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Design & Structural Analysis of a Wing Rotor by using ANSYS & CATIA

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Abstract - ***Wing rotor configuration is a conceptual design of a fixed delta wing with a cut circular part in the middle to incorporate a rotor in it for vertical take-off and landing /short take-off and landing. The primary objective of this project is to design such a configuration using the design software CATIA and later on analyzing the designed structure for its structural strength in analysis software ANSYS.This project deals with the all the necessary aerodynamic requirements of the wing as well as the rotor configuration. In today's world most the vtol/stol largely depends upon the thrust vectoring that requires huge amounts of fuel and separate devices like nozzles etc., whose production is very much tedious and costly. This is an attempt to use a rotor as in the case of helicopters for vtol/stol thus reducing the most of the cost though weight would be considered as a hindrance to the project. Large research is on a progress by prestigious organizations like NASA in this field***.

Key Words: *CATIA V5 R20, ANSYS, Inc. (NASDAQ: ANSS),Boundary conditions, Von mises stresses.*

1. INTRODUCTION

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 rotor speeds. In this, the wing configuration gets merged with the rotor configuration at its respective location, defined by the aerodynamic basics. 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.

This type of configuration is the unique compromise between the VTOL operation at high speed and altitudes. Nowadays, the rising demand in VTOL operation at high speed is a vital concern and many organizations are involved in introducing such unique configuration. In this type of configuration, the rotor configuration will be able to perform the VTOL operation in the similar fashion, as they work in the helicopter's lift generation and are also responsible for handling the maneuver control of the vehicle.

The wing configuration used for attaining the high speed and providing a mould for the rotor system, where it could be fixed and perform operation easily. The wing configuration plays an important role in the lift generation.

2. WING PROFILE

NACA 0016

The basic NACA Four-Digit airfoils are described by four numbers. The first digit specifies the maximum camber in percentage of the chord (airfoil length), the second indicates the position of the maximum camber in tenths of chord, and the last two numbers provide the maximum thickness of the airfoil in percentage of chord. The first number after the dash specifies a leading-edge radius parameter. This parameter is defined as being equal to the radius of the leading edge divided by the square of the airfoil thickness. The value given after the second dash is the location of the maximum airfoil thickness in percentage of chord aft of the leading edge. For example, the NACA 0008-1.1-25 is thickest 25% back from the leading edge while the NACA 0005-.825-50 reaches maximum thickness halfway (50%) along its length.

Thickness	16.0%
Camber	0.0%
Trailing Edge Angle	19.3°
Lower Flatness	4.3%
Leading Edge Radius	2.9%
Max C_L	1.074
Max C_L Angle	15.0
Max L/D	37.287
Max L/D Angle	6.0
Max L/D C_L	0.748
Stall Angle	10.0
Zero Lift Angle	0.0

Table -1: Experimental results of NACA 0016

3. BLADE PROFILE

NACA0012

The rotor system is having three blade rotors of NACA 0012 profile which is the symmetrical airfoil shape. The symmetrical NACA airfoil used for rudder and elevator, a thicker section may be required for structural reasons. While the aerofoil is good there are other airfoils that are better. It was discovered that thicker is better, at least up to a thickness of about 12%. A 12% thick airfoil gives the best ratio of maximum lift divided by minimum drag. Many airplanes have wings thicker than 12% but this is for structural rather than aerodynamic reasons.

Thickness	12.0%
Camber	0.0%
Trailing Edge Angle	58.6°
Lower Flatness	12.0%
Leading Edge Radius	1.7%
Max C_L	0.962
Max C_L Angle	15.0
Max L/D	55.303
Max L/D Angle	4.5
Max L/D C_L	0.533
Stall Angle	7.5
Zero Lift Angle	0.0

Table- 2: Experimental results of NACA 0012

4. MODELING

WING DESCRIPTION

The very basic procedure for modeling the wing is its co-ordinates, which helps in deciding the actual plan for the delta wing. The co-ordinates are located with the help of spline and the picture will be look like the airfoil cross section.

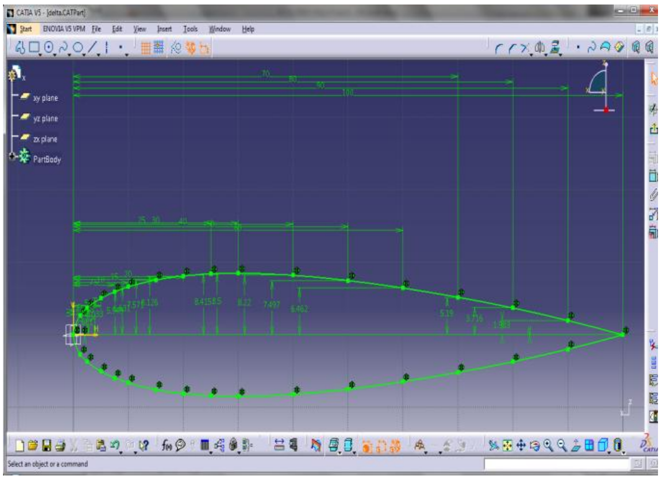

Fig -1: Wing aerofoil design

ROTOR DESCRIPTION

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 blades, 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 the similar profile what the delta wing actually having and thus it will be look like as follows:

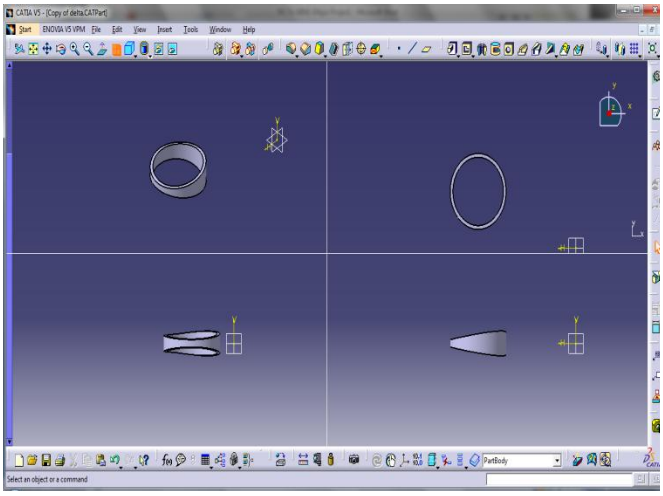

Fig -2: Rotor contact surface design

5. RESULTS & DISCUSSIONS

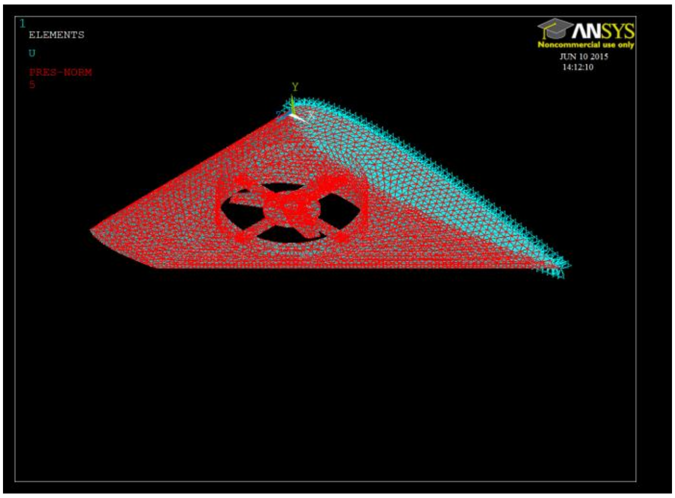

Fig -3: Boundary conditions over rotor wing

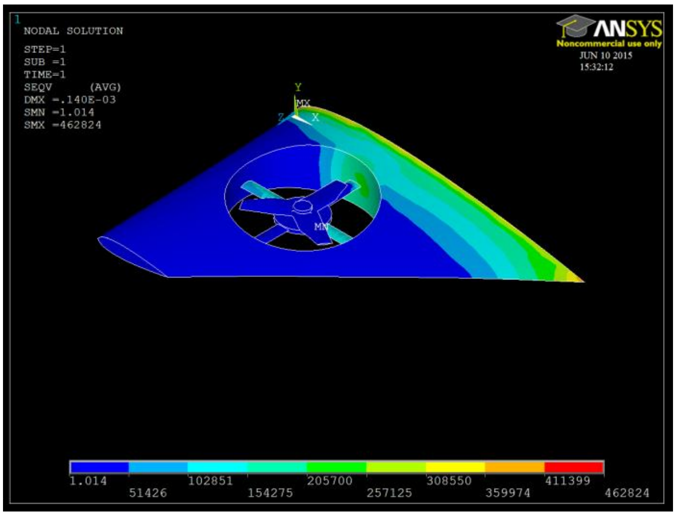

Fig -4: Von-mises stresses

In the above analysis, the element solution is performed and the stress distribution is 495.767 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 500 KPa.

6. CONCLUSIONS

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, but for now it is feasible in nature.
With the gradual thesis and the study over the Wing Rotor Configuration, one can not mention it as most superior or tactical configuration unless and until, the proper results or experiments not well performed.
This configuration might be having some features but it also having some demerits and few questions which needed to be solve but by the time, this configuration continues its research and people's interest on it.

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