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Design and Analysis of Delta Wing Rotor Configuration

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Abstract: The Wing Rotor Configuration is a fine combination of innovation and creation of a new configuration which can perform the VTOL operation at a high speed. In this, the wing configuration gets merged with the rotor configuration at its respective location, which again defined by the aerodynamic basics. The design and analysis of delta wing rotor configuration is done by using Catia v5 and Ansys workbench. It is a complex structure with two degrees of freedom; which makes the configuration more challenging. The two degrees of freedom is given to the rotor configuration in order to perform the maneuverability of the vehicle, which means that the wing configuration, itself would not perform the maneuverability for the vehicle.

Index Terms: Angle of attack, Degress of freedom, Rotor, Wing, Configuration, VTOL.

1 Introduction

THE wing configuration considered to be capable of high speed lift generation and should fulfill the entire requirement. The wing configuration should have enough area, so that the rotor configuration could be installed or equipped in it.

The regular/rectangular wing section or the sweep wing configuration will not fit in the desired role and the reason is the span area of the wing configuration is not enough for installing the rotor configuration in it. Although some great organizations like NASA, is working over the same configuration with the sweep wing combination. But the difference is that the rotor configuration gets extended by the sweep wing configuration, in order to attain the proper shape and profile, which again requires large materials and weight increments.

In the above configuration, the rotor configuration gets mounted on the sweep wing configuration and further the profile shape is given. The new and innovative engineering brings this configuration to the real world and many organizations are still working in order to achieve the desired goals.

The Delta Wing Configuration could again become the appropriate solution for this type of configuration, where the wing area is more, enough to mount the rotor configuration in it. With the help of delta configuration, the required location for the rotor system can be located by the means of aerodynamic centre, where all kind of forces results to zero and from the aerodynamic centre and the centre of gravity (C.G.), of the configuration relays 10-15% ahead.

The basic feature is the VTOL operation performance at high speed which is the prime role of this configuration but instead of all this the rotor configuration also helps in examine the real flow chart of the fluid in reality. According to the theoretical research development the body moving in the fluid gets the pressure distribution in its upper surface as well as in its lower surface due to which the velocity variation comes across and thus due to circulation of the fluid around the body, the lift generation takes place.

2 Geometric Modeling

It is a branch of applied mathematics and computational geometry that studies methods and algorithms for the mathematical description of shapes. The shapes studied in geometric modeling are mostly two- or three-dimensional, although many of its tools and principles can be applied to sets of any finite dimension. Today most geometric modeling is done with computers and for computer-based applications. Two-dimensional models are important in computer

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typography and technical drawing. Three-dimensional models are central to computer-aided design and manufacturing (CAD/CAM), and widely used in many applied technical fields such as civil and mechanical engineering, architecture, geology and medical image processing.

Geometric models are usually distinguished from procedural and object-oriented models, which define the shape implicitly by an opaque algorithm that generates its appearance. They are also contrasted with digital images and volumetric models which represent the shape as a subset of a fine regular partition of space; and with fractal models that give an infinitely recursive definition of the shape. However, these distinctions are often blurred: for instance, a digital image can be interpreted as a collection of colored squares; and geometric shapes such as circles are defined by implicit mathematical equations. Also, a fractal model yields a parametric or implicit model when its recursive definition is truncated to a finite depth.

2.1 What will be the wing and rotor blade profile?

As already mentioned, the wing profile is in the form of delta wing and the rotor system is having three blade rotors of NACA 0012 profile. The delta wing profile is NACA 0016 which is the symmetrical airfoil shape.

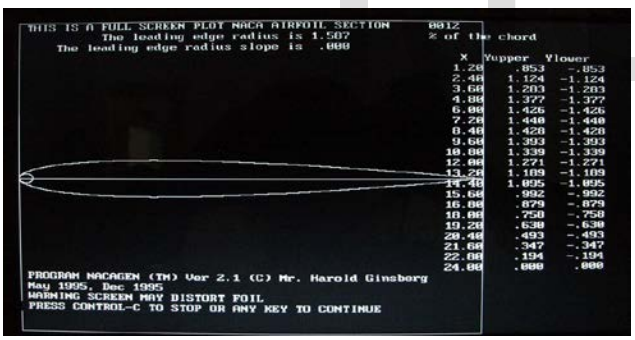

Fig. 2.1 Blade Profile NACA 0012.

The need for symmetrical profile is again related to the installation of the rotor system at the middle of the wing component and performs all the operational maneuvers. The rotor twist plays an important role in the operational VTOL and lift generation.

The profile would be in such a fashion that the fluid encountering to the wing gets twisted by the rotor system at the located point and spins about the rotor axis which allowing to leave the rotor configuration and thus; following the remaining wing path and again gets into the atmosphere. The profile selected for both the wing rotor configuration have a good L/D ratios and with a small angle of attack the lift generation could be done very easily.

2.1.1 CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systemes and marketed worldwide by IBM. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systemes product lifecycle management software suite.

2.1.2 Modeling Wing with Rotor Description

The very basic procedure for modeling the wing is its co-ordinates, which helps in deciding the actual plan for the delta wing.

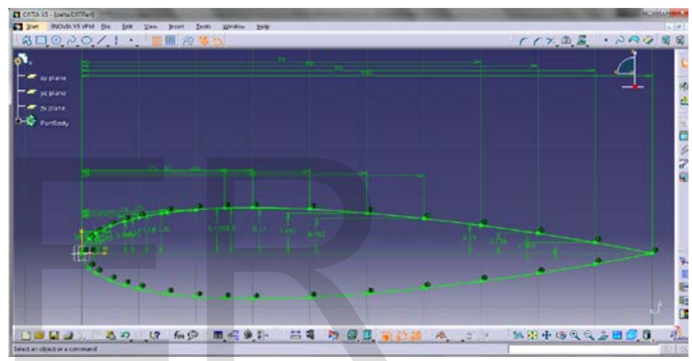

Fig.2..2 The co-ordinates are located with the help of spline and the picture will be look like the airfoil cross section.

After making the profile of the basic airfoil section, another plane will be projected at the distance of 75mm (as the basic design taken in CATIA is in mm). After placing the plane, the same airfoil gets projected to the second plane and then it go through the scaling features. The delta wing is having the taper ratio of 1:4.

After joining to the airfoil profile, the modeling again imported to the sketcher module where the desired location for the rotor system is at the aerodynamic centre by the means of wing iteration method and will be look like the following.

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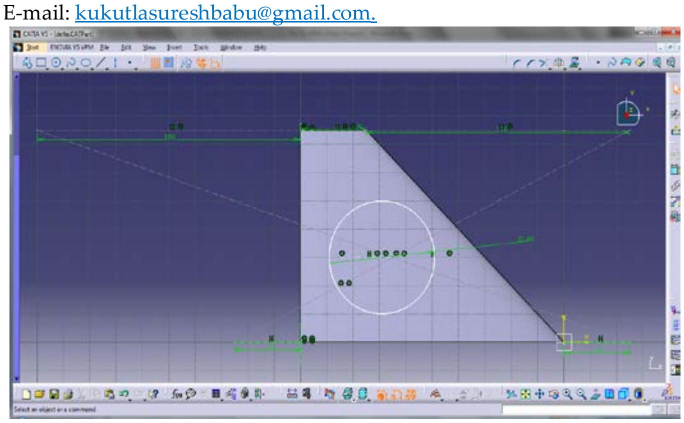

Fig.2.3 aerodynamic centre by the means of wing iteration method.

Once the sketch for the rotor description gets over, then the pocket operation applied over it which makes the wing configuration with a hole and describes the rotor description or specifies it location on the wing.

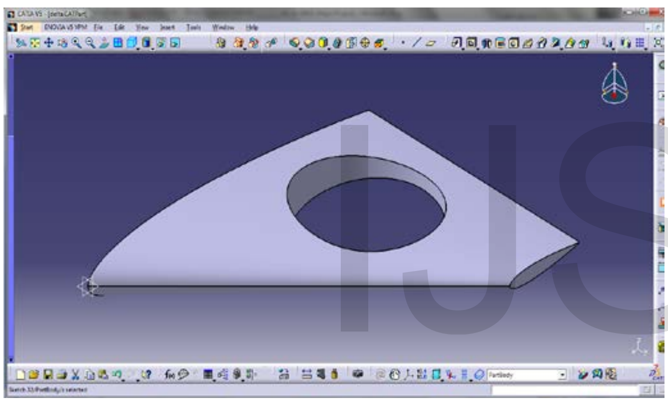

Fig. 2.4 The final wing with a hole component

This is how the first part component of the wing rotor configuration looks like. In order to make the rotor system which needs to install in its specified location, further modeling is done by taking the reference of the first part of the component.

2.1.3 The Rotor Configuration

In order to design the basic rotor modeling, the wing with rotor description is considered as the reference and with the help of that the whole configuration built up.

For performing the rotor configuration modeling, its mould and its flanges (supports), which are attached with the mould to give support to the rotor head and blade are first made. Since, the mould is a 3-D part for which its co-ordinates are required.

The mould could be more in its four views and it is created with the help of wing with rotor description, in order to attain similar profile what the delta wing actually having and thus it will be look like as follows:

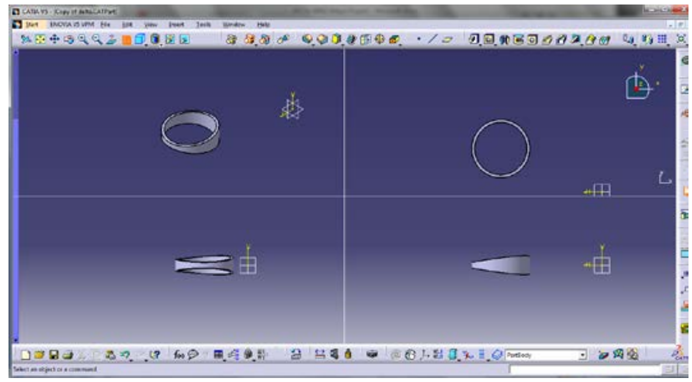

Fig.2.5 Aerodynamic centre by the means of wing iteration method.

After finishing the rotor mould, rotor head designing and its flanges get under the procedural act.

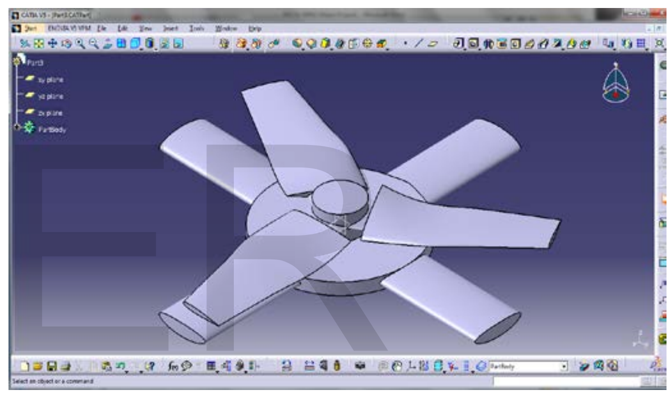

Fig. 2.6 Three twisted blades, one rotor head, four flanges

This is the way how actually the rotor configuration will be look like and that's how the blades are arranged in their respective pattern, in order to perform their operational description.

2.1.4 Assembly

The assembly section consist of the merging of all the components what are made till in order to make the mark of the wing rotor configuration and the final view will be look like the following picture, which describes the complete wing rotor configuration and shows the original structural presence, the following pictures will describe the complete component.

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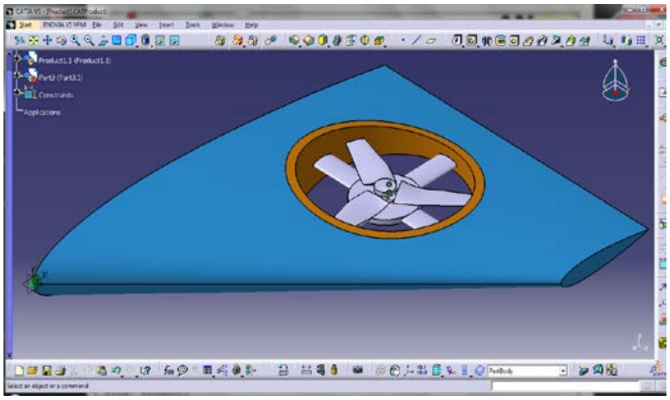

Fig. 2.7 Complete component.

3 Project Description

To check the static and model analysis over the wing rotor configuration, where the material used is Titanium Alloy (Ti-5Al-1.5B)

Given Data:

Young's Modulus: 110 GPa

Poisson's Ratio: 0.33

Density: 4.4g/cm3

Load applied: 500 KPa

3.1 Analysis Summary

Here, in the analysis section the model is being imported from CATIA in the form of ".igs" format. The main function of the analysis in this section is, about the strength and deformation of the complete component's upper surface and the reason behind the upper surface loading/boundary condition is that when the vehicle will perform the VTOL operation at that time the loading/boundary condition will be acting over the upper surface resulting in deformation and stress acting over the upper part of the body.

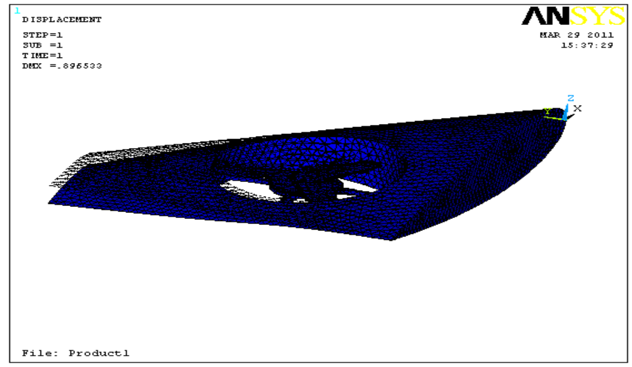

Fig. 3.1 The deformation has shown over the body when the 500 KPa pressure is acting over the upper surface of the body.

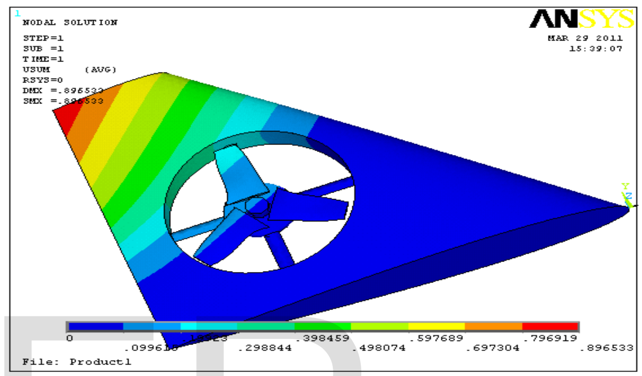

Fig. 3.2 The nodal solution is shown which describes the impact of the load.

Here, the nodal solution is shown which describes the impact of the load is not only over the wing but also over the rotor system. The deformation is about "0.896533"and the stress distribution again same as "0.896533". The high stress at the tip of the wing is because of shape edge.

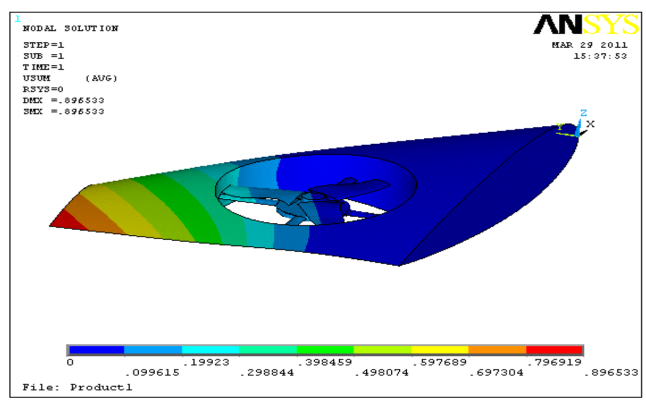

Fig. 3.3 Element solution

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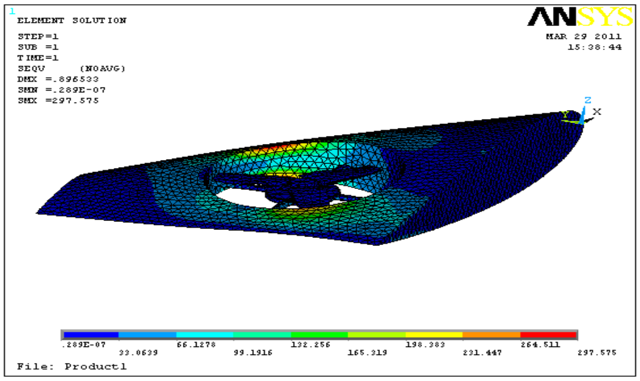

Fig. 3.4 Stress distribution of Element

In the above analysis, the element solution is performed and the stress distribution is 297.575 which is less than that of the ultimate tensile stress i.e. (950-1080) MPa and the yield strength is about 895 MPa, which explains that the configuration is feasible for VTOL operation when the pressure is equal or more than that of 500KPa.

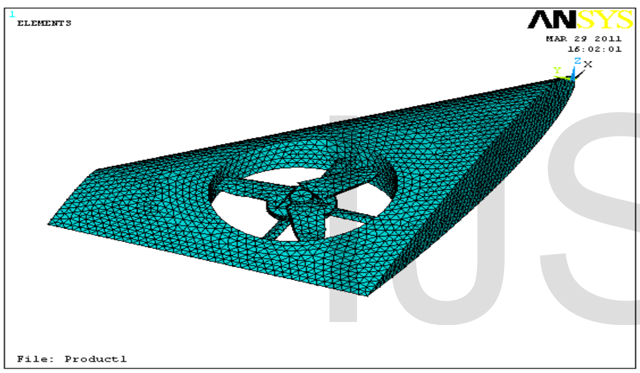

Fig. 3.5 Meshing of the entire component.

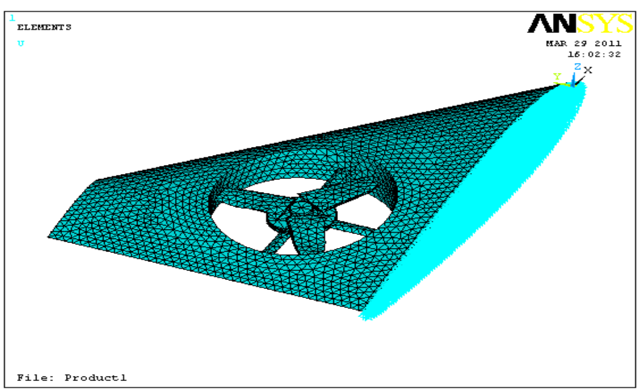

Fig. 3.6 Pressure applied over the entire structure.

The last two above figures explains the meshing of the entire component and the loads/boundary condition applied to the component. In the second figure, the displacement (i.e. the fixed boundary condition is shown), while there is the pressure applied over the entire structure which is not highlighted in the figure.

Further model analysis also performed for the component, in order to attain the deformation frequencies with respect to the natural frequency and the interesting thing is that the first three deformation frequencies are considered to be feasible.

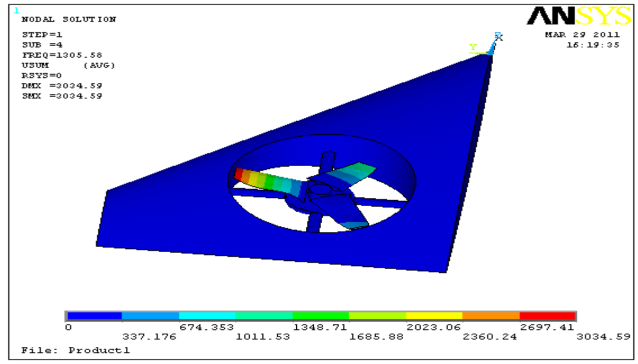

Fig.3.7a Deformation frequency of wing rotor.

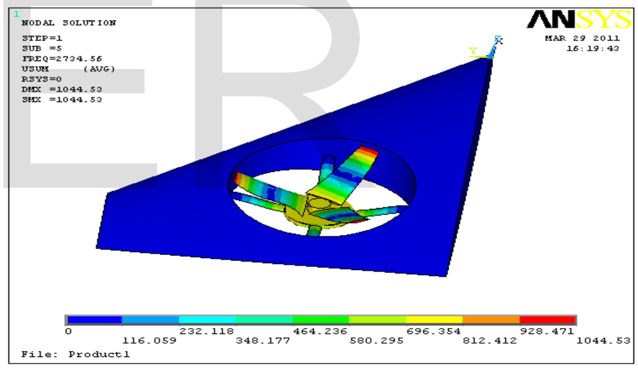

Fig. 3.7b Effect of deformation frequency on wing rotor.

The last two analyses explain that the deformation frequency is much higher and the component gets affected by it. So, the safe deforming frequency is about "1297.55 Hz".

4. RESULTS

According to the recent analytical report the component is in much good position to uphold the pressure and maintain its strength but still further research is going and that will explains the prefect feature of this upcoming configuration,

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but for now it is feasible in nature. The below fig.4.1 shows a final delta wing rotor configuration.

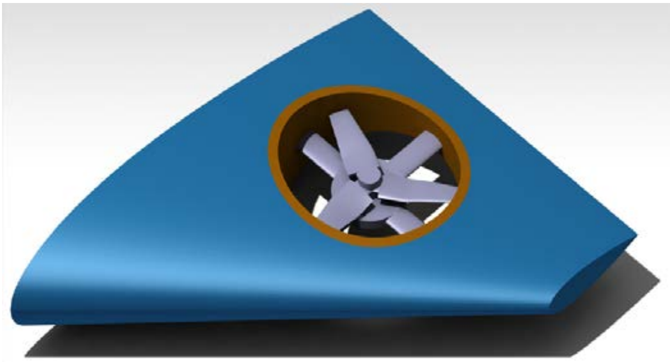

Fig.4.1. Delta wing rotor.

5. FUTUTE SCOPE OF WORK

Wing rotor configuration plays an important role in high lift generation with low fuel consumption. This project will helps in development of future VTOL Aircrafts and also in Numerous Military applications. The 3D Aircraft with Delta wing rotor configuration is as shown in below figure.

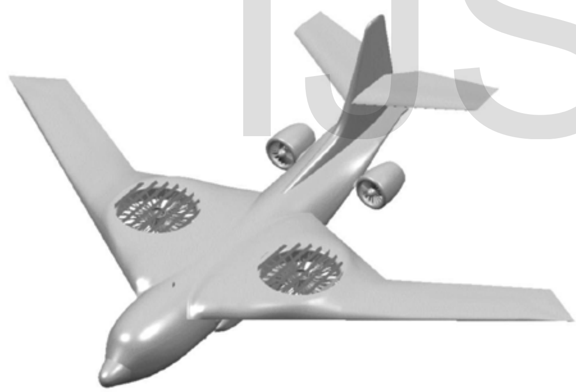

Fig.5.1 Aircraft with Delta wing rotor configuration.

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