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DESIGN AND ANALYSIS OF DIFFUSER AUGMENTED AXIAL FLOW WIND TURBINE TO ASSESS WIND ENERGY FROM HIGHWAY

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Abstract - *The aim of the project is to design a wind turbine to recapture wind energy from vehicles moving on the highway which is presently not utilized. As any automobile passes along the path, it creates a very huge air pressure on the nearby surrounding areas. In a moving vehicle air streams are sliding all sides of vehicle and dispersed in open atmosphere, that air can be collected and concentrated in an axial flow wind turbine. This high pressure of wind is till now of no use. Till now there is no as such technology developed to utilize this high pressure column of wind so generated. With concern to this, we had tried to develop a wind mill which work on the principle of these highway wind energy. This wind turbine can be installed in the divider and sideways in the highway. To increase the velocity of incoming air the turbine is augmented with a diffuser type duct.*

Key Words: Wind turbine, Moving Vehicles, Recapture of wind energy, Wind velocity, Diffuser type Duct.

1. INTRODUCTION

When the vehicles moves on highways, pressure column is created on both the sides of the road due to imbalance of high pressure/low pressure energy band created by the automobiles. Due to this pressure band wind flow and create pressure thrust. This wind Pressure thrust depends upon the:-

- The number vehicles moving on the highway.
- The size of the vehicle.
- The speed of the vehicle.

This Pressure thrust of wind energy can be converted into mechanical energy with the help of small turbines placing them on the sides of highways and center. A vertical axis wind turbine is used for this purpose which converts kinetic energy from air from highway to electrical power [1].

In 2012 a concept of vertical axis wind mills has developed which consisting of stationary shaft with ball bearing at top and bottom of the shaft can be connected to generator with the help of gear drive system. Dynamo is connected to either upper or lower part of the turbine. Turbine has a vertical axis curved shaped covering. This system is used to produce electricity and use it instantly or can be transferred to nearby village or can be used to develop and maintain a bio diversity or wild life sanctuary nearby. Clean energy will avoid greenhouse gases. By this method the overall cost per unit of energy produced is less than the cost of new coal, natural gas and its installation [1, 2].

The diffuser augmented horizontal axis tidal current turbines that will capture kinetic energy. Electricity is generated from the tides, by using horizontal axis wind turbine. The NACA 006 Airfoil is used to design wind turbines. The power generated by a tidal current turbine is directly proportional to the cube of velocity of incoming flow, thus, even a minor increase in velocity substantially increases the generated power. The role of the diffuser in diffuser augmented tidal turbines is to help accelerate the incoming current velocity. By this the efficiency of the turbine is significantly increased [3].

The concept of shroud is that it will increase the efficiency of the turbine. One advantage of the diffuser is that it should align itself into the wind, thus eliminating the need for a rudder downstream of the blades. Another advantage is that it should be maintenance free. The simulation are carried out in diffuser shroud, nozzle shroud, steam tube shape configuration and bare turbine, 300 and 600 RPM Simulations (40 Degree Diffuser Shroud).This types of turbines can generate large amount of electricity. The main part of the turbine is blade along with concept some blade efficiency and power calculation are done to improve the accuracy of the outcome .this will be helpful to develop better wind turbine with high power generation by this we can improve the use of renewable resources[4 ,5,7].

The aim of the project is to develop a diffuser to increase the efficiency of the turbine for placing the set up on dividers in the highway sides .This turbine rotates due to the energy pressure created by the nearby moving automobiles which can further be used to produce huge amount of electricity than normal wind turbine with the help of generators. [8]These turbines can be installed just near by the highways as well as railway tracks which can useful to rotate these turbines. The motivation for this project is to contribute to the global trend towards clean energy in a feasible way.

2. METHODOLOGY

Renewable energy resources are becoming an increasingly important part of our total energy demands due to the depletion of fossil fuels and the emergence of global warming. There are mainly three methods for producing electricity Hydraulic power method, Nuclear power method and Wind power method. Here we are using the wind turbine to generate electricity.

2.1 Material selection

The material mainly used for turbine blade and duct is mild steel. This is because mild steel is tough, ductile and malleable. It has good tensile strength but poor corrosion resistance. It is mainly used as an all-purpose engineering material. Mild steel is a very popular metal and one of the cheapest types of steel available. It's found in almost every metal product. This type of steel contains less than 2 percent carbon, which makes it magnetize well. Since it's relatively inexpensive, mild steel is useful for most projects requiring huge amounts of steel.

Putting a coat of grease or oil on mild steel also helps to protect it from corrosion. Because it is a soft material, mild steel is easy to weld, whereas high-carbon steels, such as stainless steel, require the use of specialized welding techniques. Also, electricity can flow through mild steel easily without impacting its structural integrity. Mild steel is a variant of hard steels, which makes it much less brittle and enhances its flexibility. Properties of mild steel are

Density - 7861.093kg/m3, Young's modulus - 200Gpa,

Poisson's Ratio – 3.

2.2 Design calculation

Step: 1 Tip speed ratio

Tip speed ratio (TSR) = ΩrVr

Where,

Ω = angular velocity

r = radius of turbine

Vr = rated air velocity (m/s)

Tip speed ratio for 3 bladed turbine is

Approximately 5-6

Step: 2 Power available using ducted wind turbine

Wind velocity=80km/hr =22.22m/s

P = 12ρAV3

P = ½∗1.225∗π∗.32* (23)3

P = 2107.08W

Step: 3 Blade Rotation per minute

RPM = 60*V*TSR/ (πD) = 60*23*6/ (3.14*.6) = 4519.

Step: 4 Design of duct

Diameter of duct =31∗2=62 cm

(Since blade dia. is 60 cm)

Diffuser angle

θ_d=22°

Nozzle angle

θ_N =40°

From the ansys cfx results,

Length of duct:

Diffuser = 7M

Duct = 2M

Nozzle = 3M, M is constant,

Let M =20 and dimension be in cm

Diffuser = 7∗20 = 140 cm

Duct = 2∗20 = 40 cm

Nozzle = 3∗20 = 60 cm

Dimensions of the setup:

Diffuser = 140 cm, Duct = 40 cm, Nozzle = 60cm.

2.3 Position of turbines

The turbines are arranged in such a manner that the fan's are opposite to vehicles.

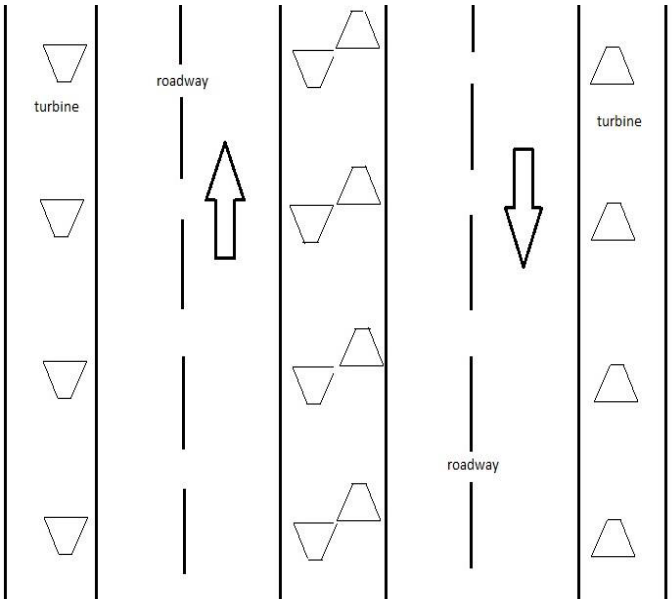

Fig -1: Position of wind turbine

3. EXPERIMENTATION

Designing in CATIA V5R20Computer Aided Three Dimensional Interactive Application is a 3D Product Lifecycle Management software suite developed by the French Company Dassault Systems. CATIA allows the user to create parts in highly productive and intuitive environment. CATIA enriches existing product design with basic part and surface design tools; easily establish assembly constraints, automatically positions parts and check assembly consistency.

3.1 Procedures in CATIA V5 R20

Sketcher, Part modeling, Assembly, Drafting, Wireframe, Surface design and Sheet metal design.

- Sketcher

  For creating 2D profiles with associated constraints which can then be used to create other 3D geometry.

- Part Design

  Designing parts using solid modeling approach.

- Assembly design

  For creating constraints, features and specifications for parts in the context of an assembly.

- Generative sheet metal design Components to get folded and unfolded representation.

- Generative Drafting

  For creating drawings from parts and assembly designs.

- Wireframe and surface design

  For creating complex part features with 3D wireframe and surface elements.

3.2 Model designed for diffuser augmented turbine

Fig -2: fully rendered model of wind turbine

3.3 ANSYS CFX

Ansys is an engineering simulation software (computer aided engineering, or CAE) developer headquartered south of Pittsburgh in the South point business park in Cecil Township, Pennsylvania, United States. One of its most significant products is Ansys CFD, a proprietary computational fluid dynamics (CFD) program. Ansys CFD Ansys CFD allows engineers to test systems by simulating fluid flows in a virtual environment for example, the fluid dynamics of ship hulls.

3.4 Procedure for analysis

- The geometry (physical bounds) of the problem is defined.
- The volume occupied by the fluid is divided into discrete cells (the mesh). The mesh may be uniform or non-uniform.
- The physical modelling is defined – for example, the equations of motion + enthalpy + radiation + species conservation.
- Boundary conditions are defined. This involves specifying the fluid behavior and properties at the boundaries of the problem. For transient problems, the initial conditions are also defined.
- The simulation is started and the equations are solved iteratively as a steady-state or transient.
- Finally a postprocessor is used for the analysis and visualization of the resulting solution.

Analysis Result

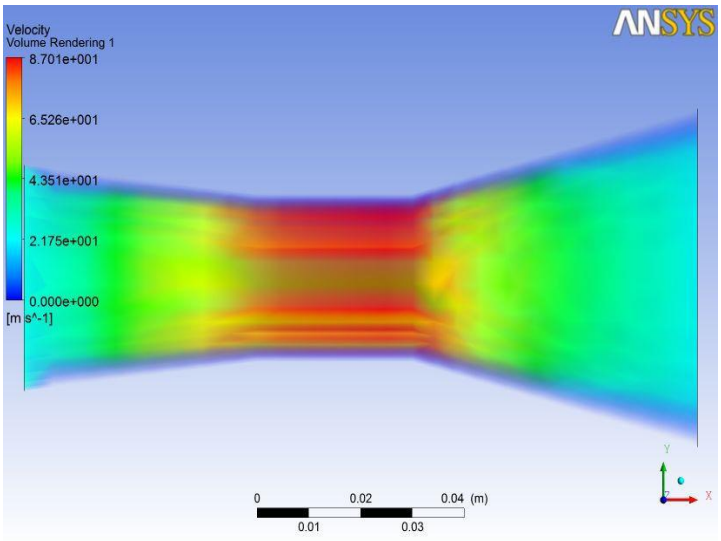

Fig-3: Velocity result of diffuser

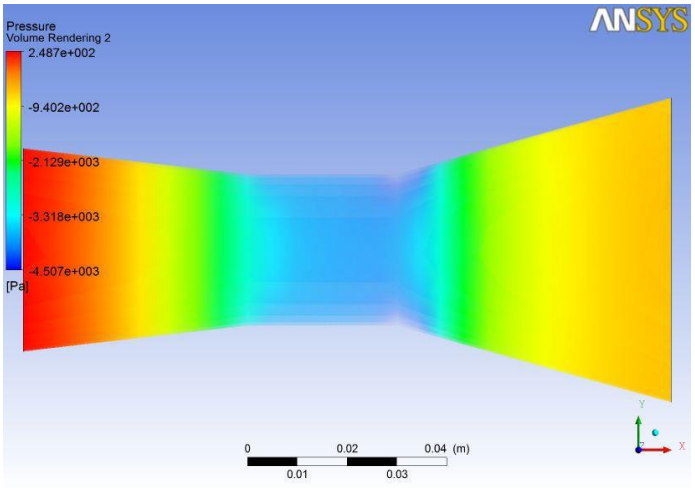

Fig-4: Pressure result of diffuser

4. CONCLUSION

Wind has a lot of potential in it and if properly harnessed then it can help solve the energy crises in the world. The study of wind turbine and its characteristics showed that how it can be properly designed and used to get the maximum output. The power electronic circuitries have helped the concept of wind power a lot. Without them this concept would have been too expensive and farfetched. With the thyristors and converters being used not only the operations have been smoothened but also the efficiency has been increased to a great extent. From the voltage stability analyses it was showed that how a doubly fed induction generator has superior characteristics than a simple induction generator. This report also showed the integration of wind farms with the transmission grid and the problems associated with it and the probable solutions that can be applied to solve them and have a better performance. Turbine on highway has potential to generate a large amount of energy that can be used to power streetlights, other public amenities or even generate profits by selling the power back to the grid this design concept is meant to be sustainable and environmentally friendly. Additionally, a wind turbine powered by artificial wind has a numerous applications. The energy produce by turbine is environmental pollution free.

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