To Study The Onsite Data For The Placement Of Vertical Axis Wind Turbine For Effective Power Generation

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Abstract: *Energy is an important aspect in our every day's life. The resources we use are limited whereas the population consuming the same is increasing day by day. Therefore, there is a need of the hour to find suitable relationship between a natural resources and growing population. Thus, researching new and innovative systems in renewable energy sector is an indispensable prerequisite. Renewable energy source is much required at the moment than ever before. And wind energy can be a suitable option in this regard, Wind energy is free of cost and available with ease. It has been harnessed for centuries but it has only emerged as a major part of our energy solution quite recently and this project focus on utilizing wind energy by using vertical axis wind turbine. The project revolves around the study of Onsite Data for The Placement of Vertical Axis Wind Turbine (VAWT) for Power Generation to harness energy from busy railway tracks. There is profound amount of energy available in these railway tracks and can provide a considerable amount of wind energy to recapture, while the trains are in motion. The system works in a fashion that, the wind produced by the rapidly moving trains hits the blades of an VAWT located at an optimum distance from the railway track and this makes them turn, converting the kinetic energy of the wind to mechanical energy (which makes the generator rotate) and finally converts to electrical energy, via the alternator below. Battery under the turbine stores the energy and, thus evaluation of how to use the electricity can be sized according to the demand.*

Keywords: *VAWT, Renewable energy, Natural resources, Harnessed, Railway tracks*

1.INTRODUCTION

As it is widely known that from the dawn of industrial age human activities, have profoundly exacerbated the biosphere (climate changes, biodiversity losses, and urban pollution); with the increased concern for the rising level of energy consumption indicates that our world is on an unsustainable trajectory, and solving this energy crisis is the need of the hour. Moreover, world's fuel needs are largely met by fossil fuels that are costly, finite and non-eco-friendly as it pollutes the environment and are exhausting at a very faster rate. Hence conservation and tapping of energy from new sources is a much-needed aspect all over the world.

Renewable energy systems is an important step for keeping national and international infrastructures intact, it's also important to understand the scalability of renewable energy solutions. It is widely known and accepted that wind and solar power are the most sustainable energy sources that is available in abundance. New improved innovative methods to harness their power are much appreciated in the present decade. The major predicament in extracting the power from wind is its variations in velocity.

This Project explains a novel concept that plans to harvests the wind power from moving trains. The idea of large-scale energy harvesting from trains is very fascinating. India has about 63000 route kilometers of railways and 14,300 trains running every day. And an extensive amount of energy can be produced through this method. A simple and efficient device to harness the wind energy in railways has not been devised yet. When considering the horizontal axis wind turbine, the efficiency is higher than vertical axis wind turbines due to high surface and body forces. On the other hand, from the economic point of view, the initial and maintenance costs are too high and the design is more complicated when compared to the vertical axis wind turbines. A simple difference in working principle is that the horizontal axis wind turbine rotates based on the lift force and the vertical axis wind turbines rotates from the drag forces that occur in the wind movement. These drag based wind machines are more suitable for harnessing the wind energy from the moving trains, due to its better torque generation in low wind speed speeds as well as high speeds. Further, the drag based wind machines are classified into different types. They are Savonius, Darrious and Giromill wind turbines. Among these, the Darrious wind turbines do not have the ability to self-start. In the case of Giromill turbines, the rotational speeds vary even due to a small wind fluctuations that occur in the wind speeds at unsteady pulsating wind speeds.

In in the SWT, end plates have some considerable amount of weight to give good inertial force to provide stable rotational speeds when there are small wind fluctuations that occur on the flow. SWT is most economical compare to other vertical axis wind turbines due to its simple design and good starting behaviour and also Due to better aerodynamic behaviour at low running speeds and low cost, the SWT was selected and used in applications like pumping water, low and high-rise applications for generating electrical energy by means of coupling an electric generator or alternators.

2.RESEARCH GAPS FOUND FROM LITERATURE

Most researchers and papers have focused their attention towards increasing the SWT's performance and behavioral characteristics by varying the wind velocities at steady state speeds at both numerical studies and wind tunnel tests. While others have concentrated on the CFD analysis of the same inside tunnel and most of the simulation or numerical study data has been assumed. But no actual validation of the theory is been conducted by a practical experiment or by measuring the actual data values at the specific sites. To the best of our knowledge, limited research has been conducted in the open space (without tunnel around) conditions and no pragmatic, prototypes have been constructed to evaluate the real-world application of this project. While most research is based on the theoretical model, which have drawbacks in practical applications.

3.OBJECTIVES OF THE WORK

This research work aims

- To find the optimum site for data collection, with the help of railway authorities.
- To study the velocities of the wind gust formed by the moving trains at 3 different horizontal locations from the track
- To observe the wind speed at the 9 different horizontal distance from the track and 9 different vertical distance from the ground and determine the most efficient point where the prototype can be located.

4.METHODOLOGY: -

The methodology adopted for this project is to commence with the Railway authority permission (which has been granted by the Divisional Office Chennai, Southern Railways). Which is followed by the literature review in order to understand the insights of the project and its real applications. The literature review is important to understand the theoretical and mathematical approach and also to validate the experiments conducted for the project. Further, the project is been proceeded by selection of optimum design of the Savonius rotor (highly efficient, concluded by literature review).

The experimentation part involves on site data collection, this part will be conducted by using measuring devices such as: anemometer, wind vane, speed gun and the array comprising all of these instruments attached at different horizontal locations and varying heights to find an optimum location so that the turbine can run at its maximum efficiency. All the wind gust measurements are been carried out, at a distance of 3 meters or more than 3m horizontal distance from the train. The speed of the train will be measured with the help of the speed gun and the velocities of the wind gust will be measure by anemometers.

5.GOVERNING EQUATIONS:

Equation (1) represents the power of the wind flowing wind turbine rotor, A*w* is the rotor swept area, ρ = the air density (kg/m3)

$$P_{wind} = 1/2 \varrho A w V^3 \quad (1)$$

Equation (2) is the mechanical power output generated by the rotation of the wind turbine rotor.

$$P_{rotor} = T\,\omega \quad (2)$$

Equation (3) shows the power output (P) of the wind turbine considering the power coefficient (CP) and A*w* is the rotor swept area, ρ = the air density (kg/m3)

$$P = 1/2 \varrho A w h V^3 CP \quad (3)$$

The rotor swept area (A*w*) is determined by the radius and height of the wind turbine.

$$Aw = 2RH \quad (4)$$

H= the rotor height (m). D = the rotor diameter (m).

The tip speed ratio (λ) is closely related to the power coefficient. The tip speed ratio is defined as the ratio of the blade tip speed and the wind speed at which the blade tip moves with rotation, as shown in Equation (5).

$\lambda = R\omega/V$ (5)

The coefficient of power is denoted by Cp and it is the ratio of total mechanical power output to total power of the wind flowing

$Cp = P_{wind} / P_{rotor}$ (6)

The Betz limit (theoretical maximum efficiency for a wind turbine) is given to be 0.59. Meaning that at most only 59.3% of the kinetic energy from wind can be used to spin the turbine and generate electricity. Similarly, the Maximum Cp of a savinious turbine in an open-air test is 0.37 and further the same value is considered for all wind turbine powers calculations.

Ct = the torque coefficient (7)

$Cts = Ts/Tw = Ts / 0.25\, \rho\, As\, d\, V^2$

T = the rotor torque (N. m) Tw = the wind available torque (N. m) ρ = the air density (kg/m3)

$T = F_{drag}\, R$ (8)

T = the rotor torque (N. m)

Blade chord length= d= R+ e/2 (9)

e = gap between two blades R= radius of rotor

Overlap ratio= δ= e/R (10)

Aspect ratio= H/D (11)

H= the rotor height (m)

D = the rotor diameter (m)

6.ONSITE-DATA COLLECTION

The on-site data collection, was conducted at Thiruvallam railway station premises, Vellore, TamilNadu. The electric measuring sensors used for the experimentation are: anemometer, speed gun and the array comprising all of these instruments attached at different horizontal locations and varying heights to find an optimum location for the model setup. The array caring these instruments was made of PVC pipes each with a diameter of 1cm in radius, the vertical heights we used to track the wind speeds are (2.5m, 2m, 1.5m) from the track level. The horizontal distances we accounted were (3m, 3.5m, 4m) from the track. According to the railway authority the minimum safe distance we had to keep was 3m. The wind gust data was recorded for 9 different points at different locations on the array. The figure below represents the experimental setup.

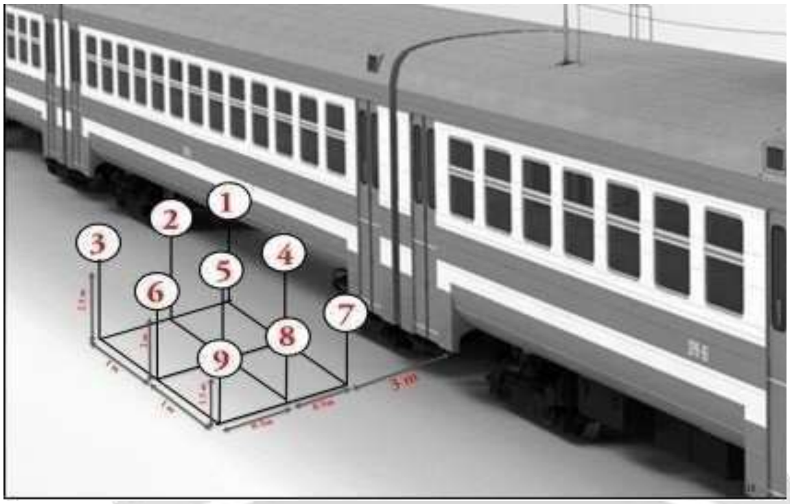

Fig 6.1 :-Experimental setup

The following tables represent the wind velocity data, maximum wind power generated at each point in the array and the maximum turbine power for nine different trains (express and wagon) throughout the day. The speed of the trains varied between 16m/s to 22m/s.

Train 1) Howrah - Ranchi Intercity Express (18617) Time: 10:15

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	3.8	5.3	63.57048	22.88537
2	2.5	3.5	3.7	5.4	67.23713	24.20537
3	2.5	4	3.7	4.9	50.23612	18.085
4	2	3	3.2	4.4	36.37357	13.09448
5	2	3.5	3.5	4.6	41.56247	14.96249
6	2	4	3	4.1	29.42927	10.59454
7	1.5	3	2.2	3.4	16.78281	6.041811
8	1.5	3.5	2.5	3.8	23.43034	8.434924
9	1.5	4	2.5	3.7	21.62883	7.786379

Table 6.1 :- Train data

Train 2) Dhanbad Express(13352) Time: 10:45

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	3.9	4.4	36.37357	13.09448
2	2.5	3.5	3.5	4.3	33.94949	12.22182
3	2.5	4	3.5	4.9	50.23612	18.085
4	2	3	3.2	4.6	41.56247	14.96249
5	2	3.5	3.4	4.6	41.56247	14.96249

6	2	4	3.1	4.3	33.94949	12.22182
7	1.5	3	2.6	3.5	18.30763	6.590745
8	1.5	3.5	3	3.9	25.32921	9.118517
9	1.5	4	2.5	3.3	15.3451	5.524236

Table 6.2 :- train data

Train 3) Jat Muri Rou Express (18110) Time: 9:35

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	3.6	4.8	47.22278	17.0002
2	2.5	3.5	3.5	5.1	56.64198	20.39111
3	2.5	4	3.2	4.6	41.56247	14.96249
4	2	3	3.1	4.2	31.63558	11.38881
5	2	3.5	3.5	4.7	44.33242	15.95967
6	2	4	2.9	4	27.328	9.83808
7	1.5	3	2.5	3.6	19.92211	7.17196
8	1.5	3.5	2.6	3.6	19.92211	7.17196
9	1.5	4	2.5	3.2	13.99194	5.037097

Table 6.3 :- Train data

Train 4) Pune Hatia SF Express (22845) Time: 17:10

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	3.9	5	53.375	19.215
2	2.5	3.5	3.5	5.3	63.57048	22.88537
3	2.5	4	3.5	5.1	56.64198	20.39111
4	2	3	3.7	5	53.375	19.215
5	2	3.5	3.2	4.6	41.56247	14.96249
6	2	4	3.3	4.2	31.63558	11.38881
7	1.5	3	2.5	3.3	15.3451	5.524236
8	1.5	3.5	2.6	3.8	23.43034	8.434924
9	1.5	4	2.2	3.5	18.30763	6.590745

Table 6.4 :- Train data

Train 5) Wagon Time: 11:30

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	4	5.2	60.03962	21.61426
2	2.5	3.5	3.9	5.3	63.57048	22.88537
3	2.5	4	4.2	4.8	47.22278	17.0002

4	2	3	4.2	5.5	71.04213	25.57517
5	2	3.5	3.9	5	53.375	19.215
6	2	4	3.6	4.8	47.22278	17.0002
7	1.5	3	2.9	3.8	23.43034	8.434924
8	1.5	3.5	2.5	4.3	33.94949	12.22182
9	1.5	4	2.3	4.1	29.42927	10.59454

Table 6.5 :- Train data

Train 6) Wagon Goods carrier Time: 11:40

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	4.6	5.6	74.98803	26.99569
2	2.5	3.5	4.4	5.8	83.31282	29.99262
3	2.5	4	4.1	5.3	63.57048	22.88537
4	2	3	4.2	5.5	71.04213	25.57517
5	2	3.5	4.7	5.5	71.04213	25.57517
6	2	4	4.1	5	53.375	19.215
7	1.5	3	2.5	3.8	23.43034	8.434924
8	1.5	3.5	2.3	3.6	19.92211	7.17196
9	1.5	4	2.1	3.5	18.30763	6.590745

Table 6.6 :- Train data

Train 7) Intracity Express (12680) Time: 12:00

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	3.6	5.2	60.03962	21.61426
2	2.5	3.5	3.7	5.9	87.69683	31.57086
3	2.5	4	3.8	5.4	67.23713	24.20537
4	2	3	3.2	4.8	47.22278	17.0002
5	2	3.5	3.4	4.2	31.63558	11.38881
6	2	4	3.5	4	27.328	9.83808
7	1.5	3	2.4	3.7	21.62883	7.786379
8	1.5	3.5	2.5	3.9	25.32921	9.118517
9	1.5	4	2.1	3.6	19.92211	7.17196

Table 6.7 :- Train data

Train 8) Pnbe Janshatabdi(12336) Time: 13:55

Points	Height	Horizontal distance	Minimum Velocity	Maximum Velocity	Max Power	Rotor Power

	(m)	(m)	(m/s)	(m/s)	(W)	(W)
1	2.5	3	3.7	5.8	83.31282	29.99262
2	2.5	3.5	3.7	5.5	71.04213	25.57517
3	2.5	4	3.8	5.8	83.31282	29.99262
4	2	3	3.4	4	27.328	9.83808
5	2	3.5	3.5	4.5	38.91038	14.00774
6	2	4	3.2	4.4	36.37357	13.09448
7	1.5	3	2.5	3.4	16.78281	6.041811
8	1.5	3.5	2.6	3.8	23.43034	8.434924
9	1.5	4	2.2	3.2	13.99194	5.037097

Table 6.8 :- Train data

Train 9) Rnc Ltt Express (12503) Time: 15:45

Points	Height (m)	Horizontal distance (m)	Minimum Velocity (m/s)	Maximum Velocity (m/s)	Max Power (W)	Rotor Power (W)
1	2.5	3	3.7	4.9	50.23612	18.085
2	2.5	3.5	3.9	5.2	60.03962	21.61426
3	2.5	4	3.6	5	53.375	19.215
4	2	3	3.6	4.8	47.22278	17.0002
5	2	3.5	3.4	4.6	41.56247	14.96249
6	2	4	3.2	4	27.328	9.83808
7	1.5	3	2.6	3.4	16.78281	6.041811
8	1.5	3.5	2.4	3.5	18.30763	6.590745
9	1.5	4	2.2	2.8	9.373504	3.374461

Table 6.9 :- Train data

10) Normal air velocities (without train movement) Time:12:30

Point	Height (m)	Horizontal distance (m)	Velocity (m/s)	Max Power (W)
1	2.5	3	1.8	2.490264
2	2.5	3.5	1.7	2.097851
3	2.5	4	2.3	5.195309
4	2	3	2.2	4.546696

5	2	3.5	1.8	2.490264
6	2	4	1.8	2.490264
7	1.5	3	1.3	0.938119
8	1.5	3.5	1.4	1.171688
9	1.5	4	1.3	0.938119

Table 6.10 :- Train data

7.CONCLUSION:

From the above train data we can see that the maximum wind power can be produced at a location where the wind velocity is higher, thus comparing the amount of power in the wind velocities we can see from each train data that the highest power is produced at 2.5m height and at 3.5m horizontal distance from the train. Which is represented as point 2. Thus it is evident that we choose point two as an optimum location for setting the prototype and consider it for further calculations.

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