Design and Fabrication of Wind and Solar Hybrid Power Plant

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Abstract - Wind turbines are considered to be only 59 % efficient (Ref :Betz, law) , and more over with large rotors a large area wake formations means that spacing between two turbines has to be kept very large , hence the conventional method of wind power generation has to thought of again with an innovative approach. The VAWT with vortex turbine is one such concept that uses the principle of generating an added vortex using a set of two vortex generators in order to improve the performance of the turbine Project work will include the design and development of a vortex chambers using unigraphics and   to make a scaled working model using 3- d modelling that will demonstrate electricity generation and testing will be done on the same to determine the effect of wind speed on , turbine speed , voltage , current and power generated by the model.

*Key Words***: Vortex chamber, Wind turbine, Unigraphics, efficient, Innovative.**

1. INTRODUCTION

Fluid-structure interaction problems are multi-physics problems where a fluid interacts with a deformable solid body exerting forces on it. These forces deform the solid body, which modifies the fluid flow as it moves. This kind of interaction is highly complex and different interesting physical phenomena arise. One of them the vortex induced vibrations (VIV), that are vibrations in the solid body resulting from the synchronization of the vortex shedding frequency and the natural frequencies of vibration of the structure through the so called lock-in effect. This interesting phenomenon has been investigated along years and has been recently used to design new wind energy generators, like the proposed by Vortex-Bladeless. Vortex-Bladeless [1] is a Spanish SME whose objective is to develop a new concept of wind turbine without blades called Vortex or vorticity wind turbine, that uses the VIV. The vortex design aims to eliminate or reduce many of the existing problems in conventional generators and represents a new paradigm of wind energy. It is morphologically simple and it is composed of a single structural component, so its manufacturing, transport, storage and installation have clear advantages. The new wind turbine design has no bearings, gears, etcetera, so the maintenance requirements could be drastically reduced and their lifespan is expected to be higher than traditional wind turbines. In the development of this new device, it is of prime importance to be able to test different geometrical configurations, operation conditions and to have energy production predictions. However, it is very hard and expensive to get all this information only through experimental test and devices. It is therefore desirable to have a numerical tool that can help and provide guidance in the design, and give useful information about the operation of the device.

2. PROBLEM STATEMENT

1. The Horizontal wind turbines are large in size, difficult to manufacture, more material required and need to place at long distances hence need more area.
2. We are the Fourth Largest consumer of electricity and we need to cutdown the usage of fossil fuels in electricity generation.
3.The flat blades turbine is giving less efficiency and constant angle couldn't give us proper blade speed, so we can change the angle of blade for different wind speed.

3. OBJECTIVES

1. To Analyze blade design.
2. To Calibrate P.V panel.
3. To Test power generations using solar P.V and spiral wind turbine separately.
4. To Fabricate and test hybrid spiral wind turbine at different locations and determining the generated power density.
5. To determine the economic feasibility of the project.

4. COMPONENTS
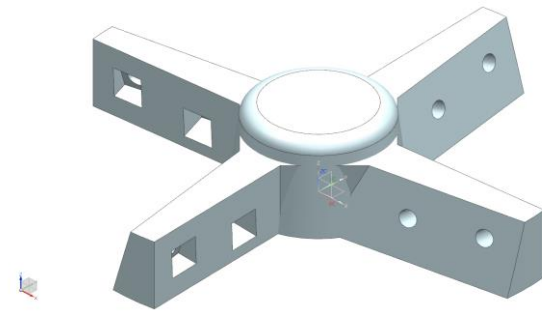
The components in hybrid power plant are: -

4.1. Vortex Chamber

   It is the part that helps to utilise the inner area of the turbine. More wind can be trapped in the middle part of the turbine.
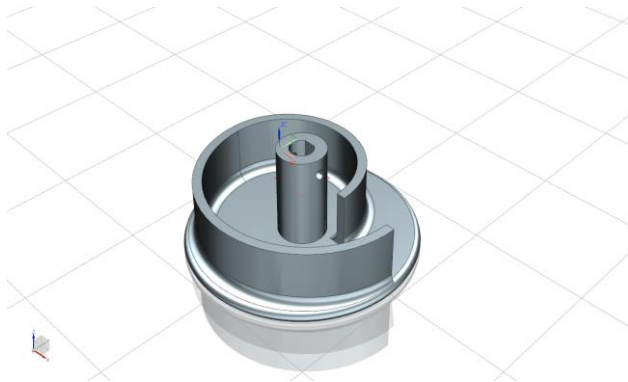
4.2. Vane Holder

They are the parts that mounts the vanes between them. There are two vane holders one on top and one at bottom. These mount the vane and helps to give it specific angle.

4.3. DC Generator

This is the component that converts Mechanical work to the electrical energy. The mechanical work produced by turbine is converted to DC electric current.

4.4. Solar Panel

Solar panel is a device that works on Sunrays. It converts Solar energy into electric current. Solar Panel is a semi-conductor device.

5. DESIGN CALCULATIONS

5.1. Design of Main Shaft

MATERIAL SELECTION

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
AL	400	320

According to ASME code permissible values of shear stress may be calculated form various relation.

= 0.18 x 400

= 72 N/mm^2

fs_{max} = 0.3 fyt

=0.3 x 320   =96 N/mm

considering minimum of the above values;

$\Rightarrow fs_{max}$ = 144 N/mm^2

Shaft is provided with key way; this will reduce its strength. Hence reducing above value of allowable stress by 25%

$\Rightarrow fs_{max}$ = 108 N/mm^2

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

TO CALCULATE ROTOR SHAFT TORQUE

$$POWER = \frac{2\,\Pi\,NT}{60}$$

MAX POWER IN WIND @ 80 KMPH 90 watt power, run at 8000 rpm,

Hence input to rotor shaft = 8000 rpm

$$\Rightarrow T = \frac{60\,x\,P}{2\,x\,\Pi\,x\,N}$$

$$= \frac{60\,X\,90}{2\,X\,\Pi\,X\,8000}$$

$\Rightarrow$ T = 0.107N-m

$\Rightarrow T_{design}$ = 0.107 N-m

CHECK FOR TORSIONAL SHEAR FAILURE OF SHAFT.

Assuming minimum section diameter on input shaft = 6 mm

$\Rightarrow$ d = 6 mm

Td = $\Pi/16$ x fs_{act} x d^3

$$\Rightarrow fs_{act} = \frac{16\ x\ Td}{\Pi\ x\ d^3}$$

$$= \frac{16\,x\,0.107x\,10^3\,X\,14}{\Pi\,x\,(14^2 - 8.8^2)}$$

$\Rightarrow fs_{act}$ = 64.5 N/mm^2

As $fs_{act} < fs_{all}$

$\Rightarrow$ I/P shaft is safe under torsional load

5.2. DESIGN OF DYNAMO COUPLER SHAFT

MATERIAL SELECTION: - Ref: - PSG (1.10 & 1.12) + (1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
EN 24	800	680

According to ASME code permissible values of shear stress may be calculated form various relation.

= 0.18 x 800

= 144 N/mm^2

OR

fs $_{max}$ = 0.3 fyt
      =0.3 x 680 =204 N/mm
considering minimum of the above values
  $\Rightarrow$ fs $_{max}$ = 144 N/mm^2

  $\Rightarrow$ fs $_{max}$ = 108 N/mm^2
    This is the allowable value of shear stress that can be induced in the shaft material for safe operation.
$\Rightarrow$ T design = 0.107 N-m
CHECK FOR TORSIONAL SHEAR FAILURE OF SHAFT.
Assuming minimum section diameter on shaft = 6 mm
$\Rightarrow$ d = 6 mm
Td = $\Pi/16$ x fs $_{act}$ x d^3

$\Rightarrow$ fs $_{act}$ = $\dfrac{16 \ x \ Td}{\Pi \ x \ d^3}$

      = $\dfrac{16 \ x0. \ 107 \ x \ 10^3}{\Pi \ x \ (6)^3}$

      $\Rightarrow$ fs $_{act}$ = 2.52 N/mm^2
      As fs $_{act}$ < fs $_{all}$
$\Rightarrow$ shaft is safe under torsional load

5.3. Design of Shaft Bearing

BALL BEARING SELECTION
Series 60

ISI NO	Brg Basic Design No (SKF)	d	D1	D	D2	B	Basic capacity	
							C kgf	Co Kgf
15A C02	6002	15	17	32	30	9	2550	4400

P = X Fr + Yfa.
Where ;
P=Equivalent dynamic load(N)
X=Radial load constant
Fr= Radial load(H)
Y = Axial load contact
Fa = Axial load (N)
In our case;
Radial load F_R= T1 +T2=
F_a = 0
P= 140.4 N
$\Rightarrow$L= (C/p) ^{p}
Considering 4000 working hours
L = $\dfrac{60 \ n \ L \ h}{10^6}$ = 336 mrev

$\Rightarrow$ 336 = (C / 140.4) ^{3}
$\Rightarrow$ C = 976 N
AS; required dynamic of bearing is less than the rated dynamic capacity of bearing ;

$\Rightarrow$ Bearing is safe.

3. CONCLUSIONS

1. In this study, a vertical axis wind turbine was fabricated. The reason for choosing VAWT was its ability to generate power at lower wind speeds.
2. The testing of the VAWT was done at various locations and was thus concluded that the setup was useful for power generation.
3. Most of the areas in India have low to medium wind speeds, hence to cater the needs of electric power for domestic use, VAWT are more suitable. This turbine of smaller capacity coupled with efficient electric generator can be installed in rural and urban areas for electric generation. This study essentially gives better design of VAWT for low wind speed application.
4. India which is facing a massive power crunch should urgently put together a comprehensive policy and regulations to fast forward the growth in this sector.

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