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DESIGN AND ANALYSIS OF A NOVEL VERTICAL AXIS WIND TURBINE

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ABSTRACT

The unit cost of electric energy is increased as increase in the demand. Frequent load shedding is taking place in these days in villages and in remote villages till there is no electricity available. Now a days, increasing trend recently of people trying to squeeze out energy from every possible nook and cranny. The case is motivated to develop the standby power generation model that minimize crisis. Novel twisted vertical blade turbine model designed which gives a maximum torque on low wind speed range of 1.2m/s and having the portable size which can helps to easily mount on the roof. DC-GM set is coupled to the shaft of the turbine. The available voltage is stored in battery can used as standby power. Analysis of novel twisted vertical blade turbine model is done for various output characteristics. A twisted blade offers maximum power output in low wind speed. The 1.53Nm, 60rpm, 12V DC-GM is used as generator, is easily lights two 20 V LED's with good light efficiency.

Keywords: DC-GM, LED, load shedding, stand by, twisted etc.

I.INTRODUCTION

Increase in power demand in recent year make the growth towards the generation. Green power generation is in new innovation compared to the conventional. Main contributions of power generation by green sources are solar and wind energy. Wind energy generation makes the technological developments in horizontal axis wind turbine and vertical axis wind turbine. The new innovation towards the development of vertical axis wind turbine having the twisted blade structure which maximum mechanical torque output in low wind speed. Wind energy generation makes the technological developments in horizontal axis wind turbine and vertical axis wind turbine. Change in wind patterns from region to region decreasing the growth in wind power generation. The new challenge is develop turbine which generate power on low wind speed and having less dimensional size. Analysis of novel twisted vertical blade turbine model gives the rise in product development which minimizes the energy demand in remote places and where lower wind speed. The development and deployment of model that generate useful energy from the kinetic energy contained in the wind. Role of twisted blade structure as prime mover convert Power available in wind into mechanical power cm-kg in the form of torque 1.32cm-kg is fed to the 1.35 cm-kg, 60rpm, 12V DC-GM generator by coupling is made between shaft of twisted blade structure and to shaft of DC-GM generator. As there is non-uniformity wind, output voltage will fluctuate continuously, voltage regulator is used to regulate the output power for 12V and 24V. This uniform voltage is used to charge the battery as rated 1Ah, 12 VDC. Stored power is used while in NO-wind condition. Charge controller is used as switch in NO-wind to Full wind condition. Charge Controller is connected between generator and storage system which performs the continuous charging of battery when there is no load, stored power is utilized directly by DC loads.

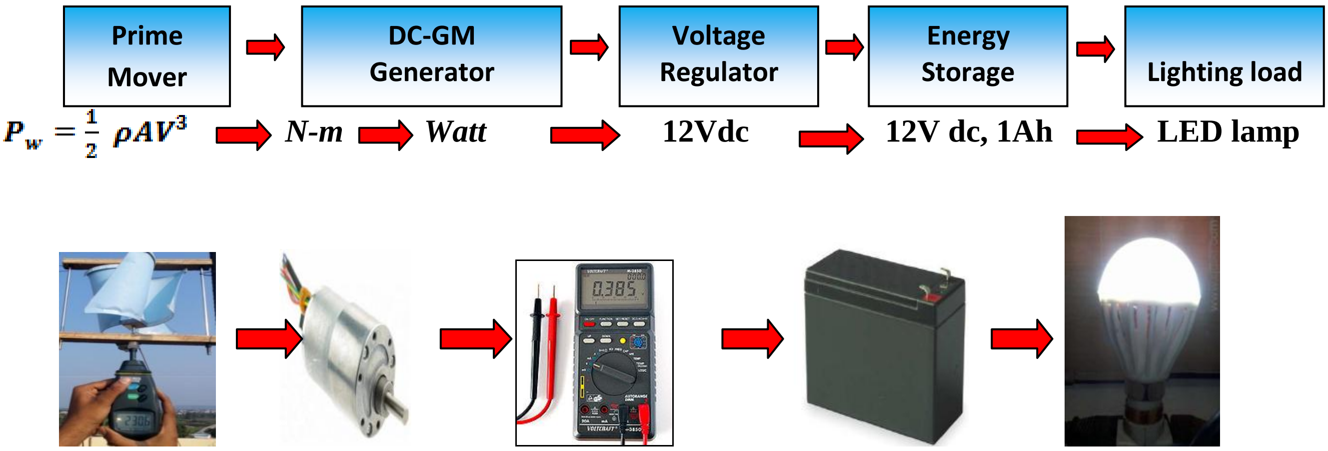

Fig.1: Block diagram of VAWT

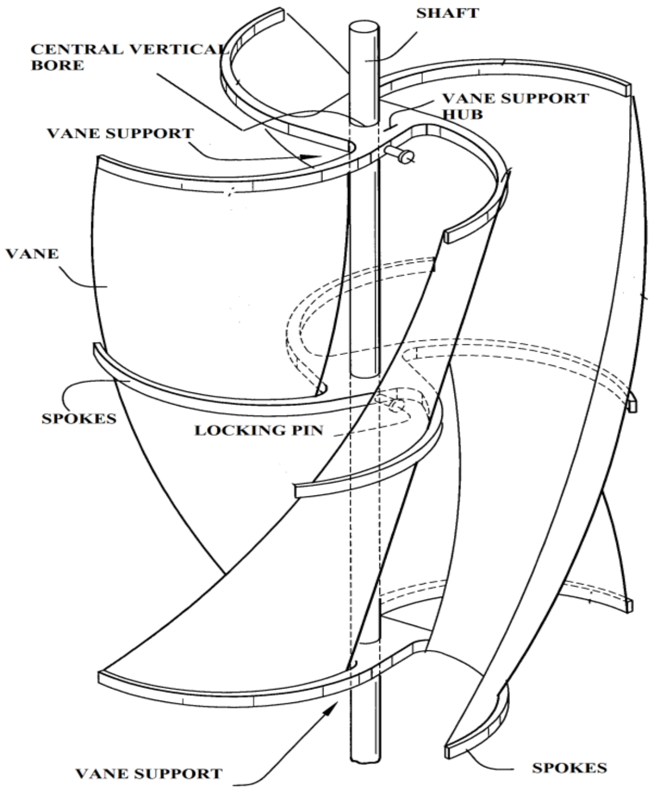

Fig .2: Twisted Blade Design

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II. PRE–DESIGN CALCULATION

2.1 Wind Power

$$Pwind = \frac{1}{2}\rho AV^3$$

Where, $\rho = \text{Air Density} = 1.152\ kg/m^2$

A=Swept Area=Height*Diameter=0.66*0.71

V=Wind Speed (m/s)

$$P_{wind} = \frac{1}{2} * 1.152 * 0.4686 * 4^3 = 17.27\ watt$$

The conversion of wind power into mechanical power is dependent of the efficiency (Coefficient of Power) of the windmill.

For VAWT, the limit is

$$Cp = \frac{16}{25} = 0.64$$

2.2 The Power Output is,

$$P = \frac{1}{2} Cp * \rho AV^3$$

$$= \frac{1}{2} * 0.64 * 1.152 * 0.4686 * 4^3$$

P =11.05 watts

2.3 Efficiency

$$= \frac{\text{Output Power}}{\text{Input Power}} * 100$$

$$= \frac{11.05}{17.27} = 63.98\%$$

2.4 Rotational Speeds

$$N = \frac{V*60}{2\pi R} = \frac{4*60}{2\pi * 0.355}$$

N=107.59 RPM =11.26 rad/sec

2.5 Tip Speed Ratio

$$TSR = \frac{\text{Tangential speed at blade tip}}{\text{Actual wind speed}} = \frac{Rw}{V}$$

$$= \frac{0.355*11.26}{4} = 0.99$$

2.6 Torque

$$T == \frac{Pw*60}{2\pi N} = \frac{17.27*60}{2\pi * 107.59} = 1.53\ Nm$$

T=1.53 N-m

III. WIND SPEED ANALYSIS

3.1 Weather data of AMGOI Campus

Table.1: Weather data of AMGOI Campus, Kolhapur. July 2015 to March 2016.

Month	Mean Daily Minimum Temperature (°F)	Mean Daily Maximum Temperature (°F)	Mean Temperature	Mean Relative Humidity At 0830 IST Hrs. (Per Cent.)	Mean Relative Humidity At 1730 IST Hrs. (Per Cent.)	Mean Daily Minimum Wind speed (m/s)	Mean Daily Maximum Wind speed (m/s)
Jul	70.0	79.4	74.7	89	83	1.13	2.48
Aug	69.5	79.3	74.4	90	82	0.96	2.15
Sep	68.8	82.9	75.9	87	73	1.07	2.37
Oct	68	86.4	77.2	82	61	0.92	2.33
Nov	61.3	86.4	74.0	65	37	1.37	2.74
Dec	58.2	85.8	72.0	61	30	1.99	3.5
Jan	58.5	86.9	72.7	61	27	1.52	3.76
Feb	60.6	89.9	75.3	57	23	1.7	3.33
March	65.7	96.4	81.1	57	26	2.38	3.78
Mean	64.5	85.93	75.25	72.11	49.11	1.45	3.00

IV. RESULT

4.1 Technical specification

Table.2: Technical Specification of designed VAWT

Cut-in wind speed m/s	1.2 m/s	
Survival wind speed m/s	10 m/s	
Rated output at 4m/s	11.05 watts	
Maximum output at 5.5m/s	28.73 watts	
Maximum rotational speed at 4m/s	107.59 RPM	
Maximun no load shaft torque (kg-cm)	1.53 N-m	
Total weight	20 kg	
Number of rotor blade	4	
Rotor blade type	Twisted Savinous type	
Rotor diameter (m)	0.71 m	

Height	0.66 m	
Swept area (m)	0.4686 m	
Generator	GM-DC geared generator	
Battery	12V,1Ah	
Typical output at Vathar	Avg. wind speed at 2m/s	1.38 watts
	Avg. wind speed at 3m/s	4.66 watts
	Avg. wind speed at 5m/s	21.59 watts

Table.3: Results are recorded at different wind speed

Velocity(m/s)	Voltage(V)	Current(Amp)	Electrical Power(W)	Speed (rpm)	Torque(N-m)
1.2	4.37	0.01	0.29	32.27	0.14
1.5	4.87	0.02	0.58	40.34	0.21
2	5.20	0.01	1.37	53.29	0.38
2.5	5.42	0.02	2.69	67.24	0.59
3	6.39	0.06	4.65	80.69	0.86
3.5	6.92	0.1	7.40	94.14	1.17
4	7.04	0.1	11.05	107.59	1.53
4.5	7.78	0.17	15.73	121.04	1.93
5	7.85	0.18	21.58	134.50	2.39
5.5	8.08	0.23	28.73	147.94	2.89

From V/V and V/C characteristics output voltage rising as wind velocity increases and is maximum were 5m/s, for the wind velocity near to the 5.5m/s, current generated by the turbine (coupled generator) increasing about 0.23A,. As the wind velocity increases rotor speed increases to rated value, further increase in wind velocity become rapid increase in rotor speed and damage the generator to protect this stalling of turbine required is analyzed by V/S characteristics, this is the limitation to maintain minimum rotor speed. From S/P Characteristics Output power generation is directly proportional to the wind velocity and speed of rotation of turbine blade. As speed of rotor increases torque increases, as results high the speed of turbine rotor blade gives the more output power is from T/V-characteristics. From the V/P characteristics, Maximum power output of generator is possible when the maximum wind velocity available. Power generated by turbine is directly proportional to available wind velocity.

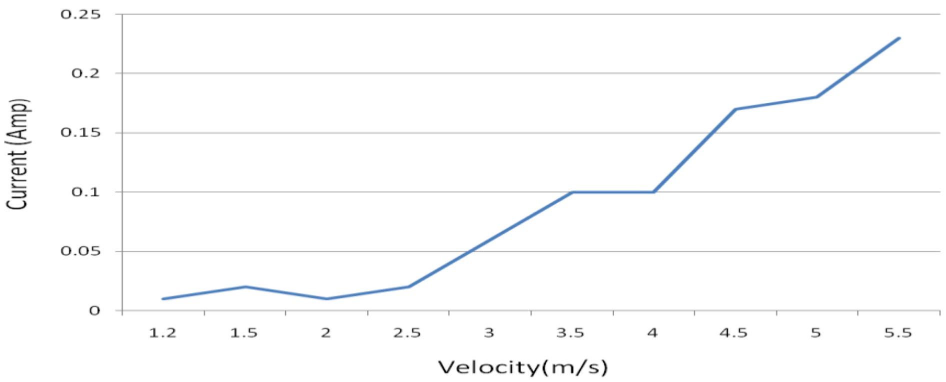

Fig.3:Velocity/Current Characteristics

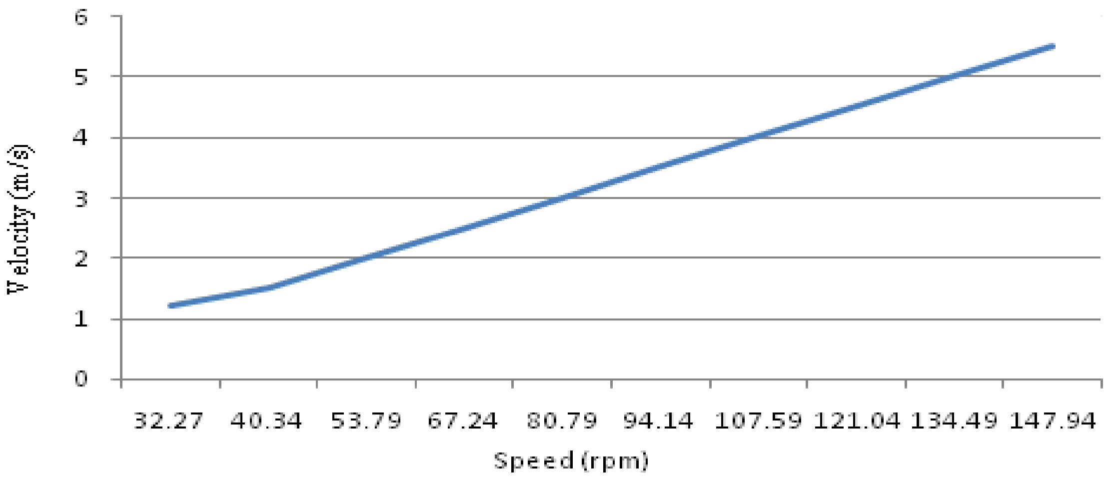

Fig.4:Speed/Velocity Characteristics

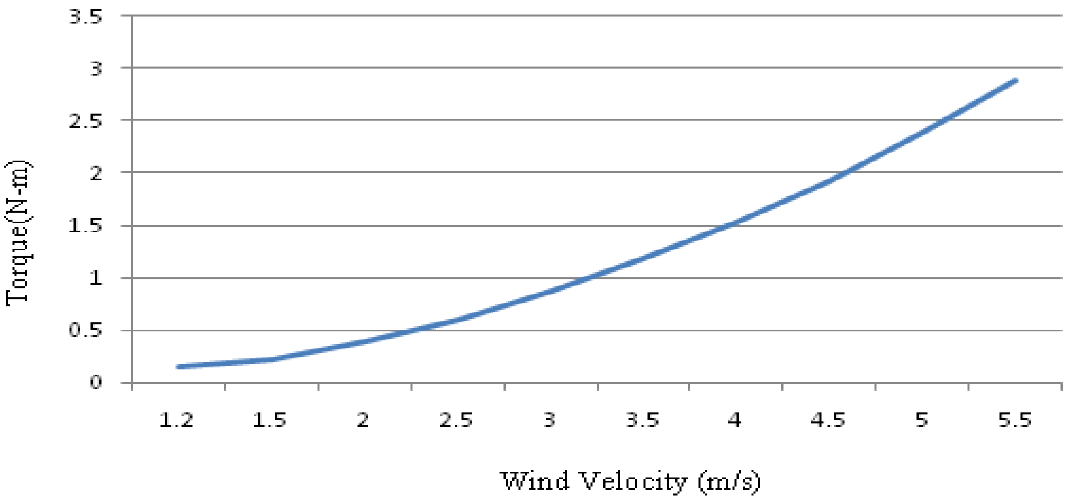

Fig.5: Wind Velocity/Torque Characteristics

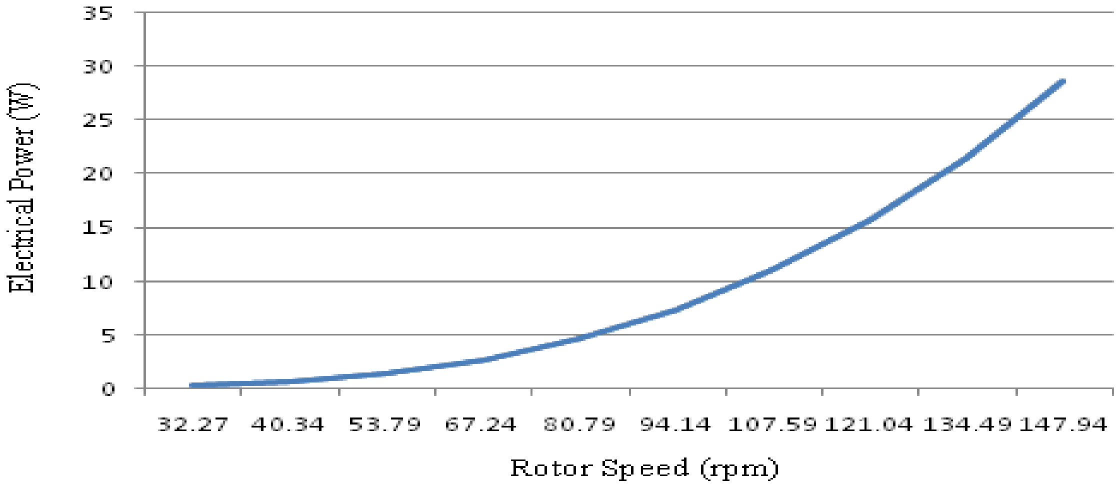

Fig.6:Rotor Speed/ Electrical Power Characteristics

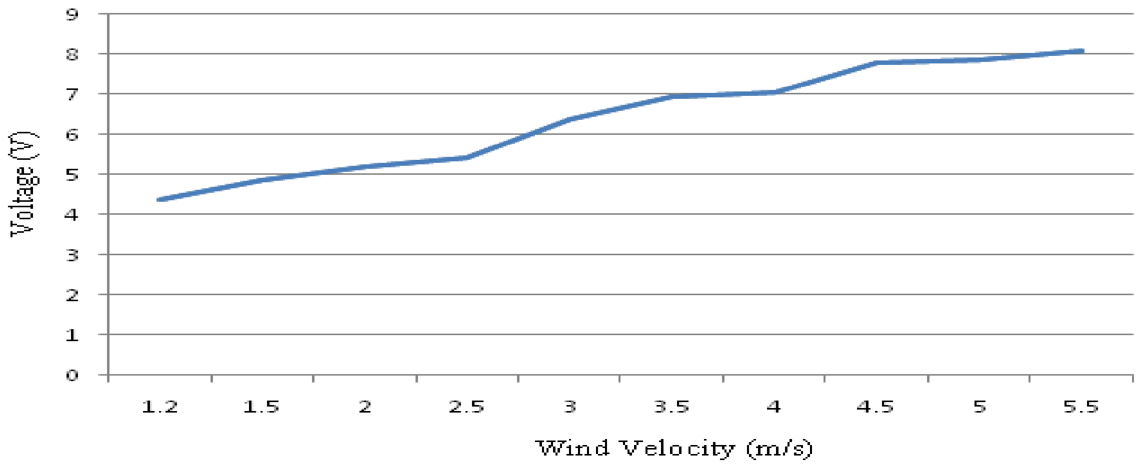

Fig.7:Wind Velocity/Voltage Characteristics

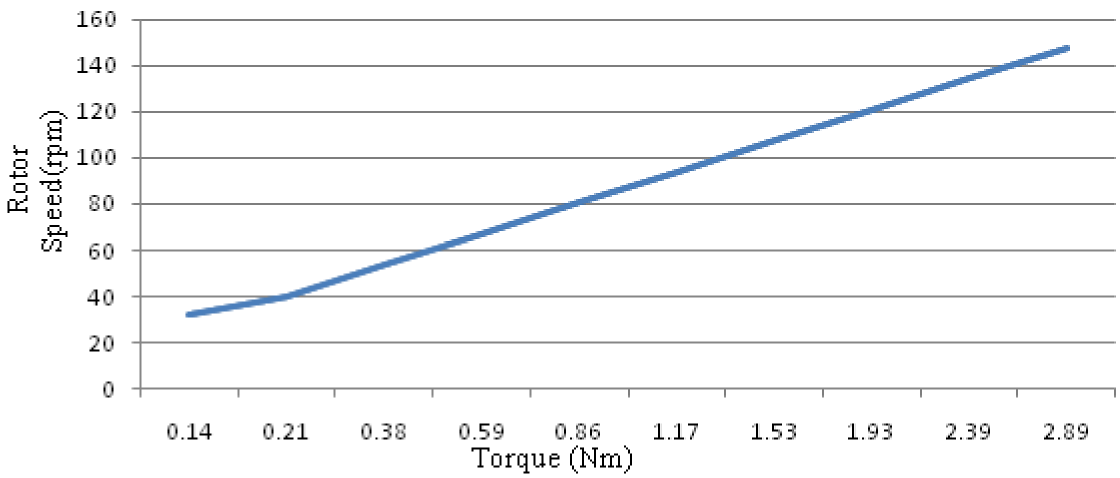

Fig.8:Torque/Rotor Speed Characteristics

Fig.9: Twisted Blade model

Fig.10: Arrangement of meters

V. CONCLUSION

Output voltage rising as wind velocity increases and is maximum were 5m/s is analyzed by V/V and V/C characteristics , for the wind velocity near to the 5.5m/s, current generated by the turbine (coupled generator) increasing about 0.23A,. As the wind velocity increases rotor speed increases to rated value, further increase in wind velocity become rapid increase in rotor speed and damage the generator to protect this stalling of turbine required is analyzed by V/S characteristics, this is the limit to maintain minimum rotor speed. From S/P Characteristics Output power generation is directly proportional to the wind velocity and speed of rotation of turbine blade. From the V/P characteristics, Maximum power output of generator is possible when the wind velocity is high, developed model is helpful to as standby power generation in remote places and where low wind velocity is available.

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