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Effect of Morphing Blade for Vertical Axis Wind Turbine on Aerodynamic Performance

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ABSTRACT

In this thesis, aerodynamic performance of a vertical axis wind turbine by morphing the trailing edges of the wind turbine will be analyzed. 3D models of the vertical axis wind turbine by morphing the trailing edges will be done in Catia.

CFD analysis will be performed and compared for pressures, velocities, lift and drag for all the models at different wind speeds. Static analysis will also be performed on the models by applying pressures obtained from CFD analysis to determine stresses and deformations using different materials for blade.

CFD and Static analysis will be done in Ansys 14.5.

INTRODUCTION

The need for electricity in present days is of prime importance due to the sort of evolved life mankind needs. The production of power using traditional methods has taken its toll on the environment and the earth has been polluted to degrees beyond imagination. Alternative energy and green energy from natural recourses is the need of the hour. Technology must be used so as to provide human needs and luxuries but still not affect our planet. With increasing awareness about our needs and priorities, one alternative source where we can draw power would be the wind.

Wind turbine was invented by engineers in order to extract energy from the wind. Because the energy in the wind is converted to electric energy, the machine is also called wind generator

Vertical Axis Wind Turbine (VAWT)

One notable difference of the vertical axis wind turbine (VAWT) is that the axis of rotation is perpendicular to the direction of the free-stream flow. VAWTs are categorized into two distinct categories; Savonius and Darrieus according to the principle used to capture energy from the wind. Savonius type wind turbines operate using the principles of drag whereas Darrieus type wind turbines operate primarily on the principle of lift. Although VAWTs are not as efficient as HAWTs, they are increasingly popular in urban residential areas. This is largely due to the fact that a VAWT possesses fewer moving parts and operates at a low tip speed ratio which makes it significantly quieter and thus well suited for urban residential areas [Eriksson et al, 2008]. HAWTs require a yaw mechanism to redirect itself in the direction of the wind, whereas VAWTs are less sensitive to the changing wind direction and turbulence. Another advantage associated with VAWTs is the simplicity in design. Unlike HAWTs, the gearbox and generator is located at ground level which significantly reduces the complexity of the design and is also relatively easy

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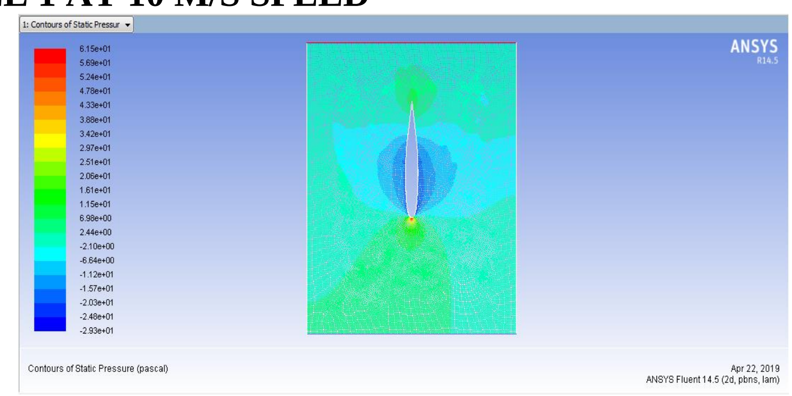
to maintain and thus lowering the maintenance cost. Figure (4) shows the vertical axis wind turbine categories.

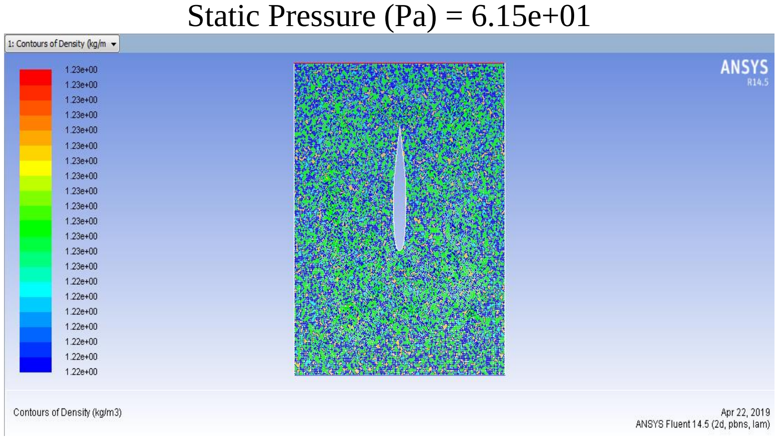
LITERATURE SURVEY

VARIABLE GEOMETRY VERTICAL AXIS MACHINES P. J. Musgrove in 1975 led a research project at Reading University in the UK whose purpose was to attempt to rationalize the geometry of the blades by straightening out the blades of a Darrieus type wind turbine. This led to the design of a straight bladed vertical axis wind turbine designated as the H rotor blade configuration. At the time it was thought that a simple H blade configuration could, at high wind speeds, over speed and become unstable. It was thus proposed that a reefing mechanism be incorporated into the machine design thus allowing the blades to be feathered in high winds. These earlier machines with feathering blades were known as Variable Geometry Vertical Axis Wind Turbines. There were a number of these designs which had different ways of feathering their blades. During the late 1970's there was an extensive research program carried out. This included wind tunnel tests and the building of a few prototype machines in the40-100 kW range. This work culminated in a final reefing arrowhead blade design for a large 25 meter, 130 kW rated machine, located in Carmarthen Bay in South Wales. This machine known as the VAWT 450, was built by a consortium of Sir Robert McAlpine and Northern Engineering Industries (Vertical Axis Wind Turbines Limited) in 1986. The project was funded by the UK government's Department of Trade and Industry.

CFD - MODEL 1 AT 10 M/S SPEED



Static Pressure (Pa) = 6.15e+01



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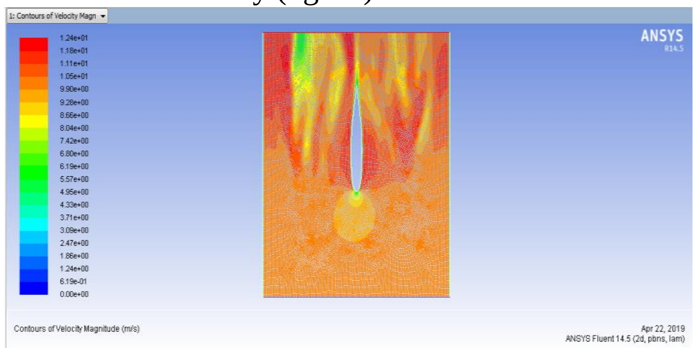
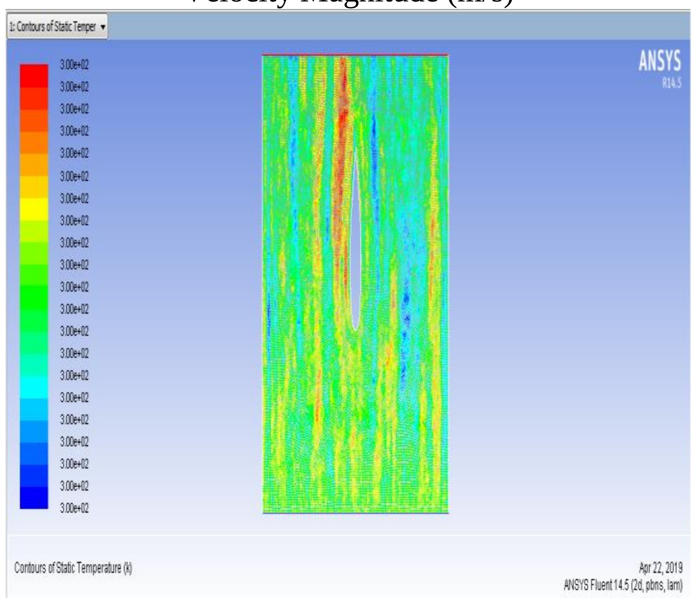
Density (kg/m^3) = 1.23e+00

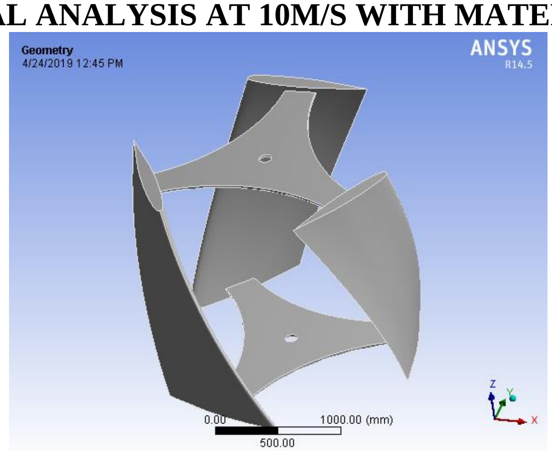


Velocity Magnitude (m/s)



Static Temperature (K) = 3.00e+02

MODEL 1 STRUCTURAL ANALYSIS AT 10M/S WITH MATERIAL AL 6061



Model 1 geometry

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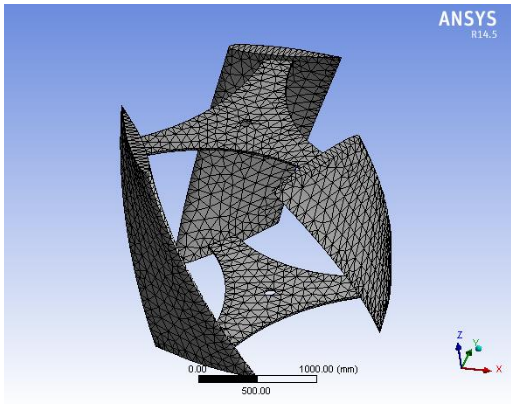
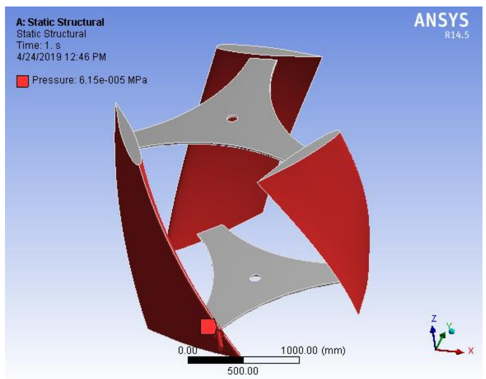
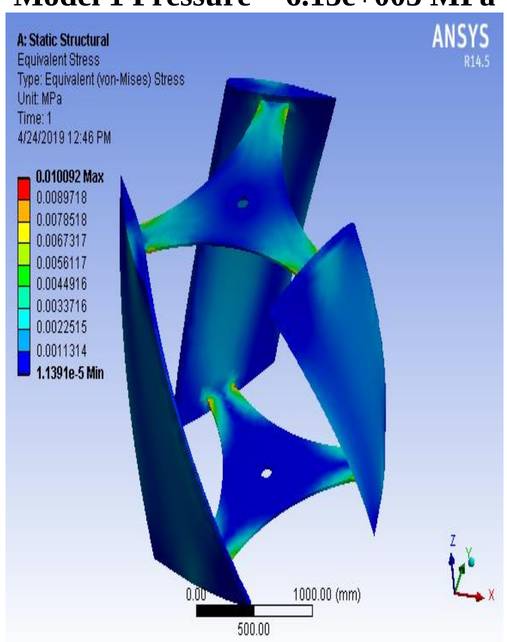


Geometry model Mesh



Model 1 Pressure = 6.15e+005 MPa



Stress = 0.010092

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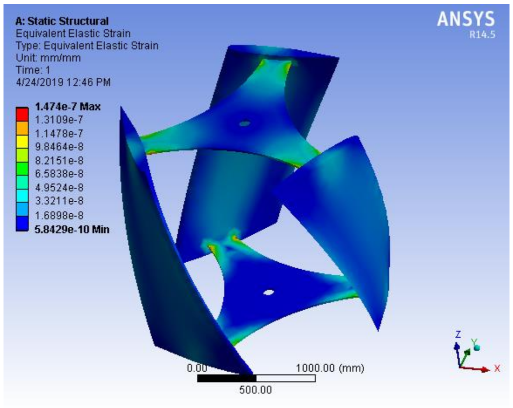
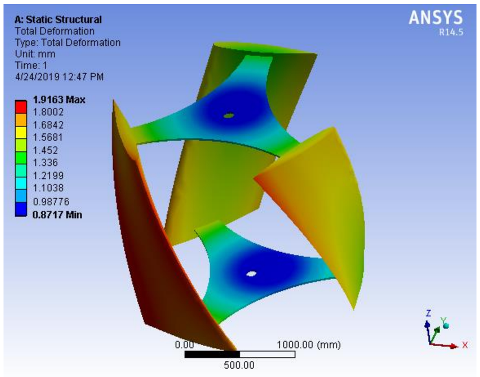
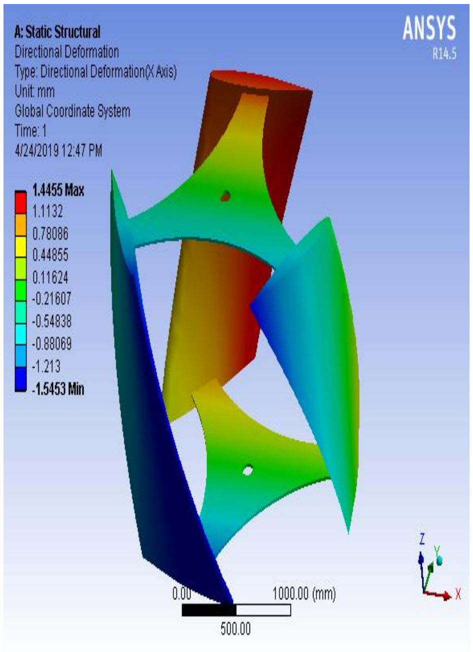


Strain = 1.474e-7

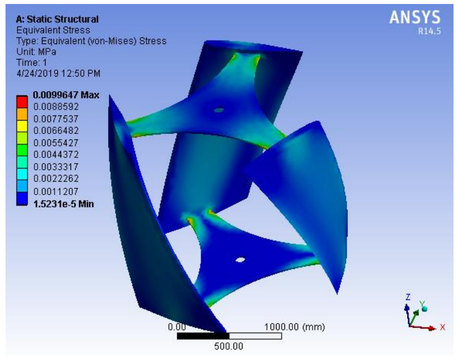


Total Deformation = 1.9163 mm

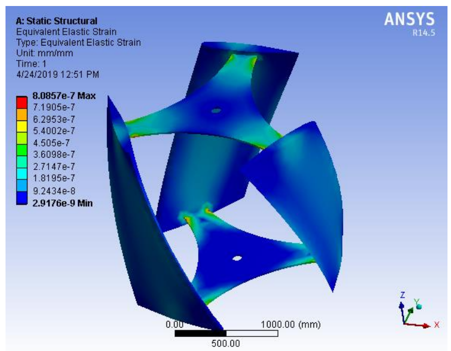


Directional Deformation = 1.4455 mm

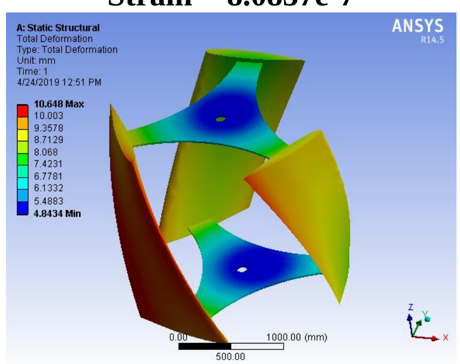
B) Model 1 structural analysis at 10m/s with material cfrp 30



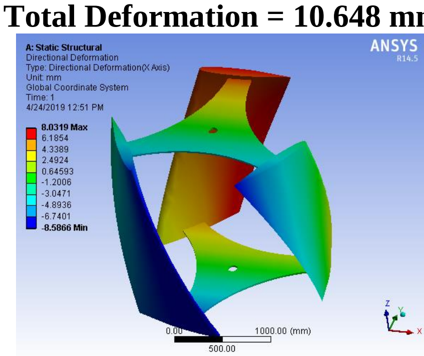
Stress = 0.0099647 MPa



Strain = 8.0857e-7

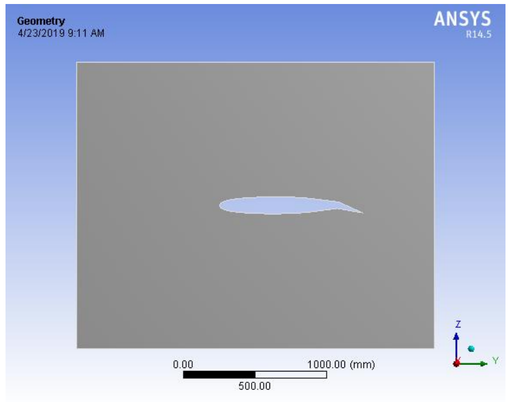


Total Deformation = 10.648 mm

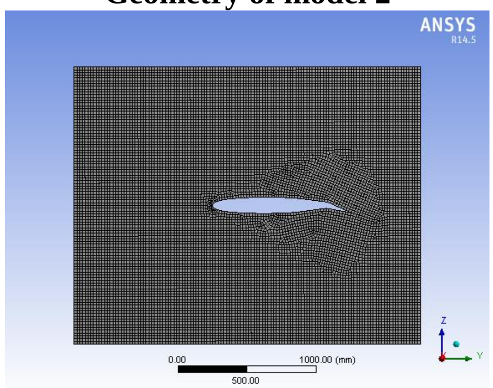


Directional Deformation = 8.0319 mm

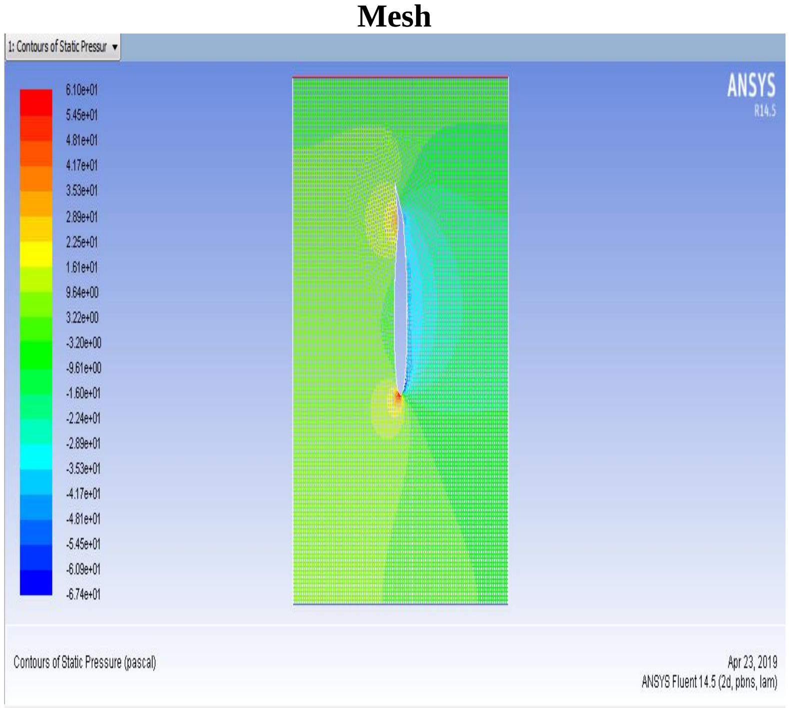
CFD - MODEL 2 AT 10 M/S SPEED



Geometry of model 2



Mesh



Static Pressure = 6.10e+01

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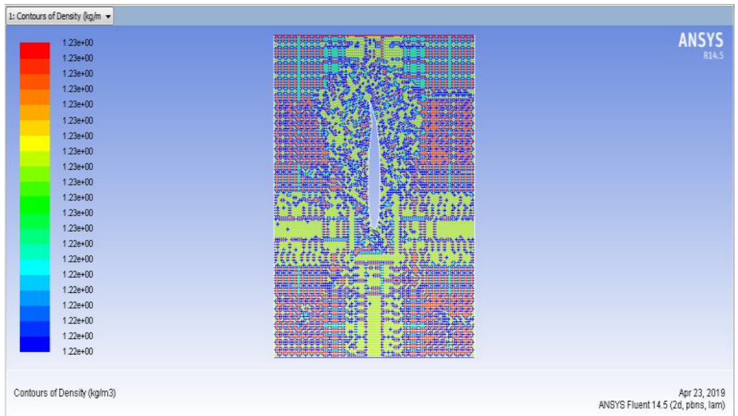
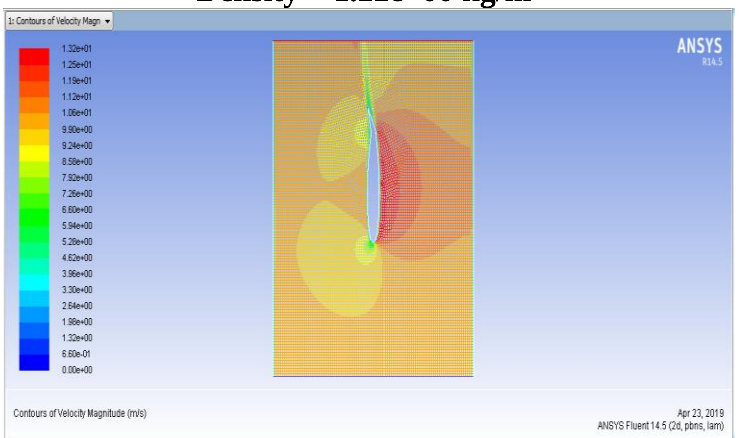
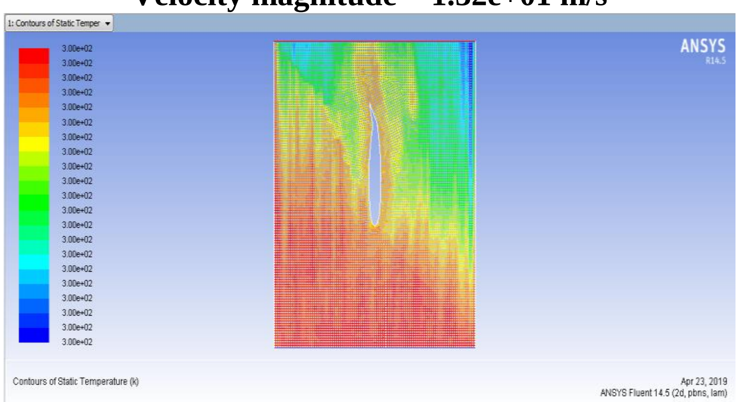


Density = 1.22e+00 kg/m^3



Velocity magnitude = 1.32e+01 m/s



Static Temperature = 3.00e+02 K

TABLES & GRAPHS

Model 1

At 10 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.010092	0.0099647	0.010233
Strain	1.474e-7	8.0857e-7	6.0591e-8
Total Deformation (mm)	1.9163	10.648	0.77664

Directional Deformation	1.4455	8.0319	0.58586

At 20 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.040368	0.039859	0.040932
Strain	5.8962e-7	3.2343e-6	2.4236e-7
Total Deformation (mm)	7.6651	42.591	3.1066
Directional Deformation	5.7819	32.128	2.3434

At 30 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.088119	0.087009	0.089352
Strain	1.2871e-6	7.0602e-6	5.2906e-7
Total Deformation (mm)	16.732	92.972	6.7814
Directional Deformation	12.621	70.132	5.1155

MODEL 2

At 10 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.009872	0.0097399	0.010021
Strain	1.4459e-7	7.9329e-7	5.9436e-8
Total Deformation (mm)	1.8981	10.547	0.76931
Directional Deformation	1.4355	7.9766	0.58179

At 20 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.032907	0.032466	0.033402
Strain	4.8196e-7	2.6443e-6	1.9812e-7
Total Deformation (mm)	6.327	35.157	2.5644
Directional Deformation	4.7848	26.588	1.9393

At 30 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.082267	0.081166	0.083506
Strain	1.2049e-6	6.6107e-6	4.953e-7
Total Deformation (mm)	15.818	87.892	6.411
Directional Deformation	11.962	66.471	4.8482

MODEL 3

At 10 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.0097679	0.0096426	0.0099078
Strain	1.43e-7	7.8504e-7	5.8742e-8
Total Deformation (mm)	1.942	10.79	0.78706
Directional Deformation	1.4858	8.2556	0.60215

At 20 m/s

	al 6061	cfrp 30	kevlar

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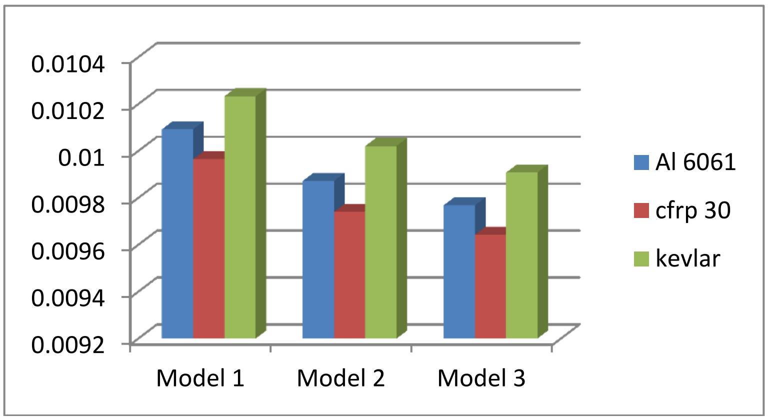
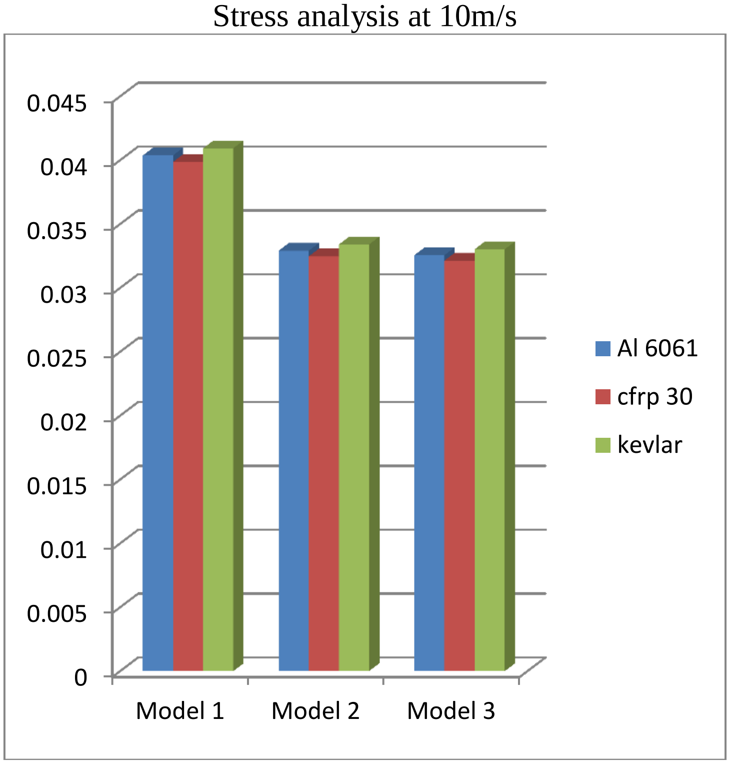
Stress (MPa)	0.03256	0.032142	0.033026
Strain	4.7668e-7	2.6168e-6	1.9581e-7
Total Deformation (mm)	6.4733	35.968	2.6236
Directional Deformation	4.9525	27.519	2.0072

At 30 m/s

	al 6061	cfrp 30	kevlar
Stress (MPa)	0.081399	0.080355	0.082565
Strain	1.1917e-7	6.542e-6	4.8952e-7
Total Deformation (mm)	16.183	89.92	6.5588
Directional Deformation	12.381	68.797	5.0179



Stress analysis at 10m/s



Stress analysis at 20m/s

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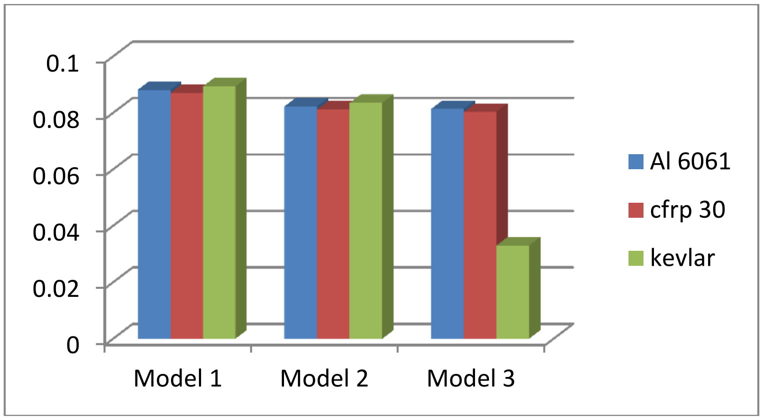
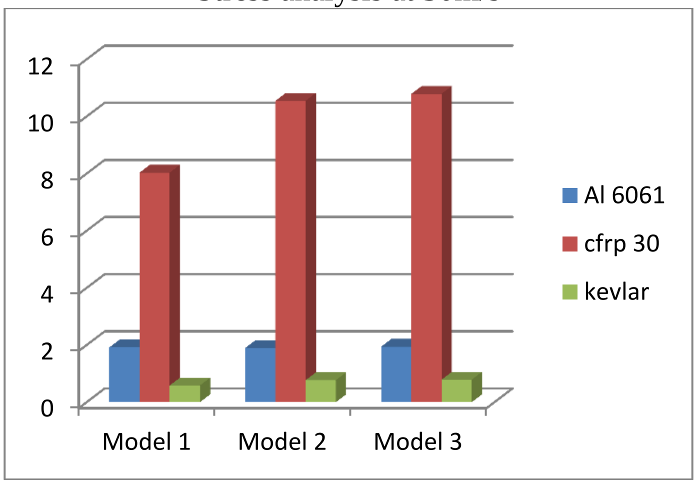
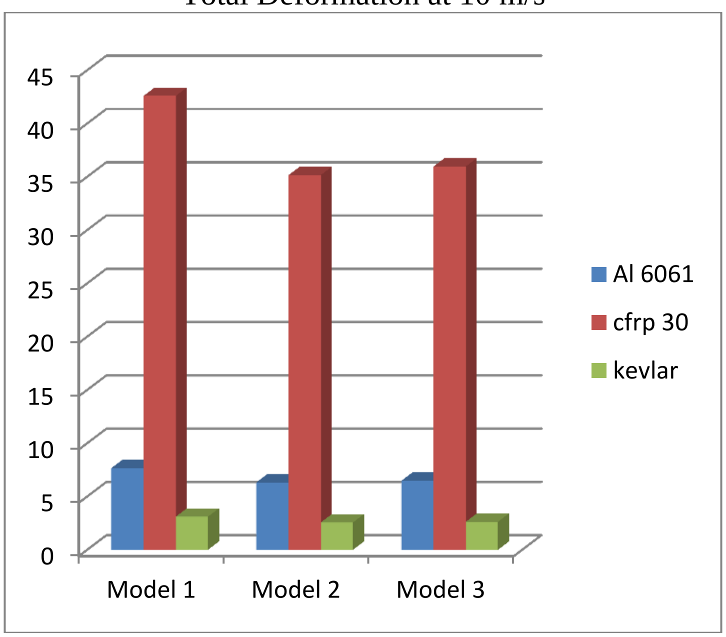


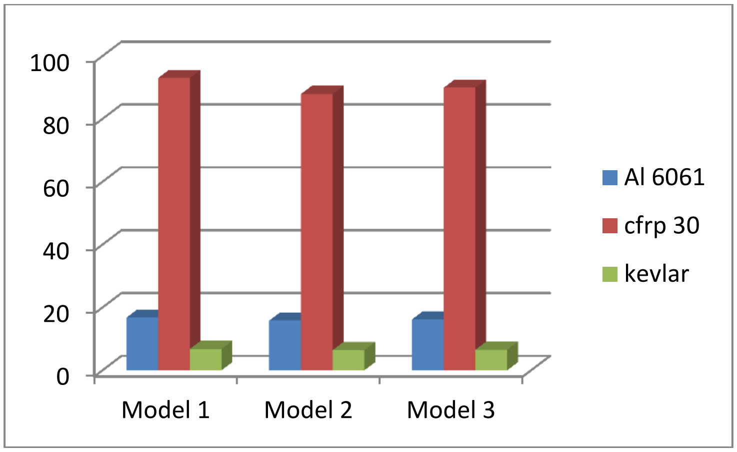
Stress analysis at 30m/s



Total Deformation at 10 m/s



Total Deformation at 20m/s



Total Deformation at 30 m/s

CONCLUSION

In this thesis, aerodynamic performance of a vertical axis wind turbine by morphing the trailing edges of the wind turbine will be analyzed. 3D models of the vertical axis wind turbine by morphing the trailing edges will be done in Catia.

CFD analysis will be performed and compared for pressures, velocities, lift and drag for all the models at different wind speeds. Static analysis will also be performed on the models by applying pressures obtained from CFD analysis to determine stresses and deformations using different materials for blade.

As if we verify all the resulted tables and graphs above we have got the output values of pressure and velocity from the CFD analysis at different speeds with different angles of blades. Here we have considered 3 angles of blades.

By verifying all the results here if we observe the stress at 10 and 20 m/s is less for the model 3 with CFRP material, but the deformation is very high when we compare there and if the speed is increased to 30m/s CFRP did not sustain there, so by observing all the three models with different materials and different speeds, we can conclude that the material with Kevlar of model 3 is having the better parameters and can sustain the maximum period of life.

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