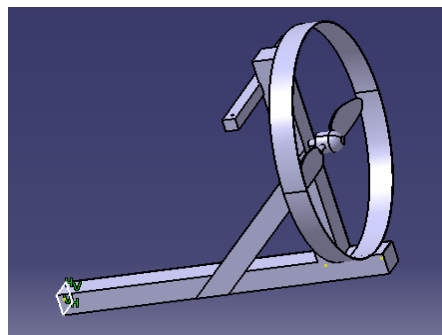


Fig.3.3. Final model of a PAV

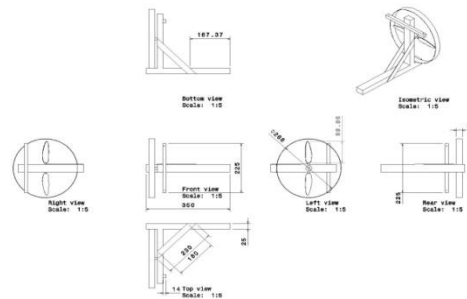


Fig .3.4: Drafting of PAV

IV. SIMULATION OF A PARACHUTE AERIAL VEHICLE

Three dimensional: The basic 3-dimensional elements are the tetrahedron, quadrilateral pyramid, triangular prism, and hexahedron. They all have triangular and quadrilateral faces. Extruded 2-dimensional models may be represented entirely by prisms and hexahedra as extruded triangles and quadrilaterals.

Static analysis

We perform static structural analysis to find out the stresses and total deformation of the parachute aerial vehicle.

- Go to start & select workbench.
- Double click on the static structural

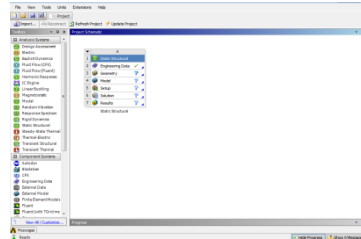


Fig.4.1.ANSYS Work Bench

- Select geometry, RMB geometry & choose import geometry Browse option

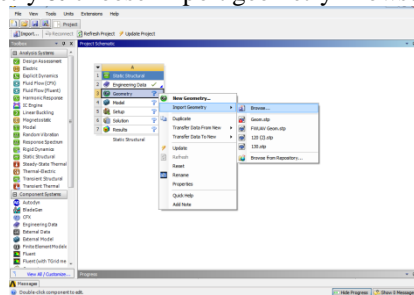


Fig.4.2.Importing the geometry

- PAV Geometry can be viewed in Design Modeler.
- Double click on Model option, Mechanical Modeler is opened.
- Generate default mesh.
-

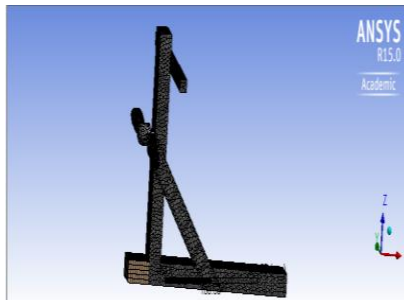


Fig.4.3.Meshing quality

- Following are the statistics after generating the mesh.

Mesh statistics	
NODES	101103
ELEMENTS	52556

Go to Static Structural, RMB & insert fixed support

- Under details view mention the face to which fixed support should be given.

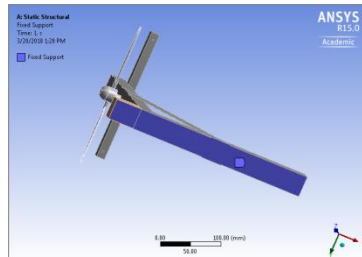


Fig.4.4. Inserting fixed support to PAV

- Again right click on SS & insert Moment
- Mention the face to which moment should be applied
- Give the specified direction in which the component should be rotated & 1000 N-m load is applied

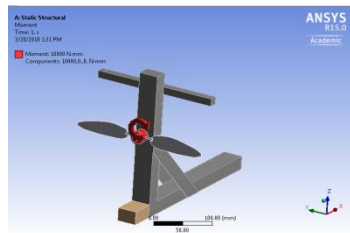


Fig.4.5 Inserting moment to PAV

- Go to Results, RMB & insert total deformation & Equivalent stress (von-mises)
- RMB & solve.
- Following Deformation & Stress contours are shown.

Aerodynamic Analysis:

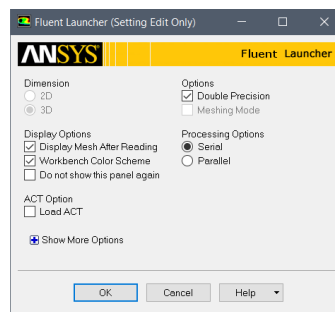
STEP 1:

Open the fluent software. Before dealing with any problem makes sure that problem is three dimensional or two dimensional and geometry is created axis symmetry or full geometry

Importing mesh file:

Go to file in menu bar → Read → Mesh

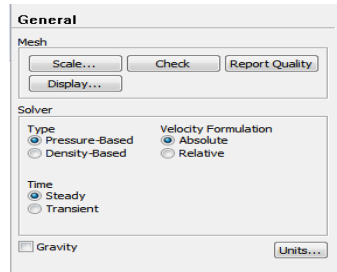
Click on mesh and import “subsonic.msh” file from the directory.



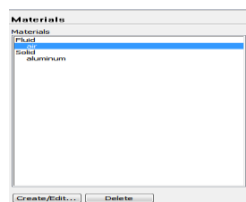
STEP 2:

Solver settings

Setup → general → Pressure based solver
Velocity formulation → absolute
Time → Steady

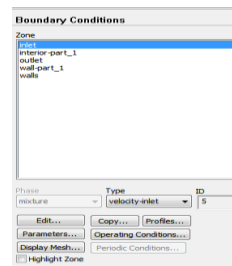


**STEP 3:
Selection of Materials:**

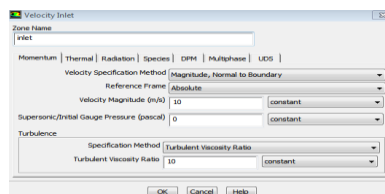


**STEP 4:
Boundary conditions:**

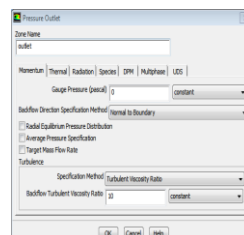
Boundary conditions play key roles in CFD simulations. It is the state of fluid at which fluid enters the computational domain. Appropriate



Mention Velocity magnitude as 10 m/s under Momentum.

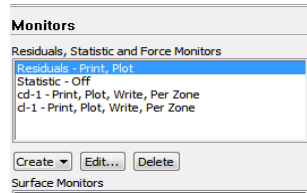


- Double click on outlet



Solution methods

For finding the lift and drag coefficients we have to give the angle of attack .



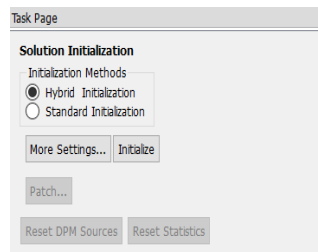
Double click on Initialization & select Hybrid Initialization

Go to Run Calculation

Double click on it.

& Set number of iterations to 500.

Click Calculate



STEP 7:

Post processing:

The main difference from experimental results and computational results we can observe in post processing.

Results → graphics → contours → setup

Contours → filled/ unfilled → contours of pressure → static pressure → display

V. RESULTS & DISCUSSIONS

Total deformation

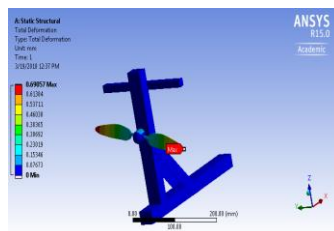


Fig.5.1.Total Deformation of PAV

- After fixing the base support with analysis workbench and after implementation of moment i.e. (1000 N-mm) at the motor as it will cause when motor will be in rotation, we are getting a deformation of 0.69057 mm.

Equivalent stress

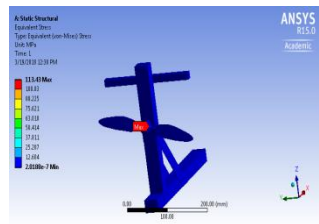


Fig.5.2.Equivalent stress of PAV

- Similarly, after giving the moment to the hub of the motor i.e.,1000 N-mm it will cause the stress which is equivalent to of 113.43 Mpa.

Pressure

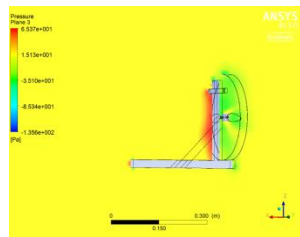


Fig.5.3.pressure of PAV

- The above contour is of pressure distribution in the plane view surrounding the PAV. The pressure variation can be seen which is varying from the maximum value of $6.53e^{+001}$ Pa to the minimum value of $-1.356e^{+002}$ Pa.

Turbulence kinetic energy

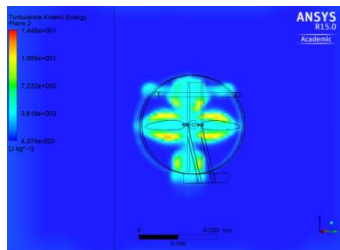


Fig.5.4.Turbulence kinetic energy of PAV

- The above contour is of turbulence kinetic energy in the plane view surroundings the PAV. The turbulence kinetic energy variation can be seen which is varying from the maximum value of $1.446e^{+001}$ j/kg to the minimum value of $4.374e^{-003}$ j/kg.

Velocity

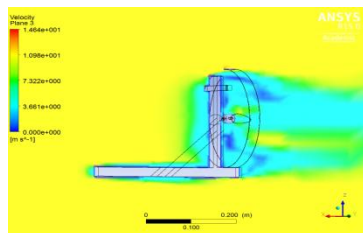


Fig.5.5.velocity of PAV

- The above contour is of velocity in the plane view surroundings the PAV. The velocity variation can be seen which is varying from the maximum value of $1.464e^{+001}$ m/s to minimum value of $0.000e^{+000}$ m/s.

C_D and C_L GRAPH

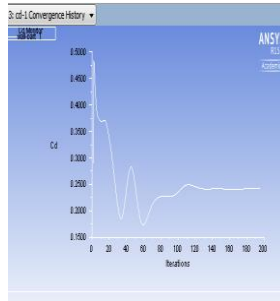


Fig.5.6.C_d and C_L for the angle of attack 6 degrees

- The C_D and C_L values calculated at each iteration and plotted against number of iterations.
- The C_D and C_L value for the AOA 6 degrees =2.2383 and 0.888.

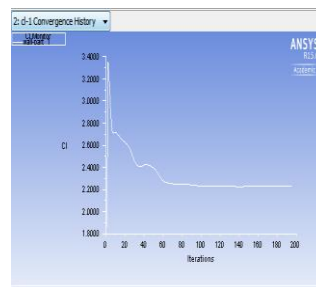
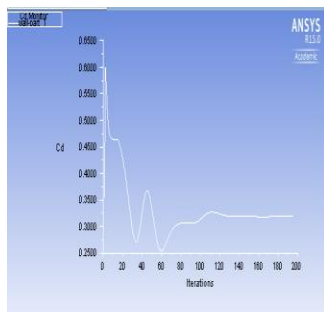


Fig.5.7.C_D and C_L graph for the angle of attack 8 degrees

- The C_D and C_L values calculated at each interval and plotted against number of iterations.
- The C_D and C_L values for the AOA 8 degrees =2.299 and 1.1755.
- From the angle of attack concept by increasing the angle of attack the coefficient of lift increases and coefficient of drag decreases. But at certain point the coefficient of lift decreases and coefficient of drag increases.

By comparing the two AOA, the 6 degrees AOA gives the better results when compared to the 8 degrees.

VI. FABRICATION PROCESS

Metal fabrication is the building of metal structures by cutting, bending, and assembling processes. It is a value added process that involves the creation of machines, parts, and structures from various raw materials. A fabrication shop will bid on a job, usually based on the engineering drawings, and if awarded the contract will build the product.. Metal fabrication jobs usually start with shop drawings including precise measurements, then move to the fabrication stage and finally to the installation of the final project.



Fig.6.1 Fabrication of PAV

VII. CONCLUSION

In this project, Modeling and analysis of a Parachute aerial vehicle is conducted using CATIA & ANSYS.

Performed both static and fluid flow analysis in order to find stress variations & fluid flow characteristics of a PAV. The aim of this work, is to find the aerodynamic coefficients i.e., Lift and drag coefficients by changing the angle of attack (6 and 8 degrees)

For 6 degree AOA, Lift coeff.=2.238, Drag coeff.=0.888, For 8 degree AOA, Lift coeff.=2.229, Drag coeff.= 1.175, Finally, the fabrication and testing of a PAV is done.

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2. *John R. Chambers(2007) - Longitudinal dynamic modeling and control of powered parachute aircraft, A Thesis Submitted in Partial Fulfillment of the Requirement for Master of Science in Mechanical Engineering, Rochester institute of technology, Rochester, Newyork.*