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Optimizational Analysis of a Windmill Hub

P.Rama Chandra Rao
M.Tech Student,
Machine Design,
Sarada Institute of Science Technology and Management (Approved By AICTE, Approved By JNTUKakinada) Srikakulam.

Mr. K Deepak, M.Tech
Assistant Professor,
Mechanical Engineering,
Sarada Institute of Science Technology and Management (Approved By AICTE, Approved By JNTUKakinada) Srikakulam.

ABSTRACT:

A wind turbine converts the energy of wind into kinetic energy. The mechanical energy is converted to electricity; the machine is called a wind generator, wind turbine, wind power unit (WPU), wind energy converter (WEC), or aero generator. The windmill blade is mounted on the wind hub, the hub is rotates continuously during the wind flow, in continuous rotation the wind hub damaged in a certain period. This project we are doing the design and structural analysis of windmill hub. The model of the windmill is designed using PRO E software, and the structural analysis of the windmill hub is done by using ANSYS software. The present material of the windmill hub is EN-GJS-400-180-LT; this is a one type of cast iron. These projects we are analyze the windmill hub in three materials one is present material another two materials are 1040 carbon steel and epoxy carbon. We analyze the three materials under same load and finally take the good material to resist the load.

KEYWORDS :

WIND TURBINE, NACELLE, WIND MILL HUB, PRO-E, FEA, ANSYS, STATIC STRUCTURAL ANALYSIS.

INTRODUCTION :

Energy is the ability to do work. While energy surrounds us in all aspects of life, the ability to harness it and use it for constructive ends as economically as possible is the challenge before mankind. Alternative energy refers to energy sources which are not based on the burning of fossil fuels or the splitting of atoms. The renewed interest in this field of study comes from the undesirable effects of pollution (as witnessed today) both from burning fossil fuels and from nuclear waste byproducts.

Fortunately there are many means of harnessing energy which have less damaging impacts on our environment.The utilization of the energy in the winds requires the development of devices which convert that energy into more useful forms. This is typically accomplished by first mechanically converting the linear velocity of the wind into a rotational motion by means of a wind turbine and then converting the rotational energy of the windmill hubs into electrical energy by using a generator or alternator.

For purposes here, we can thus view the wind turbine as a mechanical device for extracting some of the kinetic energy of the wind and converting it into the rotational energy of the blade motion. This is accomplished, in detail, by having the blades oriented at some angle to the wind so that the wind blowing past the blades exerts an aerodynamic force on them and thereby causes them to rotate.

TURBINE AERODYNAMICS :

Unlike the old-fashioned Dutch wind turbine design, this relied mostly on the wind's force to push the blades into motion; modern turbines use more sophisticated aerodynamic principles to capture the wind's energy most effectively. The two primary aerodynamic forces at work in wind-turbine rotors are lift, which acts perpendicular to the direction of wind flow; and drag, which acts parallel to the direction of wind flow.

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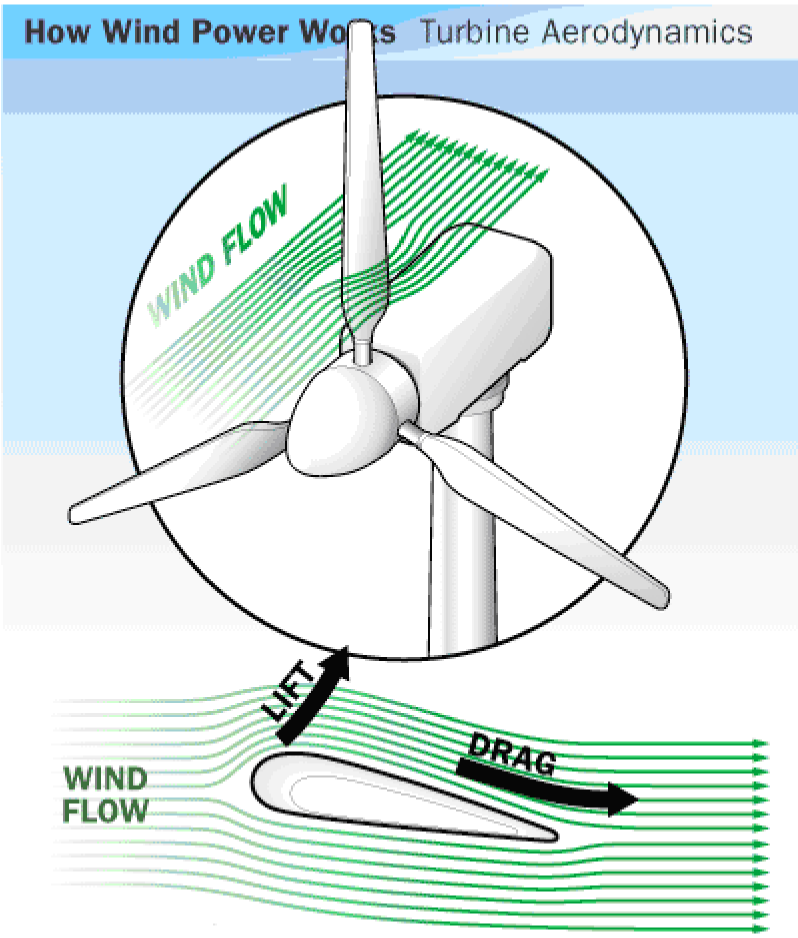

METHODOLOGY :
MODELING :

The windmill hub model has been entirely modeled by PRO E software. First of all sketch command of the pro e is opened. Then by using 2d commands sketch is created. Then 3D model of windmill hub created by using revolve and extrude command.

TRANSFORMATION OF MODEL:

Then the model is converted in to the IGES format which is most suitable and easy access for any other software's.Using the IGES format we can import the windmill hub model from PRO-ENGINEER to ANSYS. Now we can make static structural analysis.

MESHING:

After the complete structure is modeled, windmill hub is meshed. This has been done by using ansys workbench software.

The last step to be completed before meshing the model is to set the meshing controls, i.e. the element shape, size, the number of divisions per line, etc. Selecting the various parts of the model, one by one finite element mesh is generated. The critical portions are plates with sharp corners, curvature etc. These areas can be remeshed with advance mesh control options. "Smart element sizing" is a meshing feature that creates initial element sizes for free meshing operation. Proper care has to be taken to have the control over the number of elements and hence the number of degrees of freedom associated with the structure. This is done to have a control over the solution time. However, no compromise is made on the accuracy of the results.

LOADING:

The types of loading that can be applied in a transient analysis include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (nonzero) displacements

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ANALYSIS:

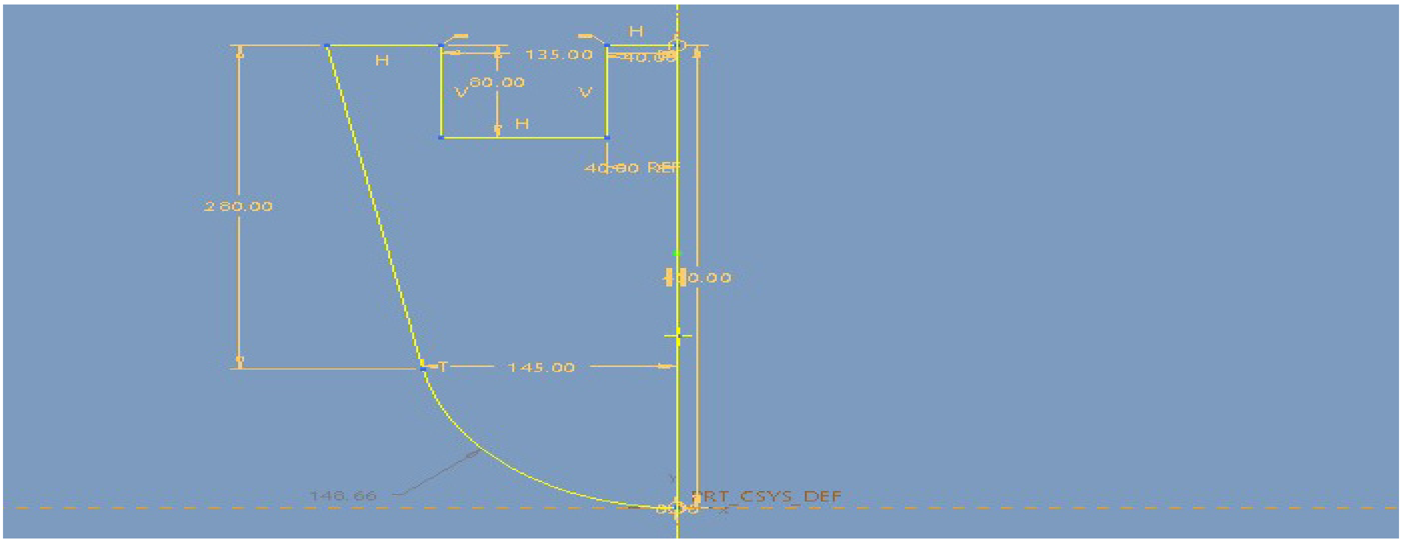
A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the windmill hub model's response are assumed to vary slowly with respect to time.

AIM AND SCOPE OF STUDY :

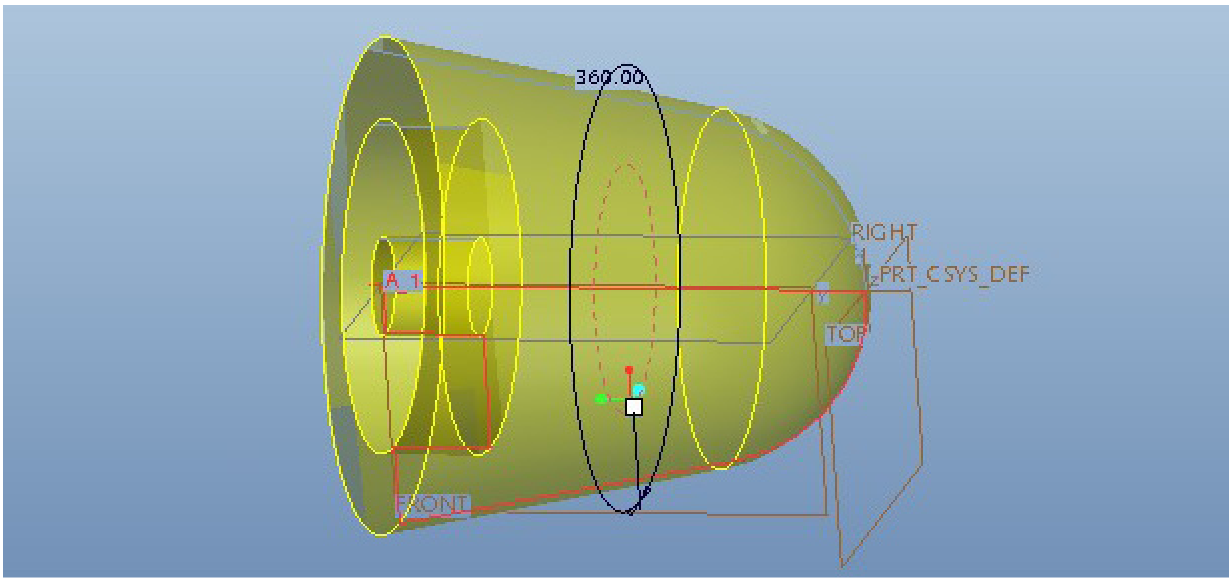
• 3D model of the structure created using pro e, then the model and perform structural analyses of the windmill hub loading conditions such as remote force and rotational velocity on the appropriate portions. The finite element software ANSYS 14.5 is used for the analyses.

• To analyze windmill hub by EN-GJS-400-18-LT (conventional) and two optimized materials such as 1040 carbon steel and carbon epoxy composite in ansys workbench. Then the results of deformation, stress and strain values are getting from ansys finite element method to find suitable material for windmill hub.

MODELLING PROCEDURE :
PRO-E DRAWINGS



2d sketch for windmill hub



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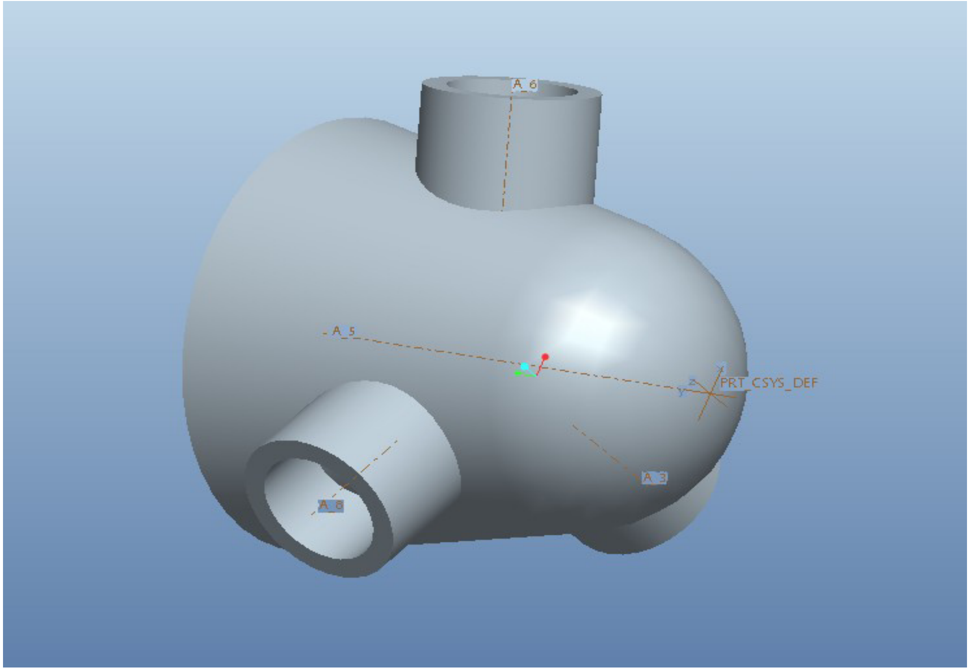
Revolved model of the windmill hub



Full Assembly view of windmill hub using pro e

STATIC STRUCTURAL ANALYSIS:
DEFINITION OF STATIC ANALYSIS:

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).

LOADS IN A STATIC ANALYSIS:

Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (non-zero) displacements
- Temperatures (for thermal strain)

ANALYZING PROCEDURE IN ANSYS :

ANALYZING THE WINMILL HUB – STEP BY STEP PROCEDURE

STEP I – IMPORTING GEOMENTRY

STEP II – MESH GENERATION

STEP III – CREATING NEW SIMULATION

STEP IV – IMPORTING THE MESH

STEP V – DEFINING THE SIMULATION IN ANSYS

STEP VI – SOLVE THE PROBLEM

STEP VII – POST PROCESS THE RESULTS

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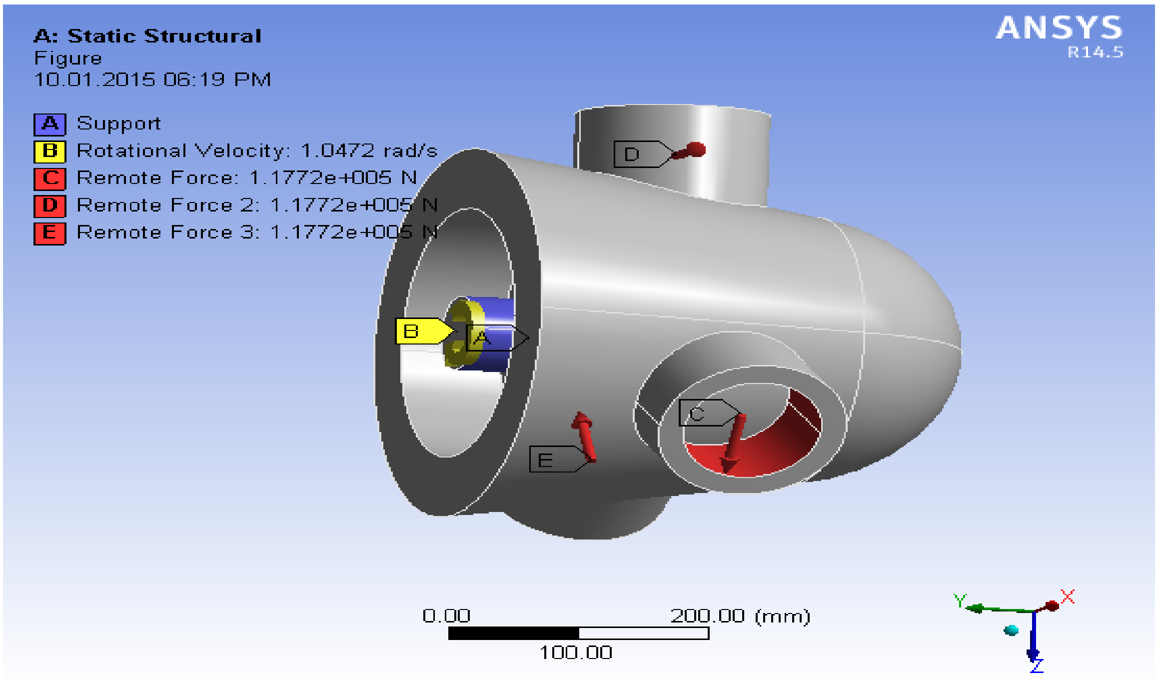
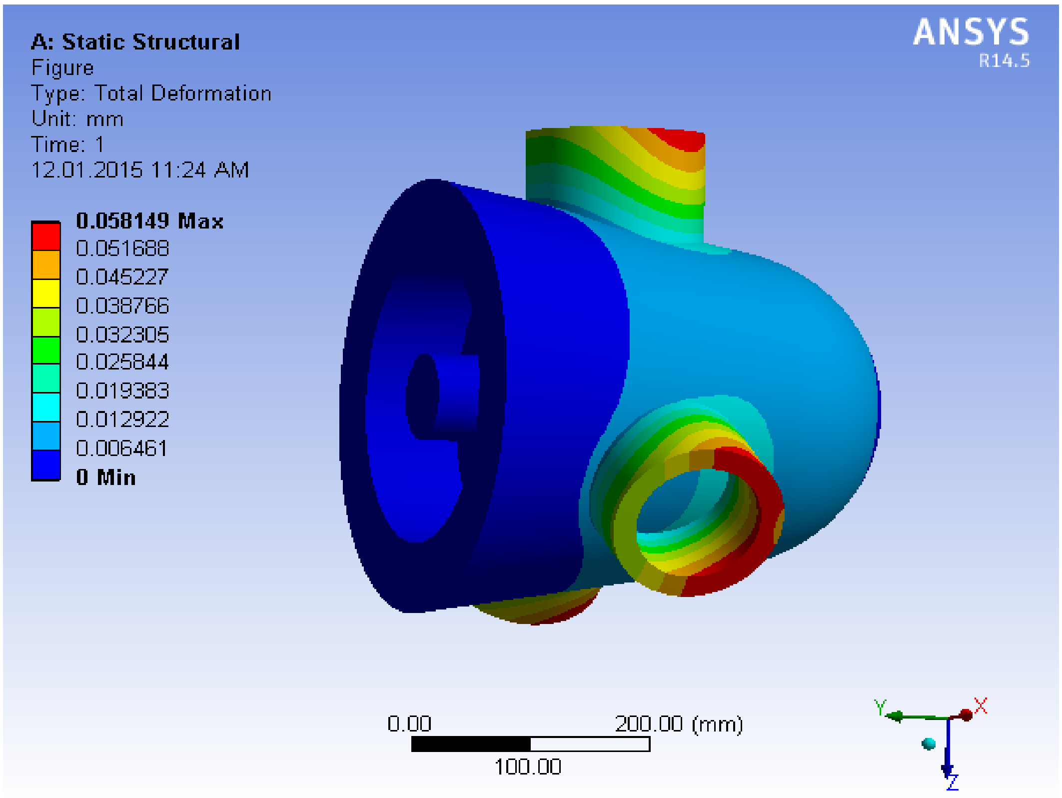
ANALYZING THE WINDMILL HUB THROUGH ANSYS



RESULTS FOR WINDMILL HUB :-



Result for Total Deformation

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RESULTS FOR COVENTIONAL MATERIAL
EN-GJS-400-18-LT SPHEROIDAL CAST IRON

	MIN	MAX
Total deformation	0	0.058149
Equivalent Elastic Strain	7.6109e-9	4.3178e-4
Equivalent stress	5.7292e-4	69.684

RESULTS FOR OPTIMIZED MATERIALS
1040 CARBON STEEL

	MIN	MAX
Total deformation	0	0.051618
Equivalent Elastic Strain	6.6842e-9	3.8459e-4
Equivalent stress	5.7044e-4	69.779

CARBON EPOXY

	MIN	MAX
Total deformation	0	0.053013
Equivalent Elastic Strain	6.8653e-9	3.9498e-4
Equivalent stress	5.7078e-4	69.779

CONCLUSION:

Analysis results from testing the windmill hub under rotational velocity and remote force are listed in the Table. Analysis has been carried out by conventional material i.e. spheroidal cast iron and optimizing the material such as1040 carbon steel and carbon epoxy. The results such as total deformation, equivalent elastic strain and equivalent stress for each material are determined. Comparing the optimized materials and the conventional material, 1040 carbon steel material has the low values of total deformation and equivalent strain. And also the carbon epoxy has low deformation and strain values compared to the existing material. But overall 1040 carbon steel has low values of deformation and strain. Hence it is concluded that 1040 carbon steel material is suitable for the windmill hub. The project carried out by us will make an impressing mark in the field of renewable energy. This project we are study about the windmill hub.

Doing this project we are study about the 3D modeling software (PRO-E) and Study about the analyzing software (ansys) to develop our basic knowledge to know about the industrial design.

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