DESIGN AND STRUCTURAL ANALYSIS OF WING ROTOR

M.Dhinesingh

M-Tech, Aeronautical Department, MLR Institute of Technology, Telangana, India

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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. .

Key Words: *Rotor blade , VTOL, , etc…*

1. WINGROTOR

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.

1.1 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 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.

1.2 ROTOR BLADE PROFILE

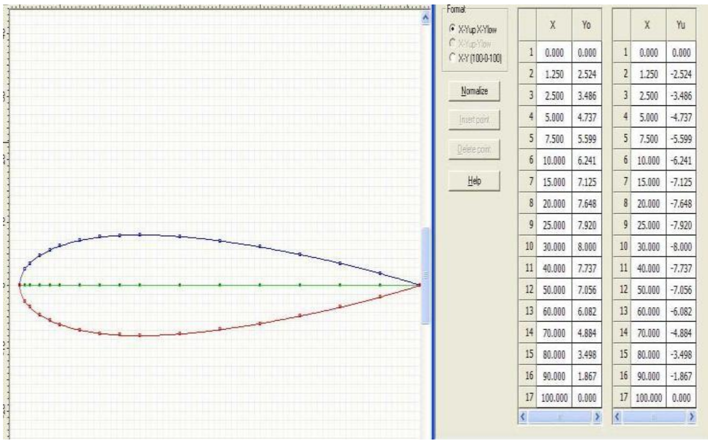
As already mentioned, the wing profile is in the form of delta wing and the rotor system is having three blade rotors of NACA 0012 profile. The delta wing profile is NACA 0016 which is the symmetrical airfoil shape. The need for symmetrical profile is again related to the installation of the rotor system 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. LITERATURE REVIEW

There have been many advancements in the field of aerospace and avionics. Scientists have increasingly started to focus on VTOL (vertical take - off and landing) aircrafts. We have built a miniature VTOL twinrotor UAV. UAVs have begun to grab a lot of attention these days due to its numerous applications such as surveillance and relief. Twinrotor is a kind of a helicopter having two main propellers instead of one and no tail fin. All three important motion of the aircraft i.e. roll, pitch, yaw are controlled by thrust vectoring using servo motors and changing the magnitude of thrust using electronics speed controllers. The paper deals with the design of a basic UAV based on application and the construction keeping in mind the different concepts that govern its motion.

3. WING PROFILE



	X	Yo
1	0.000	0.000
2	1.250	2.524
3	2.500	3.486
4	5.000	4.737
5	7.500	5.599
6	10.000	6.241
7	15.000	7.125
8	20.000	7.648
9	25.000	7.920
10	30.000	8.000
11	40.000	7.737
12	50.000	7.056
13	60.000	6.082
14	70.000	4.884
15	80.000	3.498
16	90.000	1.867
17	100.000	0.000

	X	Yu
1	0.000	0.000
2	1.250	-2.524
3	2.500	-3.486
4	5.000	-4.737
5	7.500	-5.599
6	10.000	-6.241
7	15.000	-7.125
8	20.000	-7.648
9	25.000	-7.920
10	30.000	-8.000
11	40.000	-7.737
12	50.000	-7.056
13	60.000	-6.082
14	70.000	-4.884
15	80.000	-3.498
16	90.000	-1.867
17	100.000	0.000

Fig 3.1 WING PROFILE NACA 0016

4.6 VTOL (VERTICAL TAKE OFF & LANDING)

It includes fixed-wing aircraft that can hover, take off and land vertically as well as helicopters and other aircraft with powered rotors, such as tilt rotors. The terminology for spacecraft and rockets is VTVL (vertical takeoff with vertical landing). Some VTOL aircraft can operate in other modes as well, such as CTOL (conventional take-off and landing), STOL (short take-off and landing), and/or STOVL (short take-off and vertical landing). Others, such as some helicopters, can only operate by VTOL, due to the aircraft lacking landing gear that can handle horizontal motion. VTOL is a subset of V/STOL (vertical and/or short take-off and landing).

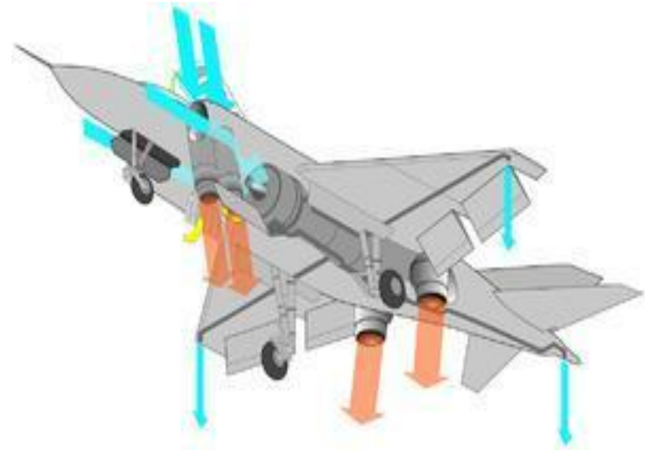


Fig 4.1 Thrust Vectoring

The first operational VTOL jet aircraft was the British Royal Air Force Harrier; its jet engines are mounted horizontally, with their blast deflected downward to effect vertical thrust for takeoff. It achieved high subsonic speeds in level flight VTOL and STOL aircraft have the distinct advantage of being able to take off and land "on a dime". They did not require a runway like traditional aircraft. The

VTOL could take off and land virtually anywhere including rooftops and ship decks other than aircraft carriers. STOL only required a short runway. There has always been an interest in developing these types of airships for strategic and practical reasons. However. There are size constraints. The largest helicopter is the Russian Sikorsky which can lift full sea container crates. The Largest and fastest VTOL is the Harrier "Jump" jet, used extensively to this day by the British and Indian Air Force. There are no commercial sized VTOL or STOL aircraft. There is a revival of interest in Zeppelins, originally popularized by the Nazis, taking them the next step further, where thousands of people can be transported.

5. CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems and marketed worldwide by IBM. Written in the C++programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. The software was created in the late 1970s and early 1980s to develop Dassault's Mirage fighter jet, than was adopted in the aerospace, automotive, shipbuilding, and other industries. CATIA competes in the CAD/CAM/CAE market with Siemens NX, Pro/ENGINEER, Autodesk Inventor, and Solid Edge.

5.1 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.

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.

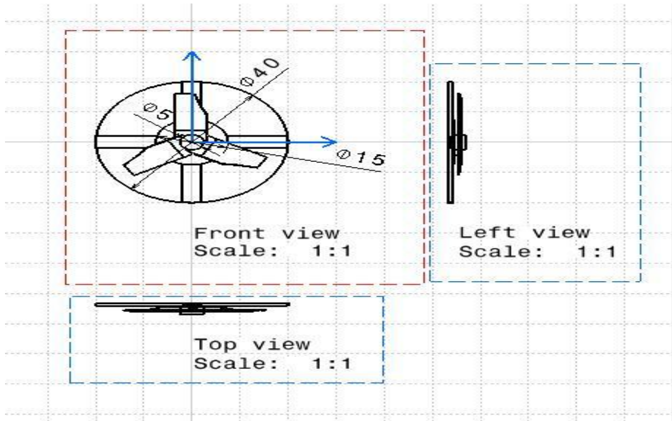
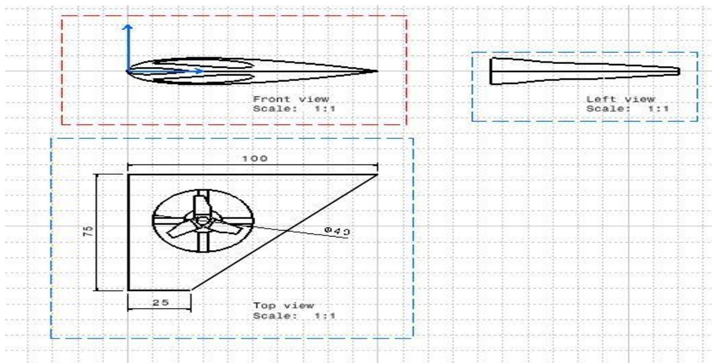


Fig 5.6 2D View of Rotor



5.8 2D design of wing rotor

6. Analysis Summary

Here, in the analysis section the model is being imported from CATIA in the form of .igs|| format. This imported file should be saved in PRO-E as.IGES|| file to get the complete volumes and surfaces in ANSYS. 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 condition/boundary condition is, when the vehicle perform the VTOL operation by the 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.

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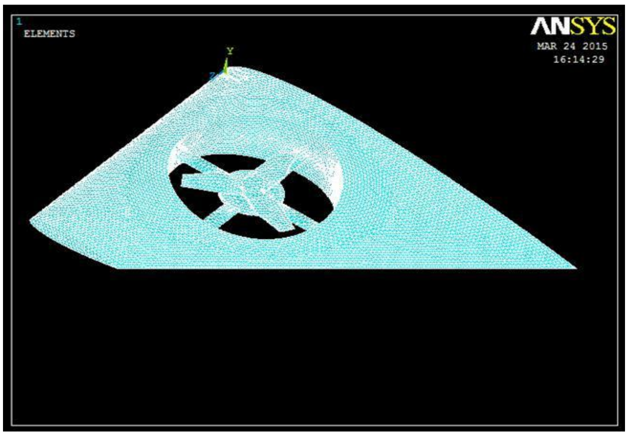

Fig 6.1 Meshed wing rotor

The above figure examines the meshing of the complete component.

The below two 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 highlighted in the figure.

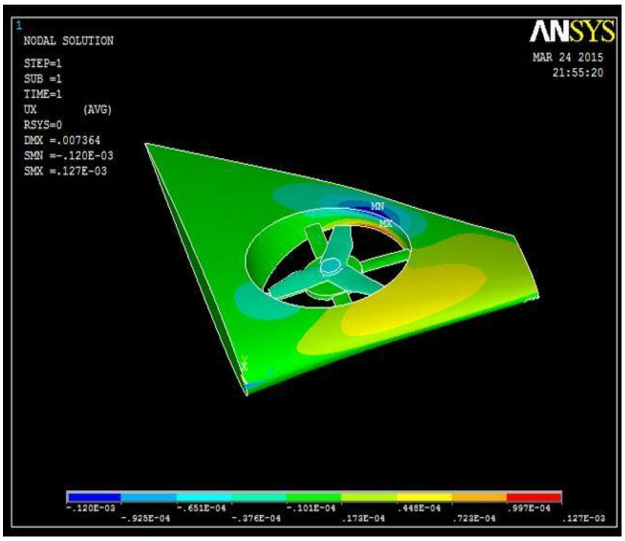

Fig 6.2 X-Displacement

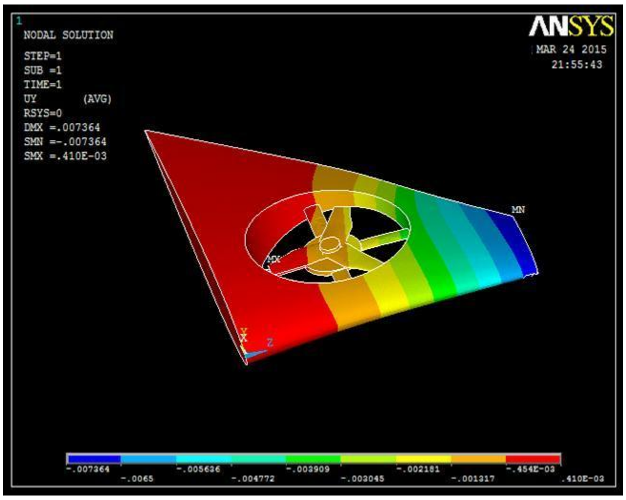

Fig 6.3 Y Displacement

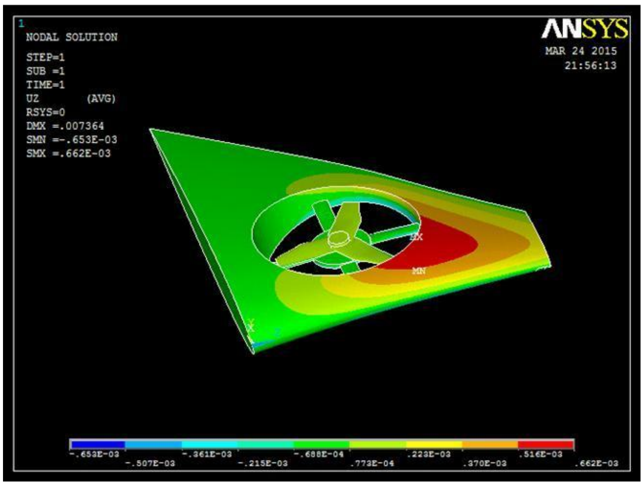

Fig 6.4 Z Displacement

These two figures explain the boundary conditions applied to the body, first one explains the displacement and another figure explains the pressure applied over the upper surface. The deformation has been shown over the body when the 500 KPa pressure is acting over the upper surface of the body.

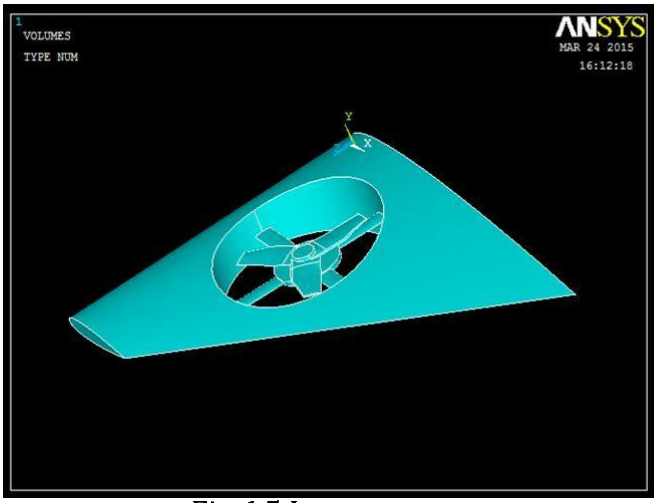

Fig 6.5 Import

All the boundary conditions or the loading conditions are applied and the solution attain in order to get the exact deformation value with which one can withstand and examines the strength and the actual loading condition of the component with respect to its materials, used for manufacturing of the component.

This result also examines the deformation and the strength value of the material strength used and the force or loading value to bear the natural frequencies acting over it

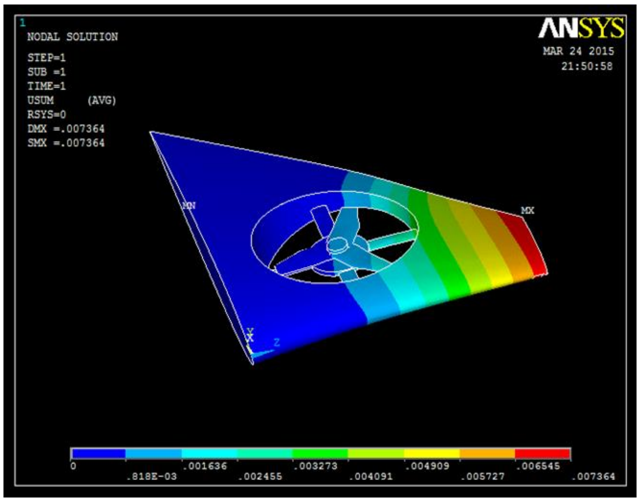

Fig 6.6 Displacement Vector Sum

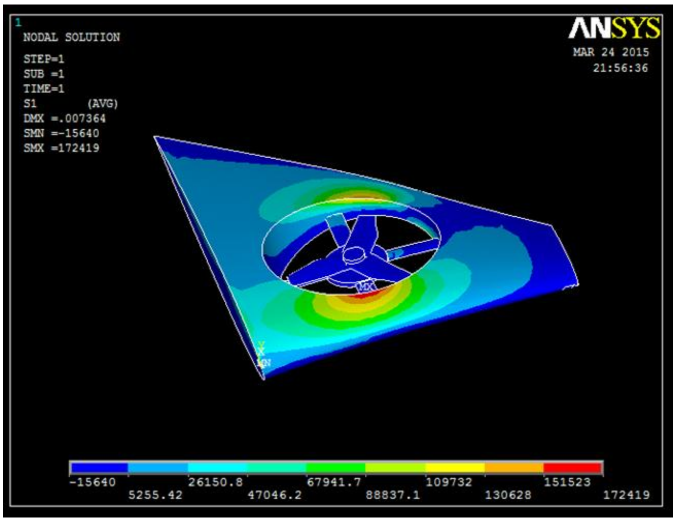

Fig 6.7 First Principle Stress

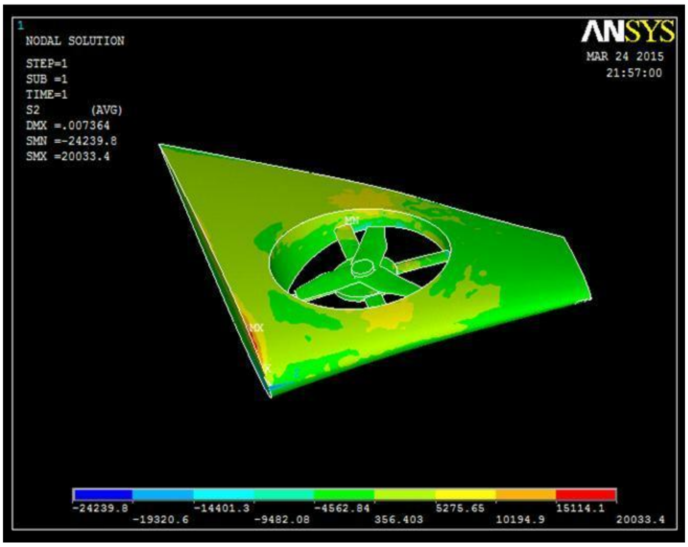

Fig 6.8 Second Principle Stress

The nodal solution is shown which describes the impact of the load is not only acting over the wing but also on to the rotor system. The deformation is about ―0.14E-06‖and the total displacement again same as ―0.14E-06‖. The displacement at the tip of the wing is because of sharp edge. The critical value for titanium alloy is ―0.14‖

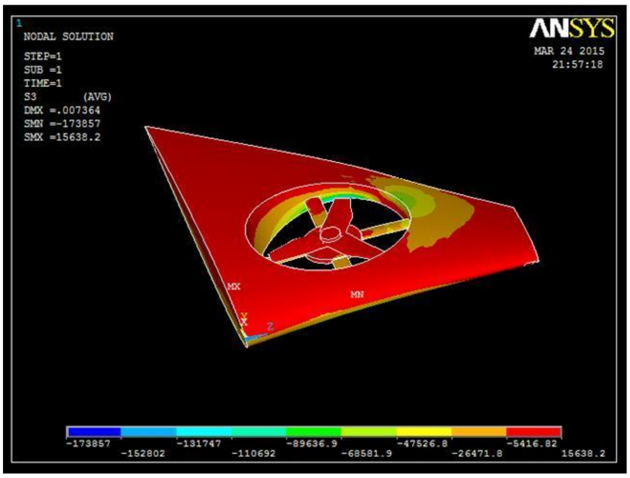

Fig 6.9 Third Principle stress

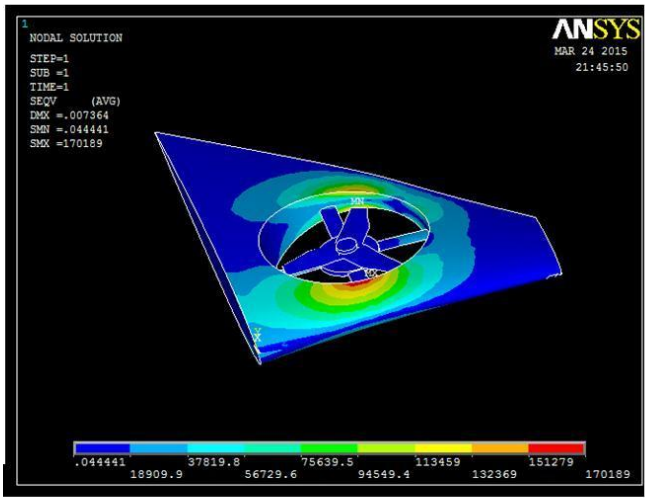

Fig 6.10 Von Mises Stress

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 VTO L operation when the pressure is equal or more than that of 500 KPa.

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

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.

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

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.

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||.

7. 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

8. REFERENCES

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