International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-1, Issue-6, January 2013

Design and Fabrication of Convergent Wind Mill

K. Maharaja, S. N. Vijayan, S. Sendhil Kumar

Abstract: ***Nowadays electrical energy is very essential for human beings to fulfill the requirements of day to day activities in various measures. The demand of the electrical energy increases day by day. It is most essential to promote renewable energies so that they definitely become a strong alternative to generate electrical power for small scale needs of society. This paper discusses the convergent horizontal axis wind mill which uses the bicycle wheel instead of using propeller blades for producing power. Design of the horizontal axis wind mill is discussed and presented in this paper considering the various design factors. The results observed through various experiments in the various time zones which validate the results obtained analytically.***

Keywords: Convergent turbines, Renewable energy, Wind power .

I. INTRODUCTION

Wind energy become as one of the fastest alternative energy source recently. The energy capacity increased over 20,000 MW by 2009. Out of the total renewable energies wind energy alone as contributed about 15,016 MW, wind industry has achieved an average growth of 25% over the past years. Various forecasts indicate average growth in annual installation of 22% p.a. The growth centre's USA, INDIA, CHINA maintains high demand of wind energy. The climate change acts as the global drivers for the growth of wind energy.

Wind power is now recognized as an efficient, large-scale, reliable source of power, a key component of the global energy mix, and one of our most effective tools to reduce CO2 emissions. Wind power has become a natural part of the modern energy supply because, among renewable sources of energy, wind power is currently the best means of ensuring the many national climate targets are reached. Windmill is a machine which converts the energy of wind into rotational energy by means of vanes called blades. Windmills are used for generating electricity which is commonly known as wind turbines. In a national energy mix, all energy sources are critical. However, the choice of clean and safe source is paramount considering long term perceptive. The natural choice is wind because it is renewable, predictable, fast to install, clean and commercially viable. Wind offer the energy independence demanded by the world's largest and fastest-growing economies. Renewable energy flows involve natural phenomena such as sunlight, wind, tides, plant growth, and geothermal heat, as the International Energy Agency . Wind is the movement of air across the surface of the Earth, from areas of high pressure to areas of low pressure. India has a potential of around 48,500 MW. With a capacity addition of 12,800 MW, it contributes to around 75% of the grid-connected renewable energy power installed capacity. The major wind power capacity is in the states of Tamil Nadu, Gujarat, Maharashtra, Karnataka and Rajasthan. Wind electric generators of unit sizes between 225 kW and 2.10 MW have been deployed across the country. Wind Electric Generators of unit capacity up to 2.10 MW are being manufactured in India. An ambitious target of 9,000 MW was set for 12th Plan, of which 5,715 MW had already been achieved by September, 2010. This has been possible because of the multidimensional approach of central and state governments.

Sources	Cost per MW (Rs. Crore)	Levelised Cost Per Kwh (Rs/kwh)
Wind power	4.5 -5.25	2.5-3.7
Small Hydro power	3.5-6.25	1.8-3.4
Biomass Power	3.5-4.0	2.2-3.2
Solar	10-12	8-10
Thermal power plant	4.0-4.8	2.5-3.0

Table I. Status of Wind Power in INDIA

Actual wind systems are diverse kinds, but most of those dedicated to generate electrical power are the divergent type. These systems tend to enlarge the flow of the wind, therefore introducing not only a reduction in the wind speed but also certain dispersion at the system's boundaries. Due to the tendency for moving the wind flow from the central region to the peripheral zones, and also due to the design of blades and the expensive technology used, these systems are suspected to be less efficient and much more expensive than certain easy-to-build convergent ones. Table.1 depicts the status of the wind power in INDIA.

On the contrary, convergent type wind mill seem to concentrate the flow instead of dispersing it, therefore avoiding some of the effects that contribute to reducing the efficiency of the system. These systems have a transparent central spot where the wind can pass freely, and that is believed to create a low pressure responsible for sucking the peripheral wind to this central zone. This is also believed to contribute to a higher efficiency than expected in the usual wind mill.

II. CAUSES OF WIND TO BLOW

Solar energy is responsible for the blowing of wind. The intensity of sun-rays is stronger near the Equator than at the Polar Regions. Due to unequal heating of the earth's surface, cooler air from the Polar Regions flow towards the equatorial regions to fill the space created by the hot rising air.

Air flows from high pressure region to low pressure region. This flow of air from one place to another constitutes wind.

Revised Manuscript Received on 30 January 2013.
* Correspondence Author
Mr. K.Maharaja*, Assistant professor in Mechanical Engineering , Anna University, Karpagam Institute of Technology, Coimbatore, India.
Mr.S.N.Vijayan, Assistant professor in Mechanical Engineering, Anna University, Karpagam Institute of Technology, Coimbatore, India.
Mr.S.Sendhil Kumar, Professor in Mechanical Engineering, Anna University, Karpagam Institute of Technology, Coimbatore, India,.

The energy of wind is used for working of flour-mills and water-lifting pumps with an electric generator. Such simple machines which work due to kinetic energy of wind are called wind mills.

The Principle of wind mill is when the blowing wind strikes across the blades of a windmill; it exerts a force on them due to which the blades of the windmill start rotating. This in turn rotates the shaft of the turbine and generates electricity.

III. WORKING PRINCIPLE

Wind turbines are used to produce electricity. The machines that generate electricity are the most conventional type with airfoil propeller employing two to three tapered blades. Electricity can be produced by rotating an armature in between the poles of a strong magnet. The shaft of the armature of a generator is connected to the wind turbine by a connecting rod. When the wind rotates the blades of the wind turbine, the shaft rotates, and this in turn rotates the armature, thereby producing electricity. Convergent wind mills of lower cost, Eco-friendly and more efficient compare to other wind mills. Nowadays most of the small scale industries are producing electricity using convergent wheel wind mills due to availability of resources and lowest cost.

IV. COMPONENTS

The various components of the Convergent wind mill are

(i) Bicycle Alloy wheel (ii) Spokes
(iii) PVC Sheet (iv) Spur gear with pinion
(v) AC dynamo (vi) Solid shaft

Fig.1 depicts the methodology of convergent wheel wind mill. It's explained that the detailed blade design for making convergent wheel and assembly of the components for making whole unit. Then it's placed on the open atmosphere and calculates the power, torque, and velocity for respective speed. Wind structure consists of Base, column and convergent wheel. Electricity has been produced and transmits through pinion and gear assembly

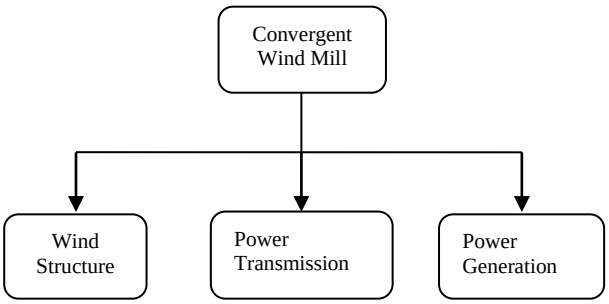

Fig.1 Methodology of convergent wheel

V. DESIGN AND SPECIFICATIONS

The blade design is based on the convergent system. The design is made by PVC plastic material. The material has been cut into tapered shape with respect to require dimensions. The design of blade is shown in Fig.2

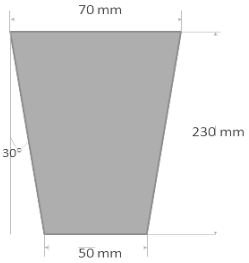

Fig.2 Blade design

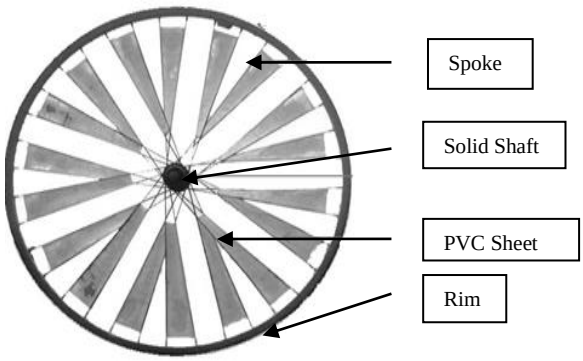

Fig. 3 Convergent Turbine

Fig.3 shows a convergent turbine wheel made with PVC sheet. The radius of the bicycle wheel is 270mm and thickness is 150mm. It consists of number of spokes, a solid soft and a rim. Solid soft is connected with the gear assembly for transmission and generate electricity

VI. SPECIFICATIONS

The specification of various parts which has been used in convergent wind mill is tabulated in Table 3, which is used to calculate various design aspects. All the blade designs have to stick over the each pair of spokes. This is the structure of most basic convergent turbine system. This scheme could even be mounted at the top of certain buildings, or on a farm in the form of an extensive wall which naturally captures the wind energy. The convergent wind mill is assembled with its specified parts. The designed convergent wheel has to be attached to the mild steel shaft by using welding. Then, the mast (support stand) is made by joining the hollow rectangular mild steel rods using arc welding. The mast is designed with respect to the mass of blade design.

Table.3 Specifications of convergent wind mill

Diameter of convergent bicycle wheel, D	540 mm
Thickness of wheel, t	150 mm
Diameter of shaft, d	10 mm
Length of solid shaft, L	255 mm
Spur gear teeth, z_1	36

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Pinion teeth, z_2	18
Gear ratio, I	1:2
Density of wind	1.225×10^{-9} kg/mm^3
DC dynamo motor	12V

The 12V DC dynamo is used to generate power from the rotational force of convergent wheel by blowing of wind. The dynamo has to convert the rotational force into the power. The spur gear is used to make a rotation of pinion it has 36 teeth and the pinion is connected with the dynamo. The spur gear is connecting with the shaft of the wheel and is meshed into the dynamo. The set of mast is fixed into the base (rectangular mild steel stand). Selection of the site and placement of the wind mill is one the important requirement for the generation of electricity. Due to the blowing wind, the convergent wheel rotates at particular speed. Speed of the convergent wheel can be measured using anemometer. At the convergent wheel rotates, the power transmission components rotates, in turn, the electrical energy is stored in the DC generator, there by energy from one form is converted into another form. Likewise, the velocity, torque, power of the convergent wind mill is also measured.

VII. POWER GENERATION

The power generates from the convergent wheel wind mill due to rotation of the wheel by the blowing of wind force. The tendency for moving the wind flow from the central region to the peripheral zones, the power can be generate and also due to the convergent design lets the turbine start at low wind speeds and the ability of accumulating energy in a mechanical form, in the wheel itself.

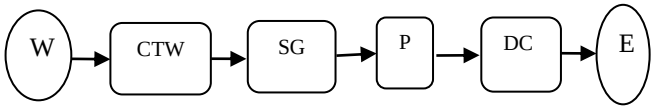

Fig. 4 Block diagram representation of convergent wheel wind mill

W – Wind, CTW – Convergent type wind mill,
SG – Spur gear, P – Pinion, DC – DC Generator, E - Electricity

Fig .4 Illustrates the generation of power from the wind mill. The power is calculated using torque and angular velocity.

VIII. CALCULATION

Theoretically the velocity, wind power and torque are calculated as per the Equation 1 to 3 with respect to various design factors.

Wind velocity:

$V = \pi \times D \times N / 60 = 14.13$ m/s ---------- (1)

Wind power:

$P = \frac{1}{2} \rho A V^2 = 395.74$W ---------- (2)

Torque:

$T = P \times 60 / 2 \times N \times \pi = 7.55$ N-ms ---------- (3)

IX. RESULTS & DISCUSSIONS

The design and fabrication of the convergent wind mill is discussed in the earlier pages. The design of the convergent wind mill is based on the torque which as to be produced by each wind mill. Table 4 illustrates the velocity, power & torque with respect to the speed of the rotation of the wheel. Obtained torque, power and velocity are very less at the low speed of the wind and increases with respect to the wind speed. When the convergent wheel rotates at a speed of 400 to 500 rpm the velocity, power & torque reaches its maximum range.

At a speed of 500 rpm the values of velocity, power & torque is of 14.13 m/s, 395.74 W & 7.55 N-mm respectively. Fig.5 & 6 represents the graphical value of the power & torque with respect to the speed of rotation. From the graph is clear that as the speed of rotation increases the power & torque also increases linearly. During the experimentation the fabricated convergent wind mill generated a power of around 5.6V at a speed of 250 rpm at around 9.00 pm.

Table 4. Range of power, torque, velocity

Rotation of the wheel (rpm)	Velocity (m/s)	Power (W)	Torque (N-mm)
400-500	11.30-14.13	202.40-395.74	4.83-7.55
200-300	5.65-8.40	25.776-83.06	0.80-2.643
100-150	2.827-4.241	3.169-10.69	0.06-0.202

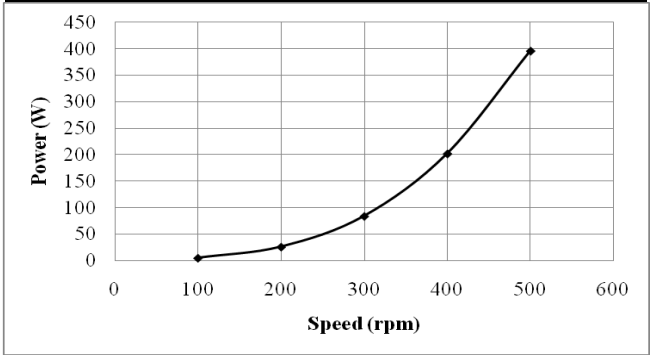

Fig. 5 Characteristic curve of speed vs Power

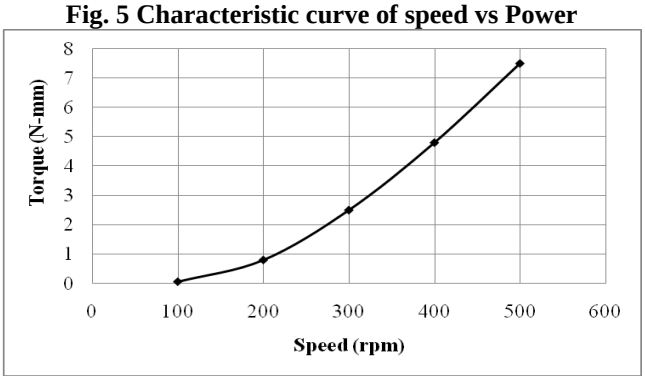

Fig. 6 Characteristic curve of speed vs Torque

The power is measured using the multimeter. The fabricated convergent wind mill is of low cost; hence it can generate power for low consumption with a maximum speed of 700 rpm. Fig.7 represents the generated power of 5.6 V at 250 rpm.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Fig. 8 represents the output voltage at 250 rpm, in this convergent wind mill maximum rotation of wheel is 700 rpm it can generate 6 – 7 V of electricity. Fig.9 represents the rotation of the convergent wind mill.

Fig.7 Voltage of 5.6 V Produced at 250 rpm

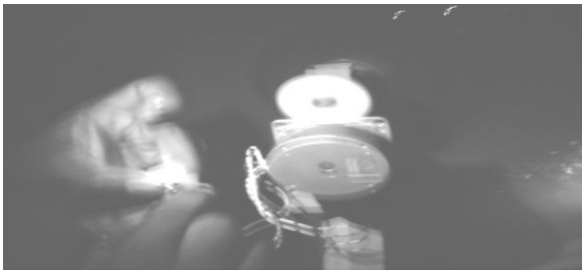

Fig.8 Power generation of the convergent wind mill

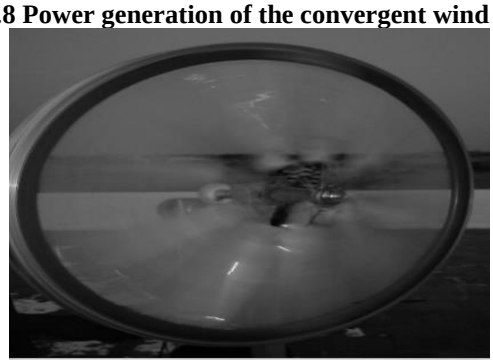

Fig.9 Convergent wheel in rotation

X. CONCLUSION

From the experiment conducted using the convergent wind mill it was clear that power can be generated using the availability of the renewable energy resources. This low cost wind mill is the tailor model of the convergent wind mill which has various features for generation of the electricity.

The low weight of the wind mill achieved with such a method will lead the system to be able to rotate at significant speeds, and the ring around it will mainly contribute to the accumulation of the energy not directly transformed by the generator into electrical power. This design is interesting for constructing efficient systems, but also that such systems will not be as demanding in terms of battery stability as the present ones. The design and working is easy to adapt several different circumstances.

XI. NOMENCLATURE

V - Velocity of wind (m/s)
D - Diameter of the convergent bicycle wheel (mm)
N - Rotation of the convergent type bicycle wheel (rpm)
Þ - Density of the convergent type wind mill (kg/m^3)
A - Area of the convergent type bicycle wheel (m^2)
P - Power of the wind mill (W)
N - Rotation of the convergent type bicycle wheel (rpm)
T - Torque of the convergent type wind mill (N-m)

REFERENCES

1. J. Manuel Feliz Teixeira, 2006, "Low-cost Convergent Turbine for Wind Power Usage",. Windmill Bicycle Wheel by EYEWE.
2. S K Tewari, Ningaiah, D V Subramanyam and A C. Samraj. "A Horizontal axis sail windmill" for use in irrigation. Proceedings of the Indian Academy of Sciences, March 1979, pp. 107-116
3. Chun Su, Quan Jin, and Yequn Fu "Correlation analysis for wind speed and failure rate of wind turbines using time series approach" Journal of Renewable And Sustainable Energy ,2012, 4, 032301
4. Sajad Tabatabaei and Taher Niknam, "Impact of wind
5. generators on distribution feeder reconfiguration", Journal Of Renewable And Sustainable Energy, 2012, 4, 053101
6. M. Veigas and G. Iglesias, "Evaluation of the wind resource and power performance of a turbine in Tenerife", Journal of Renewable And Sustainable Energy 2012, 4, 053106
7. K. Aboul-Seoud, Alaa El-Din Sayed Hafez, Mohamed Abd El-latif, A. Abou-Raya, "Wind Speed Behavioral Modeling for Economical Energy Generation using Windmills" , International Journal of Scientific & Engineering Research Volume 3, Issue 7, June-2012
8. R.S. Bajpai, Rajesh Gupta, "Design of simulator for modelling of wind turbine and transfer of maximum power using buck-boost converter", Int. J. of Renewable Energy Technology, 2011 Vol.2, No.4, pp.373 – 391
9. Gilles Notton, Vladimir Lazarov, Ludmil Stoyanov, "Productivity of small wind turbines for various wind potentials conditions: application in Bulgaria and Corsica", Int. J. of Renewable Energy Technology, 2010 Vol.1, No.3, pp.237 – 255
10. Lars Henriksen "*Wind Energy* literature survey No. 26" Wind Energy Volume 15, Issue 7, pp 945–949, October 2012
11. http://www.fe.up.pt/feliz

AUTHOR PROFILE

Mr.K.Maharaja is a post graduate in engineering design from PSG TECH, Coimbatore. He is having overall teaching experience of 2 years. His major interests are in tribology, design, material science.

Mr.S.N.Vijayan is a post graduate in CAD/CAM from Anna University, Coimbatore. He is having overall teaching experience of 2 years and 6 years of industrial experience. His major interests are in design, processing of materials. Published various papers in international and national journals.

Mr.S.Sendhil Kumar is a post graduate in computer aided design from University of madras. He is having overall teaching experience of 15 years. His major interests are in Vibration, Structures and Optimization. Published various papers in international & national journals. Published a text book titled "Dynamics of machines", Charulatha Publications, Chennai, Tamilnadu, 2004.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)