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Design and Simulation of Hybrid Wind Diesel System Software

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Abstract

The work deals with Hybrid wind diesel system is designed and the operations of different system constituents like windmill, diesel engine, load, Flow path of power and battery are simulated which aid to predict the performance of Hybrid system. The designed software can also used for monitoring of existing hybrid wind diesel engine system. Visual basic- 6 software is used for writing the program to design wind mill of particular location and Photoshop software is used to built the model hybrid wind diesel system. The designed software results are carried out followed with experimental data to validate the analysis. The comparison shows a close agreement between results obtained from designed software module and results obtained from experimental setup.

Keywords: Cut-in speed, Rated speed, Furling speed, Kinetic energy.

1. Introduction

The quest for power is an integral part of human existence in the present day as it is closely interconnected to the standard of living of the populace. There is an ever-increasing demand for power viewing the pace at which population and economy is growing. This demands for exploration of newer energy sources, which are cleaner and also reliable. Wind energy is an important contender in this respect but needs measures to make it reliable. The wind hybrid systems provide the necessary advantage to overcome the difficulties of wind standalone systems.

2. Theoretical analysis

2.1 Electrical power out put

Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass of moving air, like a sail or propeller, can extract part of the energy and convert it into useful work. Three factors determine output from a wind energy converter: they are wind speed, Cross section of wind swept by rotor and Overall conversion efficiency of rotor, transmission system and generator or pump. No device, however well designed, can extract all of the wind's energy because the wind would have to be brought to a halt and this would prevent the passage of more air through the rotor. The power in the wind can be computed by using the concept of kinetics. The wind mill works on the principle of converting kinetic energy of the wind to mechanical energy. We know that power is equal to energy per unit time. The energy available is the kinetic energy of the wind. The kinetic energy of any particle is equal to one half its mass times the square of its velocity, or ½ mv^2. The amount of air passing in unit time, through an area A, with velocity V, is AV, and its mass m is equal to its volume multiplied by its density ρ of air, or m=ρAV. Substituting this value of the mass in the expression for the kinetic energy, we obtain, kinetic energy is. $\frac{1}{2}\rho A v^3$.

The electrical power out put (P_e) is basically depends on the wind turbine characteristics like cut-in speed, rated speed and furling or cut-out speed.[3]

$$P_e = 0 \qquad (v < v_c)$$

$$P_e = a + bv^2 \qquad (v_c \le v \le v_R)$$
$$P_e = P_{eR} \qquad (v_R < v < v_F)$$
$$P_e = 0 \qquad (v > v_F)$$

Where the coefficients a and b are given by

$$a = \frac{P_{eR} v_c^{\ 2}}{v_c^{\ 2} - v_R^{\ 2}} \quad and \quad b = \frac{P_{eR}}{v_R^{\ 2} - v_c^{\ 2}}$$

And the rated electrical power output at rated wind speed is expressed as

$$P_{eR} = \frac{1}{2} C_p \ \eta \ \rho \ A \ v_R^3 \quad Watt$$

Where C_p $is\ power\ coeff = \frac{power\ extracted\ by\ windmill}{power\ available\ in\ wind\ stream}$

2.2 Relation between V_c, V_R and V_F

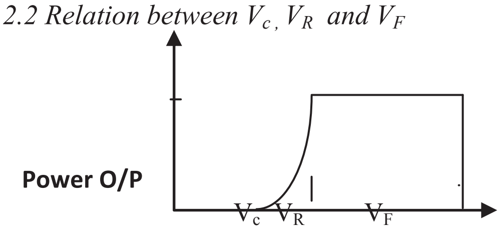

Figure 1: Wind turbine power v/s wind speed

Wind machines have operating characteristics, such as cut-in, rated & Furling speed Shown in Fig 1.

Cut-in speed (V_c): is minimum wind speed at which turbine starts generating power.

Rated speed (V_R): speed at which turbine will generate designed or rated power. At wind speeds between cut-in speed and rated speed, power out put from turbine increases with wind speed and out put of machine levels off above rated speed.

Furling speed (V_F): corresponds to high wind speeds during which the turbine ceases to generate power and is shut down. The wind speed at which the shut down occurs is also called as cut-out speed and is the safety feature which protects wind turbine from damage. Selecting a rated wind speed V_R is an important part of wind turbine design. This selection basically determines cut-in speed and also imposes certain constraints on furling speed. The investment in turbine will be proportional to turbine area so maximizing average power will minimize cost/unit of energy produced. If rated speed is chosen too low, it will lose energy in higher wind. If rated speed is too high, the turbine will seldom operate at capacity and will lose much of energy in lower wind speed.

For a given data of wind speed at a particular location, we can select Vc, V_R and V_F to maximize average power, and thereby maximize the total energy production. However, if realistic results are to be expected. The wind must contain enough power at cut-in speed to overcome all the system losses.

Relation Between V_c, And V_R : $V_c = 0.31V_R$
Relation Between V_F, And V_R : $V_F = 2V_R$
Relation Between V_R And V_{avg} : $V_R = 2V_{avg}$ Where V_{avg} is mean wind speed

Battery status in Ahr is determined using the following relationship

Energy = power x time (1) But power is the product of voltage and current i.e
Power= voltage x current (2)
Substitute eq. (2) into eq. (1) we get
Energy =Voltage * current *time

$$current * time = \frac{Energy}{Voltage} \quad \text{Ahr}$$

3. Software module results

3.1 Input parameters required for software

The input parameters required to run the software are Wind speed in m/s, Time in hrs, and Load in watt.

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3.2 Output of the Software

- Simulate operation of different system constituents.
- Various charts viz.
    - Load vs Time
    - Wind speed vs Time
    - Power output vs Time.
    - Battery status vs Time.
    - Energy stored vs Time.
- Current total power generated by wind mill in Watts.
- Battery status after every interval (10min) in Ahs.
- Diameter of the turbine in meter.
- Total run time of diesel engine.
- Total run time of Hybrid Wind-Diesel system.
- Finally produces brief report.

The main window of Hybrid wind diesel power system software module is shown in Fig 2. It contains different constituents like windmill, diesel engine and battery with three text boxes in the top row of the main window where it required to enter the input data like wind speed in m/s, Time in min or hr and required load in watt of that particular time. After entering the input data of any locality, run the software by clicking a green arrowhead button, which is positioned at top right corner of the software module. The software compiles and gives different design parameters of system as shown in Fig. (2).

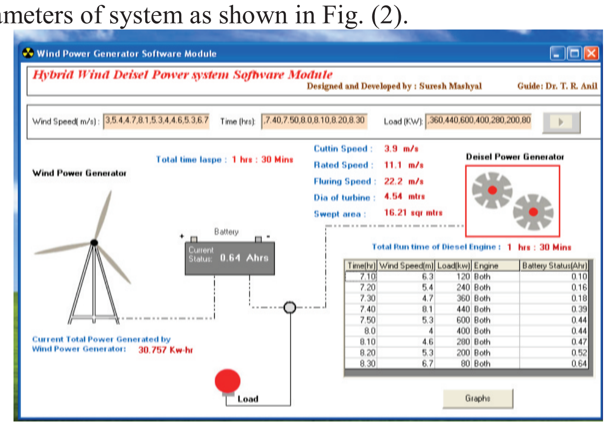

Figure 2: Main window indicating results of software

The main application of the software is once the input data of particular locality like wind speed, time and load is entered. The software not only simulate the different constituents of the system but also before installing the actual hybrid wind diesel system the software gives optimum wind diesel characteristics like cut-in, rated and furling speed of the wind mill required. Power produced by wind turbine on the basis of cut-in , rated and furling speed of designed wind mill, and total run time of the diesel engine by this value we can predict the total consumption diesel to fulfill the remaining load. Another main application of developed software that it is possible to monitor exiting hybrid system continuously.

3.3 Various charts obtained from software

The some of various charts obtained from software after giving the input parameters are as follows,

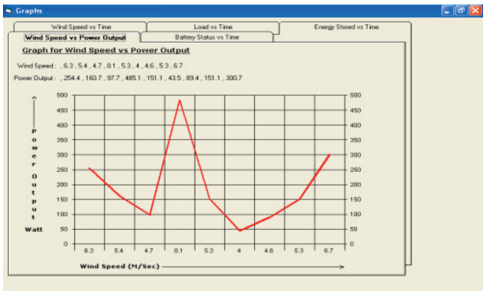

Figure 3: Power output v/s Wind speed

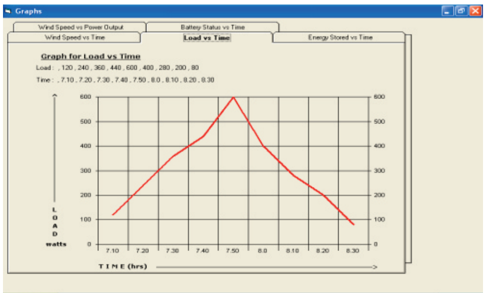

Figure 4: Load v/s Time

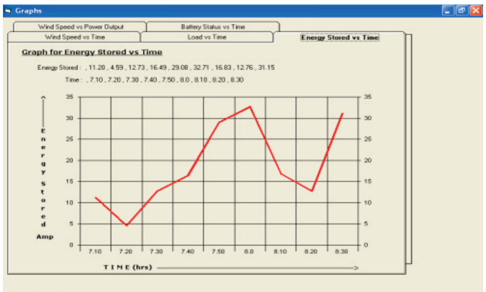

Figure 5: Battery Status vs Time

Table 1 Comparison of Software and Experimental results of wind turbine characteristics

	Software	Expt	% Error
Cut in speed (m/s)	3.2	3	6
Rated speed (m/s)	11.1	11	1.7
Furling speed (m/s)	24.4	25	2

Hence from Table 1 we can conclude that there is good agreement with in 6 % error, between the software and experimental result of wind turbine characteristics, which is thought to be quite acceptable.

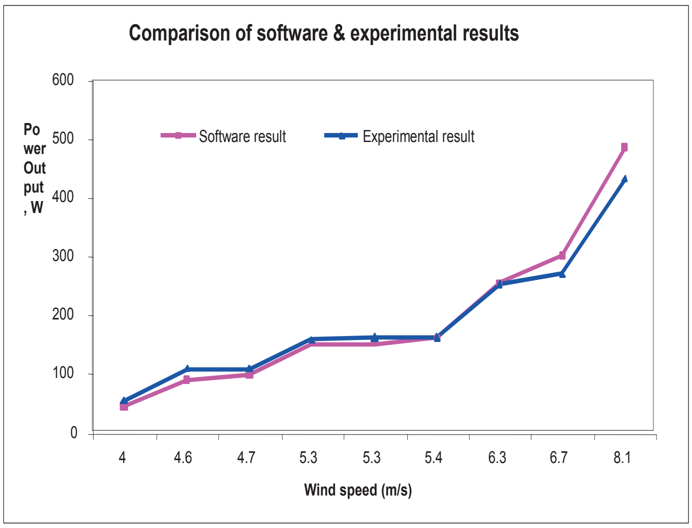

Figure 6: Comparison of Software and Experimental power output

The Fig.ure 6 shows the graph of comparison of software and experimental obtained result. The comparison shows a close agreement with in 5 % error, which is thought to be quite acceptable.

4. Conclusion

- The software developed simulates operation of Wind diesel hybrid system with respect to the constituents like wind mill, Diesel engine, load and battery.
- It can be efficiently used for the monitoring of existing system.
- The software aids in design and analysis of hybrid wind diesel system and predicts wind turbine characteristics and other features like power generation, battery status, total run time of diesel engine, wind turbine power before actual installation of system on site.

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