Design and Fabrication of Gorlov VAWT for Highway Street Lights

Naveen kumar.P[1], Vikas Varma.S[2], Jayanth Aditya.T[3], Vinay.Y[4]

[1]Assistant Professor Department of Mechanical, Hindusthan Institute of Technology, Coimbatore, Tamil Nadu, India.

[2,3,4] Student Department of Mechanical, Hindusthan Institute of Technology, Coimbatore, Tamil Nadu, India.

******

ABSTRACT:

Wind energy is one of the non-conventional forms of energy. In renewable sources of energy wind energy has its applications at times as it is abundantly available in the environment. Electrical energy can be generated with the help of VAWT (Vertical Axis Wind Turbine). The main motive of this project is to generate energy for useful work by using wind energy in the most effective manner, i.e., getting the maximum output. For installing this type of setup spacious area where we can find wind with high speed as it is our requirement and therefore we selected highways as our installing sites. We can also take advantage of moving vehicles with their speed when they are passing over these turbines. In this project we are using Gorlov Vertical Axis Wind Turbine. The working of this VAWT follows as, the blades connected to a disc which is connected to a shaft. The shaft is then coupled with pulley with the bearing, and then pulley is connected to an alternator, which generates electricity.

KEY WORDS: Helical wind blades, Support stand, Gear box, Dynamo, Self-aligning bearing.

1. INTRODUCTION:

The Gorlov wind turbine is a type of vertical axis wind turbine (VAWT) consists of helical blades which is a unique design optimized for areas where the air flow is low and erratic. It is designed to be compact, cost effective and efficient solution for generating power to the highway lights. Therefore, we aim to design and fabricate a Gorlov vertical axis wind turbine as a project.

To design the wind turbine we will be using the Solid Works software and to fabricate this CAD That it is functioning properly and generating the required amount of electricity

2. LITERATURE REVIEW:

There were projects done by others on Gorlov vertical axis wind turbine (VAWT). There have been various researches, studies and experiments to design and fabricate Gorlov wind turbine for highway lights.

One study by V. Jayaram, (Department of Mechanical Engineering) and B. Bavanish, (Department of Fire Technology and Safety Engineering), Noorul Islam Center for Higher Education, Tamil Nadu, India).

Material Today: Proceedings 37(2021)3343-3351. Article Received: 15 July 2020, Accepted: 7 September 2020, Available online: 22 October 2020.

Their article reviews the various technologies in crossflow hydro turbines and the viability of installing Gorlov helical turbine inn possible potential sites. Various design approaches to Gorlov helical turbine are outlined with simulation.

Another study on design and development of vertical axis wind turbine blade done by D. A. Nikam (PG Scholar, CAD/CAM) and S. M. Kherde (Principal & professor CAD/CAM), Dr. Sau Kamalatai Gawai Institute of Engineering and Technology, Darapur.

International Journal of Engineering Research and Application (IJERA) ISSN: 2248-9622 National Conference on Emerging Research Trends in Engineering and Technology. (NCERT 2nd &3rd November 2015).

Kumar and Dwivedi (2015) designed and fabricated a Garlov wind turbine for street light applications. The authors used a mathematical model to design the turbine, and then fabricated it using low-cost materials such as PVC pipes, aluminum strips, and steel rods. The authors conducted experiments on the turbine and found that it performed well in low wind speed conditions, producing up to 30 watts of power.

Shaligram and Kulkarni (2017) also designed and fabricated a Garlov wind turbine for street light applications. The authors used a mathematical model to optimize the design of the turbine, and then fabricated it using aluminum blades and steel shafts. The authors conducted experiments on the turbine and found that it produced up to 50 watts of power in wind speeds of 4-6 m/s.

Hasanuzzaman et al. (2018) designed and fabricated a Garlov wind turbine for street lighting systems in rural areas. The authors used a mathematical model to optimize the design of the turbine, and then fabricated it using fiberglass blades and an aluminum frame. The authors conducted experiments on the turbine and found that it produced up to 80 watts of power in wind speeds of 4-6 m/s.

Sridhar et al. (2020) designed and fabricated a Garlov wind turbine for street light applications. The authors used a mathematical model to optimize the design of the turbine, and then fabricated it using PVC pipes, fiberglass blades, and an aluminum frame. The authors conducted experiments on the turbine and found that it produced up to 60 watts of power in wind speeds of 4-6 m/s.

Raveendran and Sathish Kumar (2021) conducted experimental investigations on a Garlov wind turbine for street light application. The authors used a mathematical model to optimize the design of the turbine, and then fabricated it using aluminum blades and a steel shaft. The authors found that the turbine performed well in low wind speed conditions, producing up to 25 watts of power.

3. PROPOSED METHODOLOGY:

Using the following methodology, a Gorlov wind turbine for street light can be design and constructed:

A .Requirement Analysis: Identify the power requirement of the street lights, the location of the wind turbine, and the available wind resources. This will help determine the size and specification of the wind turbine.

B. Design the Blade: Design the blades of the wind turbine with help of Solidworks software. The blades should be aerodynamically efficient, and the shape should be such that it can rotate smoothly even at low wind speed.

C. Design of Rotor: The rotor is the central rotating part of the turbine. The rotor can be designed using Solidworks and then fabricated using 3D printer.

D. Design of Dynamo: The Dynamo is used to convert the rotational energy of the rotor into electrical energy.

E. Fabricate the components: Once the design is finalized, the components of the turbine can be fabricated. The blades can be made of Aluminum, while the rotor can be made of iron.

F. Assemble the turbine: The turbine can be assembled by attaching the blades to the rotor and then mounting the Dynamo on the turbine shaft.

G. Install and test the turbine: The turbine can be installed at the site where the street lights are located. The turbine should be tested to ensure.

4. COMPONENTS REQURIMENT:

A. Blades:

Wind turbine consists of three blades. The blades are made up of Aluminum because they provide better strength and light weight material. The design of the individual blades also affects the overall design of the rotor. Blades are connected to the rotor parallel.

Specifications:

Material- Aluminum, thickness- 1.2mm, length *breadth- 65*100.

Figure 1: Blades

B. Shaft or Rotor:

The shaft is the part that gets turned by the turbine blades. The material used for manufacturing the shaft is iron.

Specifications: Diameter of shaft- 25mm.

C. Self-aligning bearing:

The type of the bearing we used in the wind turbine is Self-Aligning Ball Bearing – open, double row (1205). The features of ball bearing is the inner ring, ball, cage shaft have alignment properties that allow them to freely rotate around the center of the bearing. Since the friction is smaller than that of roller bearing, it is difficult for the temperature to rise even at high speeds.

Figure 2: Self-aligning bearing

D. Clamps:

Clamps are a tool that used to hold work securely to place, so that the work remains rigid in the desired position.

Figure 3: Clamps

E. Gear Set:

Gears are used to transfer motion and power between moving parts. Gear is connected to main shaft therefore when the driving gear rotates along with main shaft.

Specifications:

Type: Spur gear
No. of teeth on large gear= 50 teeth
No. of teeth on small gear= 12 teeth
Ratio= 4.16

Figure 4: Gears

F. Dynamo:

A dynamo is an electrical generator that utilizes mechanical energy to generate electricity. Dynamo converts mechanical energy to electrical energy. Dynamo is connected to gear.

Figure 5: Dynamo

5. PROBLEM DESCRIPTION:

The design and fabrication of Gorlov vertical axis wind turbine is raised due to need of sustainable energy source for highway lights. We observed many highway lines are in use which has no light posts for a long distance and failure of highway lights due to not enough extension of power supply lines and other causes which has no immediate fixtures.

This may be able to cause many accidents and misleading of vehicles into path of dangers. Whereas, this problem can be fixed with the help of renewable energy source which can be reliable at times of difficult circumstances.

This method is suggestable and the best way to generate the electricity by using nature as primary resource, as air abundantly available in environment. Traditional sources of energy can also be used and can be more effective, but the resources are finite and cause environmental pollution and climate change.

Street lights and the lights at the highway lines are crucial in modern cities, towns and villages for providing safety and security to both vehicle drivers and pedestrians.

However the cost of supplying power to such extents can be significant. Because as we know how the situation can be in remote areas to access the power to basic needs and the grid is unreliable. Now here , the Gorlov vertical axis wind turbine promises the potential to produce the enough electricity required for street lights at highways in rural area. The compact size and design of the vertical axis wind turbine will make it suitable for both urban and rural areas.

Regardless of space and height limitations the installation of a vertical axis wind turbine would be so much practical rather than a horizontal wind turbine.

The limitations like space and height are not taken into considerations when it comes to vertical axis wind turbine because VAWTs have lower wind start up speed and can generate electricity at 10km/h.

Additionally, the Gorlov wind turbine is durable, efficient and need low maintenance when compared to other sources of energy. The main challenge is optimizing its performance in a range of various wind conditions. On final note, the Gorlov wind turbine for highway street lights providing the need for a sustainable and reliable source of energy, while also provides a cost effective and efficient solution.

6. PROBLEM STATEMENT:

The main objective of this project is to generate electricity to power the highway street lights through sustainable and renewable energy by designing and fabricating a Gorlov vertical axis wind turbine. This design of wind turbine is going to produce electricity in a sustainable and efficient manner. The design and fabrication of this vertical axis wind turbine will involve a multi-disciplinary approach which includes elements of mechanical and electrical engineering.

We know the importance of functioning of highway street lights, and difficulty may arise in achieving that goal due to unreliable or non-existing power grids at the highway lines near to remote areas and fail to supply the power lines to the far extents. With the help of this project the above goal can be achieved in a sustainable and efficient manner to produce power to the highway street lights to a far extent.

Developing this design of Gorlov vertical axis wind turbine can be a revolutionary aspect in renewable energy sources to produce electricity in most efficient way. The most advantageous aspect of this project is, it needs low maintenance and durability is high This design can help in reducing the reliance on traditional energy sources and contribute to a more eco-friendly future.

7. SOLUTION:

The solution to the problem of producing the power to the highway street lights with a renewable and reliable source of energy is the design and fabrication of Gorlov vertical axis wind turbine which is optimized for use to power the highway street lights in both urban and rural areas.

There are some necessary steps that are need to take into consideration to develop an effective solution for the present problem:

The first step in this process is to conduct site survey where the Gorlov wind turbine is going to be installed. This survey will determine the speed and direction of wind, as well as the height and location of the turbine.

Second step involves the designing of wind turbine. The wind blades, rotor, gear set, body frame and generator can be designed using various design software like computer-aided design (CAD), Solid works, CATIA and etc.

Now the designed components need to fabricate. That can be done by various approaches like using combination of 3D printing and manual techniques. The materials selection for fabrication is on the basis of durability, strength and cost-effective.

The last step in this process is to test the turbine performance in different wind conditions. The work efficiency and reliability of the wind turbine should be measured and required alternatives have to be done in order to optimize its performance. After completion of performance test of the wind turbine, it needs to be installed at the locations where it is needed.

This solution provides the most sustainable, efficient and eco-friendly manner to produce the electricity to power the highway street lights and offers several advantages.

It reduces the reliance on the traditional energy sources like fossil fuels, gas, coal and etc. which leads to environmental pollution. It cost effective, low maintenance and contributes to a more sustainable future.

8. GORLOV VERTICAL AXIS WIND TURBINE:

We are using Gorlov vertical axis wind turbine (VAWT) for highway lighting system. Gorlov vertical axis wind turbine was invented by Alexander M. Gorlov, a professor of Northeastern University. Gorlov wind turbine is a variant and evolved version of Darrieus wind turbine design. The design of Gorlov wind turbine varies from Darrieus wind turbine at rotor blades section.

The rotor blades of Gorlov wind turbine are kind of helical which means they are bent at certain angle and attached to the rotor shaft. The reason for this design is to increase the drag force. This feature leads Gorlov turbine into various applications.

It will be most suitable in the situations where the areas have low cut in wind speed. Vertical axis wind turbines are reliable as it can use air regardless of its direction. This type of vertical axis wind turbine has no restrictions regarding theheight and spacious requirement as its main components located near to the ground, it can receive non-directional and low cut-in wind speed.

We designed this Gorlov axis vertical wind turbine which differs from the most of the existing model. There is a curved plate attachments which have been welded between the rotor blades to the rotor shaft. This additional attachment will increase the drag force due to air and number of rotations of the rotor blades due to increase in torque. With the help of this attachment, the wind turbine can generate more output in an efficient way.

We installed dynamo capacity of 12 volts which has gear setting to its shaft and connected to another gear which is attached to the main rotary shaft the wind turbine. So, the maximum output generated maybe 12 Volts.

3D Image of garlov:

Figure-6 : 3D Image

2D Image of garlov:

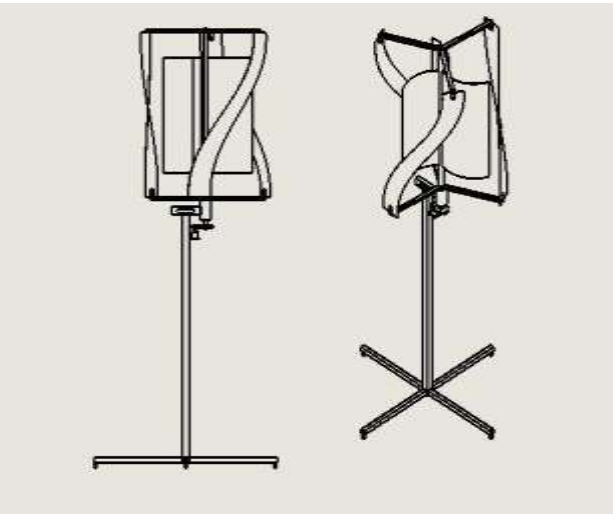


Figure 7 : 2D Image

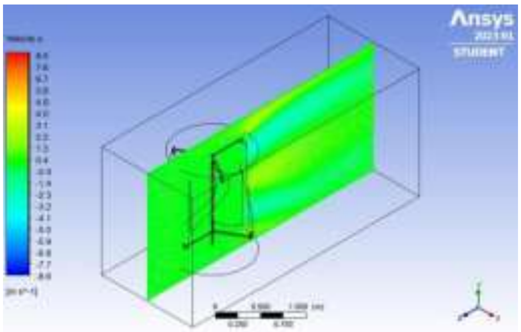
9. WORKING:

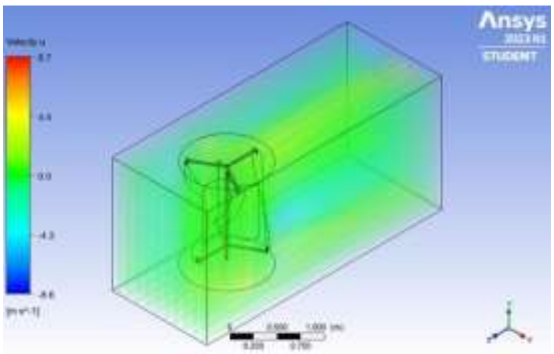
The working of Vertical Axis Wind Turbine is to convert Rotational energy in Electrical energy. Vertical axis wind turbine components are blade, shaft, bearing, support stand. For vertical axis wind turbine, the axis of rotation of the turbine is perpendicular to the wind stream. Blades are connected to rotor vertically. The shape of the turbine blades is curved to get the wind for revolution from road Where the vehicle speed will makes this turbine turns. The rotors in the turbine revolve around a vertical shaft by using vertically oriented blades.

A vertical axis wind turbine is connected to the Gearbox which includes gears. This gearbox is directly connected to the electric dynamo shaft. This turbine will revolve once the wind blows & the gearbox in this system will enhance the turbine rotations internally & send these rotations to the generator like a mechanical input. So the dynamo will generate the output as the electrical energy by using this input. LED is connected to dynamo when the turbine will rotate it blinks the LED. This turbine is arranged on the dividers of the highway roads.

Figure 8 : Prototype

10. WIND ANALYSIS





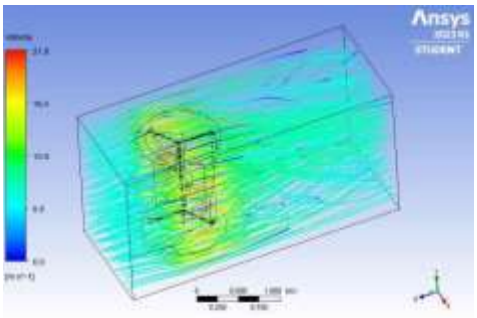


Figure 9 : Wind Analysis

The above scenario shows the wind analysis of Gorlov vertical axis wind turbine (VAWT) blades and how it acts under different wind ranges. The description of the above analysis process is given below in detail.

File Report

Table 1. File Information for FFF

Case	FFF
File Path	C:\Users\Y.VINAY\final project analysis_files\dp0\FFF\Fluent\FFF.flp
File Date	03 May 2023
File Time	07:12:48 AM
File Type	CFF
File Version	--

Mesh Report

Table 2. Mesh Information for FFF

Domain	Nodes	Elements
enclosure	34571	183395
rotary	50530	172412
All Domains	85101	355807

Physics Report

Table 3. Domain Physics for FFF

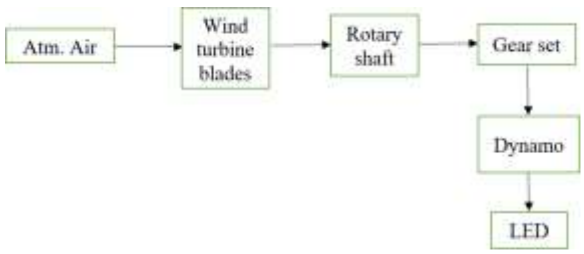
Domain - enclosure	
Type	FLUID
Location	enclosure
Domain - rotary	
Type	FLUID
Location	rotary

Table 4. Boundary Physics for FFF

Domain	Boundaries	
enclosure	**Boundary - inlet**	
	Type	VELOCITY-INLET
	Location	inlet
	Boundary - inlet1 contact_region trg	
	Type	INTERFACE
	Location	inlet1-contact_region-trg
	Boundary - inlet2 contact_region trg	
	Type	INTERFACE
	Location	inlet2-contact_region-trg
	Boundary - inlet3 contact_region trg	
	Type	INTERFACE
	Location	inlet3-contact_region-trg

	Boundary - opening	
	Type	WALL
	Location	opening
	Boundary - outlet	
	Type	OUTFLOW
	Location	outlet
rotary	**Boundary - int 1r contact_region src**	
	Type	INTERFACE
	Location	int-1r-contact_region-src
	Boundary - int 2r contact_region src	
	Type	INTERFACE
	Location	int-2r-contact_region-src
	Boundary - int 3r contact_region src	
	Type	INTERFACE
	Location	int-3r-contact_region-src
	Boundary - wall	
	Type	WALL
	Location	wall

11. BLOCK DIAGRAM



12.COMPARISON BETWEEN EXISTING MODEL AND DEVELOPED MODEL:

Existing Model:

Figure 10

- The existing model has blades in a helical shape configuration.
- Less efficiency.
- Low starting torque.
- No additional attachments done to increase the number of RPMs.
- Covers very low swept area.
- It traps less air in the bent of the rotor blades. Thus, the drag force is comparatively low.
- Generated output maybe low compared to the developed design.

DEVELOPED DESIGN MODEL:

Figure 11

- This design is done to improve the performance than the existing Gorlov vertical axis wind turbine model.
- The developed design is somewhat similar to the existing model at the blades portion.
- But there is an additional attachment which makes it different from the existing model.
- Curved plates have been welded between the each of the three blades to the rotary shaft.
- This additional attachment helps to trap more air to increase the drag force.
- Hence, the number of rotations of the rotor blades increases with the torque produced due to the drag force.
- High efficiency can be achieved compared to the existing model.
- Swept area is more compared to the existing model.
- Generates more output than the existing model.

13. ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

A. Vertical axis wind turbines comparatively have lower noise operation than horizontal axis wind turbines.
B. Electricity can be generated regardless of wind direction.
C. No environmental pollution. VAWTs relatively have start up at lower wind speed than HAWTs.
D. Space and height limitations may not be taken into consideration.
E. Easy installation.
F. Smoother torque curve.
G. Less vibration and noise.

DISADVANTAGES:

A. Most of the VAWTs produce energy at only 50% of the efficiency of HAWT.
B. Changing the parts of VAWTs is nearly impossible because they are located on the ground and under the weight of the structure above it.
C. VAWTs may not produce as much energy as HAWT because the rotors are located near to the ground where the wind speeds are low.
D. Access to lower wind speed.
E. Efficiency of rotation is less.

14. CONCLUSION:

In conclusion, the design and fabrication of a Gorlov vertical axis wind turbine (VAWT) for highway street lights providing a reliable solution to the criteria of supplying power to the street lights in the highway lines with a sustainable and efficient source of energy. The design and compact size of the Gorlov vertical axis wind turbine making it ideal for use at the highway lines near remote area and urban area. Drawbacks like space, height and direction of wind flow and etc. don't make an obstacle for a vertical axis wind turbine. As the rotor blades are parallel to the shaft the drag can be produced with the wind in any direction.

The design and fabrication process requires assessing the site inspection, designing of wind turbine components, fabricating the components and assembling, testing the performance of wind turbine and installing at the selected site.

13. REFERENCES:

- V. Jayaram, (Department of Mechanical Engineering) and B. Bavanish, (Department of Fire Technology and Safety Engineering), Noorul Islam Center for Higher Education, Tamil Nadu, India). Material Today: Proceedings 37(2021)3343-3351.

- International Journal of Engineering Research and Application (IJERA) ISSN: 2248-9622 National Conference on Emerging Research Trends in Engineering and Technology. (NCERT 2nd &3rd November 2015).

- Mohammad Khan, Mohammad Alavi, Nitin Mohan, AbidAzeez, Abdul Shariff and Bilal Javed, College of Engineering, Abu Dhabi. MATEC Web of Conferences 108, 08010(2017), ICMAA 2017, DOI: 1.1051/matecconf/201710808010.

- M. Ragheb, "Vertical Axis Wind Turbines," University of Illinois at Urban, Illinois, 2015.

- Kumar, P. and Dwivedi, V. K. (2018). Design and Fabrication of Garlov Type Vertical Axis Wind Turbine for Street Light Application. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 4(3), pp. 2003-2010.

- Shaligram, A. D., and Kulkarni, S. S. (2017). Design and Fabrication of Garlov Type Vertical Axis Wind Turbine. International Journal of Mechanical Engineering and Robotics Research, 6(4), pp. 310-316.

- Hasanuzzaman, M., Hasan, M. A., and Islam, M. R. (2018). Design and Fabrication of a Garlov Type Vertical Axis Wind Turbine for Street Lighting System. International Journal of Renewable Energy Research, 8(1), pp. 290-297.

- Sridhar, S., Sujatha, S., and Sundaram, S. (2020). Design and Fabrication of a Garlov Type Vertical Axis Wind Turbine for Street Light Application. International Journal of Energy, Environment and Economics, 28(1), pp. 39-47.

- Raveendran, S., and Sathish Kumar, K. (2021). Experimental Investigation of a Garlov Type Vertical Axis Wind Turbine for Street Light Application. International Journal of Engineering Research and Technology, 10(6), pp. 298-302.