Experimental Investigation and Comparison of Wind Turbine on moving Electric Vehicle for Battery charging

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Abstract— In this project, experimental comparison and investigations were carried out to study the performance and make a comparison between two, three, and four blade savonius wind turbine mounted on a vehicle to increase the runtime of electric vehicle at a constant speed of 50 to 60 Kmph.

For this purpose, three models of two, three, and four blades were designed and manufactured from G.I.Sheet of Gauge 18, each of them has an aspect ratio of (As = H/D = 0.465), and the dimension is (H= 270 mm Height and diameter D=570 mm). All those models were placed in a casing having curtaining angle α=45o and β=15o. in order to increase the performance of Savonius rotor.

Keywords— **Renewable energy, savonius rotor, electric vehicle, battery charging**

I. INTRODUCTION

Rate of energy production is decreasing with diminishing of fossil fuels, which leads a need to harness renewable energy which will help in reducing the climate changes, like global warming which increases with use of fossil fuel, basically used in automobiles.[1] Also it is important to increase the efficiency of renewable energy. Hence a special attention is being provided toward the wind energy which is one of the clean energy resources.

Electric vehicle is powered by electric motors or traction motors for propulsion.

Existing electric vehicles are powered in following ways:-

- Directly powered from an external power stations.
- Powered by on-board electrical generator as in hybrid vehicles.
- Stored electrical energy in batteries.[2]

Newton's 3rd law of motion states that, "every action has equal and opposite reaction". When a vehicle moves it experiences wind resistance of two different types i.e. – frictional drag and form drag. In which frictional drag arises due to viscosity of air while form drag arises due to variation of air pressure in front and rear side of vehicle [1]. Students of Arizona University worked on a stationary wind turbine placed near bye road to extract energy from wind stream generated due to the movement of vehicle [3]. If it is possible to capture the wind stream in vehicle it may be used to convert kinetic energy of wind into electrical energy by implementing wind turbine on a vehicle roof. Wind turbine is basically classified into horizontal axis turbine (Darrieus rotor) and vertical axis turbine (Savonius rotor). Due to the height constraints savonius turbine can serve the best on a vehicle roof. Also savonius rotor is simple in construction, cheaper, and good beginning torque at lower wind speed at starting condition. Because of its advantages it finds applications in irrigation and electric need in rural areas. Numerous studies have done to improve the efficiency of savonius wind turbine.

In this study, objective is to increase the performance by mounting savonius wind turbine into casing on a vehicle roof. Burcin Deda Altan carried out experimentation on a curtain angle of curtains provided in front of savonius wind turbine to increase the speed of wind striking on blades. He found that as the curtain angle increases leads to improve the efficiency of turbine. This paper will explain how to make use of kinetic energy to run savonius wind turbine.[4]

II. PROBLEM DEFINITION

Electric vehicle can run only upto 90 to 100 km in full charged battery of 48mah. Whereas it takes 5 to 6 hrs to get completely charged. Hence with the help of wind turbine mounted on roof of the vehicle effort is taken to increase the runtime of electric vehicle by continuous charging of a battery. For that purpose trial is to be taken on two blade, three blade and four blade rotor wind turbine at a constant speed of 50 to 60 kmph.

III. OBJECTIVES OF PRESENT STUDY

1. Design of savonius wind turbine blade rotor with enclosed casing.
2. Power calculation from different number of wind turbine blades i.e. two, three, four blade rotor.
3. Comparison between different numbers of wind turbine blades.
4. Increase the rotor efficiency by curtaining the opening angle.

IV. PARAMETERS TO BE CALCULATED:-

1. Swept area = A_s = H*D
   Where,
   H = rotor height (m)
   D = rotor diameter (m)
2. **The Angular speed (ω)** = $\frac{\lambda V}{r}$
   Where,
   λ = Tip speed ratio,
   ω = Angular speed in rpm,
   V = Wind velocity (m/s)
3. The Tip speed ratio (λ): The tip speed ratio is the ratio of the product of blade radius and angular speed of the rotor to the wind velocity. The tip peripheral velocity of the rotor (Vrotor).
   Where:
   Vrotor = the tip speed
   ω = the angular velocity of Savonius rotor (rad/sec).
   d = the diameter of the semi-cylindrical Savonius rotor(m).

Now the Tip Speed Ratio (TSR) of a turbine is expressed as:

The tip speed ratio (TSR) = λ = $\frac{Vrotor}{V} = \frac{w*d}{V}$ [2]

Parameters	Values
Swept Area, A	0.18 m^2
Aspect Ratio	0.465 mm
Rotor diameter	580 mm
Rotor height	270 mm
End plate diameter	600 mm
Blade thickness	0.853 mm
End plate thickness	0.55 mm
Curtaining angle (α , β)	45^o , 15^o

V. EXPERIMENTAL SETUP OF THE MODEL

This model consists of casing with varying cross sectional area at the entry and exit, a turbine and generator. These components will be mounted on roof top of car. When a car moves in a forward direction, air will move with the same speed but in opposite direction on the surface of vehicle. The drag force acting on vehicle is captured in a casing by placing it at a point where the intensity of drag force is high. Casing is made of varying cross section to provide a jet of air having a high speed. When this air jet strikes the blade of a turbine, it will rotate the turbine with a very high speed. Generator is connected with shaft whose speed is increased with the help of chain and sprocket arrangement. Entrance of duct should be rectangular in cross section, because it can intake more air compared to a circular cross section of same height and secondly it will have a lesser height so that no additional drag can be developed on vehicle. [5]

The whole setup of turbine unit which is to be installed on a vehicle roof is shown in figure1(a)


Fig 5.1: Setup of wind turbine on vehicle roof**.**

Wind turbine consisting two, three and four blades are been tested at a constant speed of 40 – 50 Kmph in order to investigate the performance of different blade wind turbine.

VI. OBSERVATION TABLE:-

1) Two Blade Rotor Wind turbine

Following readings were taken at a speed of 40 – 50 Kmph.

Table No.6.1 Observations of two blade rotor wind turbine.

W_{in}(m/s)	W_{out}(m/s)	Revolution (RPM)	Voltage Volts	Current Amp	Power Watt	Torque (Nm)	TSR
7.45	6.55	790	12	4.8	58	0.696	3.08
7.5	6.6	800	12	4.8	58	0.688	3.09
7.6	6.7	810	12.1	4.85	59	0.692	3.09
7.7	6.8	820	12.2	4.9	60	0.696	3.09
7.85	6.9	840	12.2	4.95	60	0.687	3.10
7.95	7.1	850	12.25	4.95	61	0.681	3.10
8.1	7.25	865	12.3	5	62	0.679	3.10
8.15	7.4	875	12.35	5.05	62	0.681	3.11
8.2	7.55	885	12.4	5.15	64	0.689	3.13
8.3	7.9	895	12.5	5.2	65	0.694	3.13

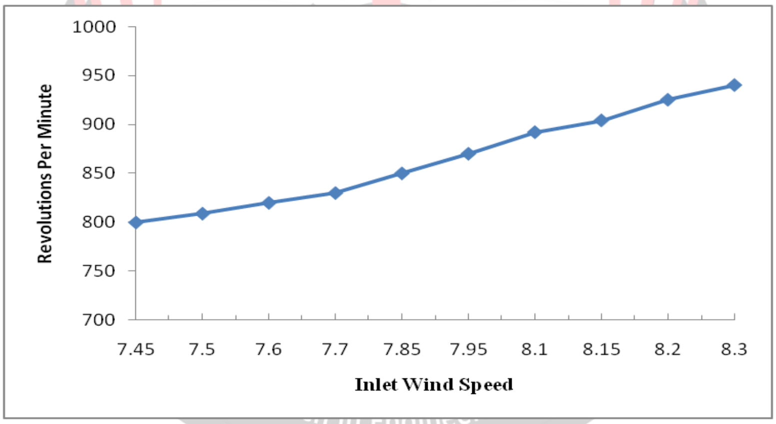

Fig 6.1 RPM Vs Wind speed

From the Graph No. 1.It gives that as the inlet wind speed in the casing increases revolutions of the rotor also increases. But due to the loss of wind passing from the casing reduces in the revolutions of the turbine.

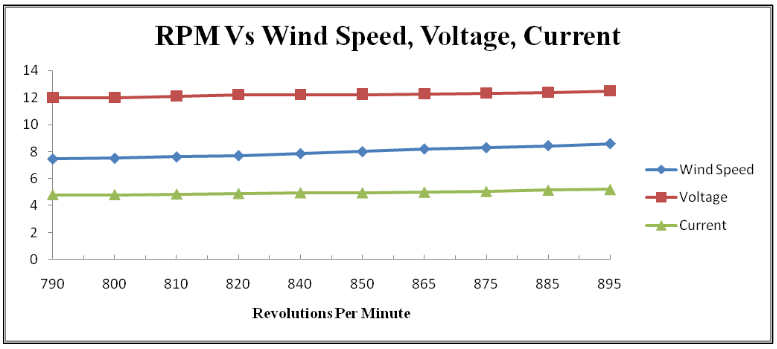

Fig 6.2 Wind speed, Voltage, Current Vs RPM

Above graph gives the comparison of the wind speed, voltage and current vs. RPM of the rotor.

Table No6.2 Three blade rotor wind turbine

W_{in}	W_{out}	Revolutions (RPM)	Voltage (Volts)	Current (Amp)	Power (Watt)	Torque (Nm)	TSR
7.45	6.5	800	12	5	60	0.716	3.11
7.5	6.55	809	12	5	60	0.708	3.13
7.6	6.6	820	12.1	5.1	61.71	0.719	3.13
7.7	6.78	830	12.2	5.1	62.22	0.716	3.13
7.85	6.9	850	12.3	5.2	63.96	0.719	3.14
8	7.1	870	12.4	5.3	65.72	0.721	3.15
8.2	7.25	892	12.5	5.35	66.875	0.716	3.15
8.3	7.4	904	12.6	5.4	68.04	0.719	3.16
8.45	7.5	925	12.8	5	64	0.661	3.17
8.6	7.6	940	13	5.5	71.5	0.726	3.17

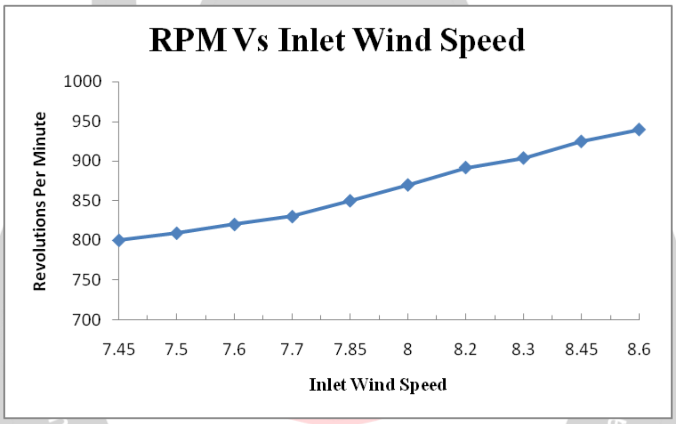

Fig6.3 RPM Vs Wind speed

From the above graph it is clear that revolutions of rotor are reaching 940 rpm which is more as compared to two blade rotor.

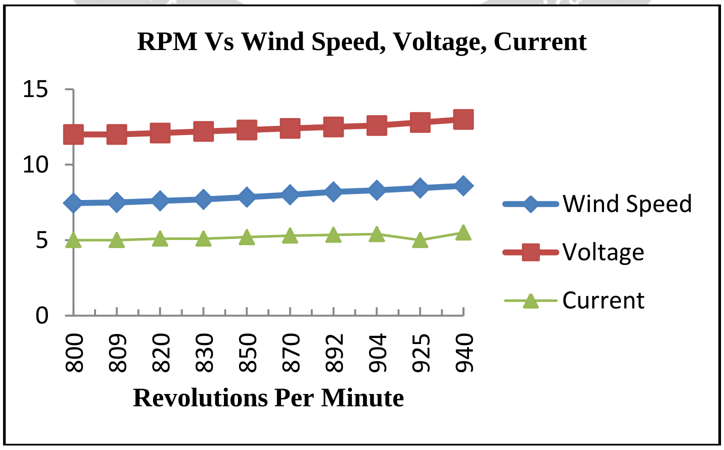

Fig 6.4 Wind speed, Voltage, Current Vs RPM

As revolutions of the three blade goes on increasing it is found that the current produced is constant in the range of 4-5Amp. If we supply constant current of 5Amp to battery of 12mah, time taken to charge the battery is approximately 2.75 hrs

Table No 6.3 Four blade rotor wind turbine

W_{in}	W_{out}	Revolutions (RPM)	Voltage (Volts)	Current (Amp)	Power (Watt)	Torque (Nm)	TSR
7.7	6.55	780	12	4.8	58	0.705	2.94
7.8	6.6	795	12	4.8	58	0.692	2.96
7.9	6.7	810	12.1	4.85	59	0.692	2.97
8	6.8	820	12.2	4.9	60	0.696	2.97
8.15	6.9	835	12.2	4.95	60	0.691	2.97
8.3	7.1	855	12.25	4.95	61	0.677	2.99
8.4	7.25	870	12.3	5	62	0.675	3.00
8.5	7.4	880	12.35	5.05	62	0.677	3.00
8.6	7.55	895	12.4	5.15	64	0.681	3.02
8.7	7.9	910	12.5	5.2	65	0.682	3.03

From the above table we can observe that the torque developed by four blade rotor wind turbine is more compared to two blade and three blade rotor wind turbine. Also constant current of 4-5 amp is efficient to charge the battery.

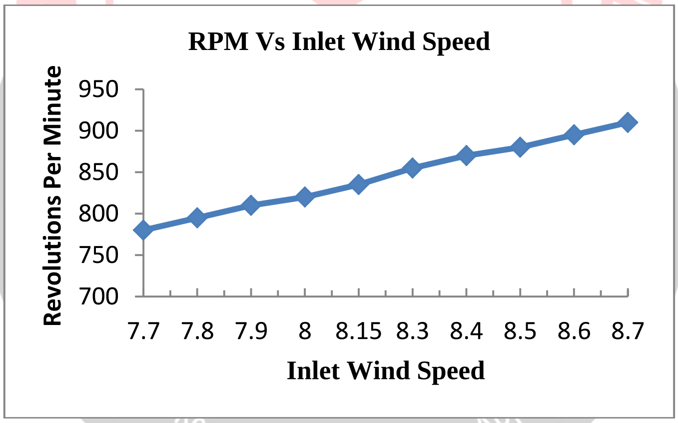

Fig 6.5 RPM Vs Wind speed

From above graph it is clear that for a wind speed of 8.7 m/s , rotor gets 910 rpm.

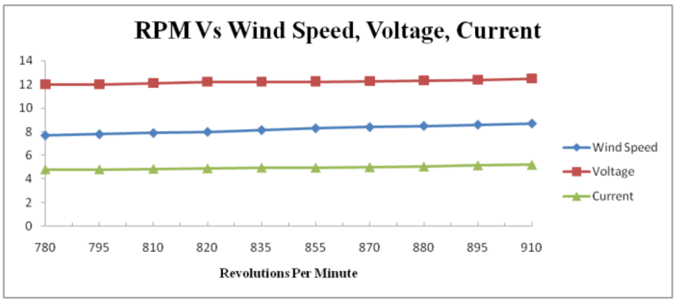

Fig 6.6 Wind speed, voltage, current Vs RPM

As the torque developed is maximum there is a scope of increasing the revolutions of rotor by introducing gearbox which will help in generating maximum current.

VII. CONCLUSION

As the speed of wind car is maximum up to 80kmph, hence readings were taken at a constant speed of 50 to 60kmph. Different number of blades was taken for the purpose of investigation and performance measure. For those two blades, three blades, four blades were taken for trial. After taking trials it was found that three blade rotor gives maximum rotations of rotor and produces maximum current. Also we come to know that the torque developed by the four blade rotor is maximum, hence there is a scope of increasing the rotation by introducing gearbox. Losses in two blade rotor are more hence rotations are less.

If current of 5amp remains constant time required to charge the Lithium-ion battery of 12mah is approximately 2.75 hr. Hence I conclude that we can increase the runtime of electric vehicle by 20 to 25 km.

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