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DEVELOPMENT OF VERTICAL AXIS WIND TURBINE WITH MULTI-DIRECTIONAL NOZZLE

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Abstract— *Now a days every country wants to generate energy from Renewable Energy sources instead of traditional fossil fuels. In that Renewable energies mainly concentrated on Wind energy because it's easily available everywhere. By using wind turbine and generator we can generate electrical energy. There are two types of wind turbines, they are horizontal axis wind turbine, vertical axis wind turbine. To rotate Horizontal axis wind turbines high torque is required so which is preferable to only higher altitude areas, Vertical axis wind turbine are good for low speeds, which is useful for common places where wind speed is low. Here there is one problem which is some of the friction drag forces acting on the rear end of turbine blades while running. To overcome this problem here adding some extra accessories namely Nozzle and Deflector with casing. Then the Drag forces are completely neglected with the help of casing such that speed of the turbine shaft is increased faster than the normal by nozzle. In this work, the design of wind turbine with deflector and nozzle structure in CATIA V5 R20 and fabricated a model to get better result with casing, nozzle and deflector structure as compared to traditional model and Seasonal wise power generations also evaluated.*

Key words*—Nozzle, Friction Drag, Deflector, Casing, Savonius Turbine*

I. INTRODUCTION

The Windmill extracts energy from moving air by slowing down the wind, and transferring this harvested energy into a spinning shaft, which usually turns an alternator or generator to produce electricity. Wind energy is a renewable power source which generated from wind current flowing across the earth's atmosphere. This energy can be used for quenching the energy thirst of the world. Wind energy is one among the fastest growing sources of alternate power generation in the world today.The energy produced from the wind is clean because generation procedures have no effect on atmosphere hence no pollution or greenhouse gases. Wind energy is a self-sustained resource and presents abundantly in nature. This infinite energy makes the investors make a stable investment for our energy demand as well as for our future generation.

To extract the wind energy from wind two types of wind turbines are there namely,

1. Horizontal axis wind turbine (HAWT)
2. Vertical axis wind turbine (VAWT)
    a. Savonius VAWT
    b. Helical VAWT
    c. Darrieus VAWT

Savonius turbines are drag type turbines, the blades are in the form of semi-circular cylindrical shape. Which are used in the high reliability types and low wind speed areas. The construction of turbine looks like S-shaped rotors. So it is called S-Rotors.The turbine design with two half cylinders then moving the two half or semi cylindrical surfaces by side by side along the cutting section plane like the symbol S. The two semi or half circular surfaces are called as buckets or blades, which are mounted on a vertical axis that is perpendicular to the wind stream direction. The turbine works similar to cup type anemometer. These type of turbines no need of starter to overcome the torque.

The designed shape of blades is suitable for rotating for small velocities also. The figure demonstrates how the wind strikes the blades surfaces and how it separated on convex, concave shapes of turbine blade. When the wind is strikes convex shape the wind is separated in to two direction, one wind stream goes and hits concave shape anther one goes outside of turbine. Already concave force hits on concave shape by adding convex force it moves faster. It is repeated throughout wind flows the turbine rotates. Figure 1 demonstrates the working procedure of Savonius wind turbine.

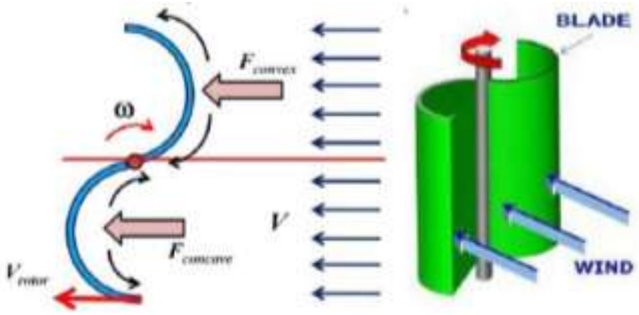

Figure 1: Working principle of rotation of Savonius turbine

II. PROBLEM DEFINITION

Power generations in low velocity wind areas vertical axis wind mills are preferred. In vertical axis wind mills Savonius wind turbines are more preferred. For the generations of power the turbine rotation is main task. For the generation of power two factors are most effected on turbine rotation those are

1. Low wind speed

For low wind speed the turbine rotates slowly which effects on power generations. So to minimise this problem a new design is required.

2. Surrounding wind stream obstacles

The direction of wind is not constant. In the atmosphere no of wind streams are passes on single point only one strong wind stream rotates the turbine remaining wind stream oppose the turbine rotation so new designed should avoid this problem.

By imagine these two problem a new design is proposed which maximum vanish the problem. The modifications are, to increase the wind speed for low speeds a convergent diffuser is used which increases the wind speed.To avoid the surrounding wind speed obstacles a shield is provided surrounding the turbine with offset distance. Which is surrounded on turbine and holding the nozzle for increasing speed. But direction wind changing simultaneously so for the direction of nozzle a deflector is added at exactly opposite to the diffuser.

By using the new modified design utmost minimise the problems.

III. WIND TURBINE DESIGN THEORY

The coefficient of power (Cp) is stated as the ratio of maximum power obtained from the wind stream to the total power available from the wind stream as

$$C_p = \frac{Maximum\ power\ obtained\ from\ the\ wind\ stream}{Total\ power\ available\ from\ wind\ stream}$$

$$C_p = \frac{0.209NT}{\rho A V^3} \quad \text{-------- Eqn 1}$$

The coefficient of torque (Ct) is stated as the ratio between the actual torque develop by the rotor to the theoretical torque available in the wind as,

$$C_t = \frac{Actual\ torque}{Theoretical\ torque}$$

$$C_t = \frac{MR^3\omega^2}{\rho A V^2 R} \quad \text{-------- Eqn 2}$$

Where,

M = mass of air strikes on turbine (Kg)

V = velocity of air (m/sec)

ρ = density of air (Kg/m^3)

A= swept area = Diameter of rotor × height of rotor =D × H =2RH (m^2)

N= Turbine Rotations per minute (RPM)

ω = Angular Velocity (Rad/sec)

For Savonius turbines coefficient of Torque is taken as 0.38, coefficient of power for Savonius turbine is 0.141, this value determined by a fluid mechanics constraint known as the Betz limit. The density of air is 1.2 kg/m^3

By solving Eqn 1 and Eqn 2, Diameter and Height of Turbine obtained.

IV. SETUP LOCATION

To generate power with good efficiency, the selection of site is taking more criteria. To select location of plant the following conditions should be satisfy. Those are

1. Keep away from obstruction throughout surroundings because obstructions slows down the velocity of air and creates turbulence.
2. The height of setup location should be at high compared to ground
3. The setup location nearer to power grid to transform the power to avoid long transmission line system.

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Before fix the assembly need to collect the window report for last one years to get average value of wind speed for constant power output, in this work last one year's wind speed reports are collected from AWS means automatic weather station which is located in "Yogi Vemana University"-Kadapa. AWS measures different parameter present atmospheric weather those are wind speed along with rain density, barometric pressure, humidity ratio etc. The Figure 2 shows automatic registration machine.

Figure 2: Automatic Weather Station

The velocity of wind is changing when going from ground to top in vertical direction. So the velocities are differ with height the phenomena is called wind gradient. By considering wind gradient the velocities of wind for different seasons is tabulated in table 1.

Table 1: Seasonal wise wind speed Reports

S.No	Season	Months	Minimum wind speed (m/sec)		Maximum wind speed (m/sec)		Average wind speed (m/sec)	
			AWS	JNTU	AWS	JNTU	AWS	JNTU
1	Winter	Dec, Jan, Feb	0.1	0.107	5.2	5.587	2.78	2.98
2	Summer	March, April, May	0.1	0.107	5.5	5.91	2.9	3.116
3	Monsoon	June - Nov	0.1	0.107	6.4	6.87	2.66	2.858

Where,
AWS- Automatic Weather Station
JNTU- Jawaharlal Nehru Technological University Pulivendula

V. RESULTS AND DISCUSSION

5.1 Structure without casing:

After assembling all the parts the final view of the vertical axis wind turbine without casing is demonstrates in figure 3.

Figure 3: Final structure without casing

After the installation the experiment examined in open atmosphere to get natural air with natural wind velocities. The wind speed is obtained from the thermo anemometer and the revolutions of the turbine is taken by contact type tachometer. The obtained values are list out in table and calculations of dynamo rotations, torque of dynamo shaft and power obtained calculations are also list out same table 2.

Table 2: Experiment results without casing structure

S.NO	Velocity of air (V m/s)	Turbine revolutions (N_1 RPM)	Dynamo shaft revolutions (N_2 RPM)	Dynamo shaft Torque $T=0.1\ MR^3\omega_1^2$ N-m	Power $p=\frac{2\pi N2T}{60}$ Watt
1	1.3	2.7	27	0.001	0.003
2	1.4	6.1	61	0.003	0.019
3	1.7	6.2	62	0.003	0.019
4	2.1	29.6	296	0.065	2.015
5	2.3	41.6	416	0.127	5.533
6	2.4	47.7	477	0.168	8.392
7	2.8	51.7	517	0.197	10.666
8	2.9	52.6	526	0.204	11.237
9	3.0	54.3	543	0.217	12.339
10	3.3	58.9	589	0.255	15.728
11	3.4	60.2	602	0.267	16.832
12	3.7	67.3	673	0.334	23.539
13	3.9	72.1	721	0.383	28.918
14	4.4	82.3	823	0.499	43.006
15	4.8	92.5	925	0.630	61.025
16	5.2	102.4	1024	0.772	82.784

5.2

Final structure with casing:

After removing turbine holding stand the casing structure is installed on the casing stand which is placed on the table with bolt and nuts. After installing all the components the wind speed and turbine rotations are taken from the thermo anemometer and contact type Tachometer. Which is demonstrates in figure 4

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Figure 8.2: Final structure with casing

The obtained values are tabulated in table and calculated values of dynamo shaft rotations, torque of dynamo shaft and the power obtained in dynamo is also list out same table 3.

Table 3: Experiment results with casing structure

S.NO	Velocity of air (V m/s)	Turbine revolutions (N_1 RPM)	Dynamo shaft revolutions (N_2 RPM)	Dynamo shaft Torque $T=0.1\ MR^3\omega_1^2$ N-m	Power $p = \frac{2\pi N2T}{60}$ Watt
1	1.3	0	0	0	0
2	1.4	0	0	0	0
0	1.7	0	0	0	0
4	2.1	37.5	375	0.104	4.084
5	2.4	53.9	539	0.214	12.079
6	2.5	57.3	573	0.242	14.521
7	2.6	59.3	593	0.259	16.084
8	2.9	64.3	643	0.304	20.470
9	3.1	67.9	679	0.340	24.176
10	3.3	73.1	731	0.394	30.161
11	3.4	73.9	739	0.402	31.110
12	3.6	77.7	777	0.445	36.208
13	3.9	83.1	831	0.509	44.294
14	4.0	87.2	872	0.560	51.137
15	4.3	93.9	939	0.649	63.817
16	4.4	98.0	980	0.707	72.556
17	4.6	110.9	1109	0.906	105.218
18	4.8	121.1	1211	1.080	136.961

By adding the casing structure along with nozzle at very low speeds the turbine didn't rotates because the speed of the just sufficient to directing the nozzle for the speed of 2.1 m/sec onwards the speed of turbine increases and simultaneously generated power also increases.

5.3 Seasonal wise power calculations:

The wind speeds changing every minute so power obtained also changes. In this work power generation at different seasons are also be calculated by taking the wind speeds in annual wind report which is taken from "Automated Weather Station in Yogi Vemana university". The wind velocities in different seasons are demonstrates in table. For that velocities we calculated power generation by adopting present results which are demonstrates in table 4 and table 5.

5.3.1 Without Casing structure:

By taking velocities from table the turbine revolutions are taken from table 1.If the velocities are not available in table then by averaging two values which neighbour numeric to obtained value. The maximum velocity obtained in table is not available in present experiment the value is replaced with maximum obtained value in table 2. The table 4 shows the power generation without casing season wise.

Table 4: Season wise power calculation without casing

WINTER SEASON					
Position	Velocity of wind (m/sec)	Turbine revolutions (RPM)	Dynamo shaft revolutions(RPM)	Torque (N-m)	Power (Watts)
Minimum	0.107	0	0	0	0
Average	3.0	54.3	543	0.217	10.666
Maximum	5.2	102.4	1024	0.722	82.784
SUMMER SEASON					
Minimum	0.107	0	0	0	0
Average	3.15	56.6	566	0.236	13.988
Maximum	5.2	102.4	1024	0.722	82.784
MONSOON SEASON					
Minimum	0.107	0	0	0	0
Average	2.9	21.7	217	0.204	11.237
Maximum	5.2	102.4	1024	0.722	82.784

5.3.2 With Casing Structure:

The velocities are taken as same way of previously taken and calculating average two neighboured values if not available in the same of above. The table 8.4 shows the power generation with casing in season wise.

Table 5: Season wise power calculation with casing

WINTER SEASON					
Position	Velocity of wind (m/sec)	Turbine revolutions (RPM)	Dynamo shaft revolutions(RPM)	Torque (N-m)	Power (Watts)
Minimum	0.107	0	0	0	0
Average	3.0	66.1	661	0.322	22.289
Maximum	4.8	121.1	1211	1.080	136.961
SUMMER SEASON					
Minimum	0.107	0	0	0	0
Average	3.1	67.9	679	0.340	24.176
Maximum	4.8	121.1	1211	1.080	136.961
MONSOON SEASON					
Minimum	0.107	0	0	0	0
Average	2.9	64.3	643	0.304	20470
Maximum	4.8	121.1	1211	1.080	136.961

5.4 Battery charging calculations:

$$\text{Time taken to full charge battery} = \frac{\text{Ampere hour of battery}}{\text{current prodecued in dynamo}}$$

$$\text{Current required for load} = \frac{\text{power required for load}}{\text{voltage of load}}$$

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From the calculations the time required to fully charged for battery when constant charge available is 42 min and the time taken to drain the fully charged battery is 135 minutes.

VI. CONCLUSION

Finally the design and fabrication of VAWT has been completed with dimensional accuracy and the machine is tested in open atmosphere with casing structure and without casing structure. From the investigation it has been proved that the power has been increased from “61.025 watts to 136.961 watts” at ‘4.8 m/sec’ velocity of wind by installation the casing structure.

The power generation throughout the year is calculated seasonal wise by taking the annual wind speed reports from Automatic Weather Station (AWS) which is located in Yogi Vemana University, Kadapa.

The generated power from the dynamo is charged the 9AH battery in “42 minutes” of time at constant current charge and “135 minutes of time” taken to drain the battery for the load of 40W, 10V.

REFERENCES

[1] An experimental study on the performance of savinious wind turbines related with the number of blades by Frederikus Wenehenubun, Andy Saputra, Hadi Sutanto. Science direct Energy procedia 68 (2015) 297-304

[2] Effect of the blade arc angle on the performance of a savonius wind turbine by Zhaoyong Mao and Wenlong Tian. Advances in mechanical engineering 2015. Vol7(5) 1-10

[3] Increasing the Theoretical Power Coefficient of a Vertical Axis Wind Turbine Using Novel Mantle Nozzle by N.Yogi Manash Reddy, Dr.P.Srinivas, Sameera Reddy Manasa, Mounika Kavya. ISSN: 2278-0181,Vol. 3 issue 4,april-2014

[4] Experimental Comparison Study for Savonius Wind Turbine of Two & Three Blades at Low Wind Speed by Mohammed Hadi Ali.Vol. 3, Issue. 5, Sep - Oct. 2013 pp-2978-2986 ISSN: 2249-6645

[5] Design, analysis and fabrication of vertical axis wind mill by B. Mahesh, M.Rajesh.

[6] Wind turbine technology (Renewable energies) by Ahmad hemami.

