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Wind Turbine Building for Saving Home Electricity

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Abstract: *This paper presents design and building wind energy system. Even though, wind power is not popular in Iraq but it is widely used in other countries. Nowadays, our electricity bill always increases every year cause of increasing fuel and generation price. This paper will discuss about small wind energy system construction and building to save our home electricity. Building small wind turbine as alternative to reduce our electricity bill every months, and also compensate the poor of electricity provided from national grid. This system will use home inverter with battery storage, three blades small wind turbine and wiring. If the wind speeds at our area are high to generate enough power, we will supply that power from home inverter that use storage energy in battery that provided from wind turbine to low electrical equipment such as lighting, wireless gateway and more. Also install this home small wind system and make study on it by using real wind speed data inIraq in Najaf city. For providing electricity use permanent magnet DC generator connected to three blade wind turbine constructed on 1.8 m tower practically build as the wind energy system.*

I. Introduction:

The process of designing a wind turbine involves the conceptual assembling of a large number of mechanical and electrical components into a machine which can convert the varying power in the wind into a useful form. This process is subject to a number of constraints, but the fundamental ones involve the potential economic viability of the design. Ideally, the wind turbine should be able to produce power at a cost lower than its competitors, which are typically petroleum derived fuels, natural gas, nuclear power, or other renewable. At the present state of the technology, this is often a difficult requirement, so sometimes incentives are provided by governments to make up the difference. Even in this case, it is a fundamental design goal to keep the cost of energy lower than it would be from a turbine of a different design. The cost of energy from a wind turbine is a function of many factors, but the primary ones are the cost of the turbine itself and its annual energy productivity. In addition to the first cost of the turbine include installation, operation and maintenance. These will be influenced by the turbine design and must be considered during the design process [MohdAfizan, 2008].

II. Designing Procedure:

There are a number of approaches that can be taken towards wind turbine design, and there are many issues that must be considered. This section outlines the steps in one approach. The following sections provide more details on those steps. The key design steps include the following [Manwell and others, 2002]:

1. Determine application
2. Preliminary loads estimate
3. Develop tentative design
4. Predict performance
5. Evaluate design
6. Estimate costs and cost of energy
7. Design production machine

Wind Turbine Component:

Most modem wind turbines used for generating electricity have three blades, although some have two or even one. Three blades have the particular advantage that the polar moment of inertia with respect to yawing is constant. This characteristic contributes to relatively smooth operation even while yawing. Atwo-bladed rotor, however, has a lower moment of inertia when the blades are vertical than when they are horizontal. This 'imbalance' is one of the reasons that most two-bladed wind turbines use a teetering rotor. Using more than three blades could also result in a rotor with a moment of inertia independent of position, but more than three blades are seldom used. This is primarily because of the higher costs that would be associated with the additional blades [Manwell and others, 2002].

1. Blade:

To design and making blades we will use a PVC pipe of 72cm in long and the diameter of 16cm then traveled into two halves along its so that became each half-length 72cm, and then measured 10cm from one of two sides and 4cm from the other side on the same part of the two halves. We have making the blade by cutting the PVC pipe according the measurements described above using Jigsaw repeat the process three times as the number of blades. Each blade must be sharpening at the side that cut the air, the process described above shown below:

Fig.(1) The PVC pipe shape.

Fig.(2) The halved PVC pipe.

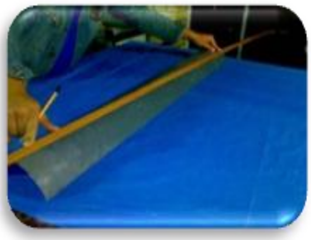

Fig.(3) Measuring dimensions of blade.

Fig.(4) Primary blade shape.

Others materials may be used to make a blade such as wood. Blade material wood is really an ideal material for blades. But in our wind turbine we used blades made from PVC pipe because it is very strong for its weight, easy to carve, inexpensive, and the resistant to fatigue cracking. Steel and aluminum blades are much too heavy and prone to fatigue cracking; sheet metal would be a poor choice, and extremely dangerous...check out the photo of fatigue cracks on a sheet metal windmill at the vibration would do to sheet metal blades! Cast reinforced Fiberglas blades are very strong, and are common on commercial windmills. Diameter blades that are too short attached to a large alternator will not be able to get it moving fast enough to make good power. Blades that are too large for a small alternator will overpower and burn it up, or over speed to the point of destruction in high winds--there's not enough of an alternator available to collect the energy coming in from the wind but in our turbine has 150cm in diameter. The following figure illustrates the final shape of worked blade.

Fig.(5) Final shape of worked blade.

Blade design experiments are an entertaining place to explore how design affects power production. The blades on modern turbines "capture" the wind and use it to rotate the drive shaft of a generator. As we mentioned above the spinning shaft of the generator spins wires near magnets to generate electricity. How well you design and orient your blades can greatly impact how fast these blades spin and how much power your turbine produces. Experiments with blades can be simple or very complicated, depending on how deeply you want to explore. Some blade variables you can test include :(length, number, pitch shape and materials) [Sargent Avenue, 2006].

2. **Tail:**

The generator is mounted off-center horizontally from the yaw bearing. The tail is also angled in this axis. The tail is also angled in the vertical axis, and hinged. When the wind force back on the rotor is strong enough to overcome the off-axis generator making it want to yaw and the angled tail trying to keep it from yawing, the tail folds up and turns the alternator away from the wind direction, forcing the wind turbine to yaw out of the wind. When wind speeds drops, the tail is returned to normal operating position by gravity, or springs. Many commercial and homemade designs (including ours) use this system, and it has proven to be very reliable.

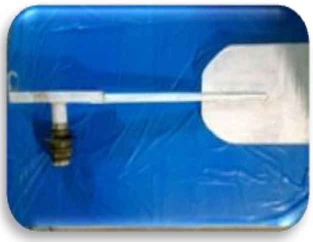

Fig.(6) The tail Shape.

3. **Tower:**

Your tower must be *extremely* sturdy, well-anchored, and tall enough to get above obstructions. We've seen 2.25 inch steel pipe bend like a pipe cleaner in 50 mph winds, underneath a wind machine with only an 8-foot rotor. Some wind energy guidelines tell you to plan on spending at least as much on your tower and power wiring as on the wind generator itself! The two basic kinds of tower are the Tilt-Up and Stationary. A stationary tower is the most sturdy and trouble-free, but you have wiring as on the wind generator itself! The two basic kinds of tower are the Tilt-Up and Stationary. A stationary tower is the most sturdy and trouble-free, but you have to climb it to install, maintain or remove the wind machine. A crane is often used for installation, an expensive proposition--though you can do it yourself by climbing the tower and moving a gin pole up it as you add each new section. If climbing towers disagrees with you, go for a tilt-up. Then all maintenance can be performed while standing safely on solid ground.

III. Permanent Magnet DC Generator Construction:

In following describes how to build a permanent magnet generator (PMG). We can also call it an 'alternator', because it generates alternating current (AC). It will not generate 'mains voltage' or 'utility power' AC. It generates low voltage, 'three phase' AC, and then changes it into 'direct current' (DC) for charging a 12 volt battery.

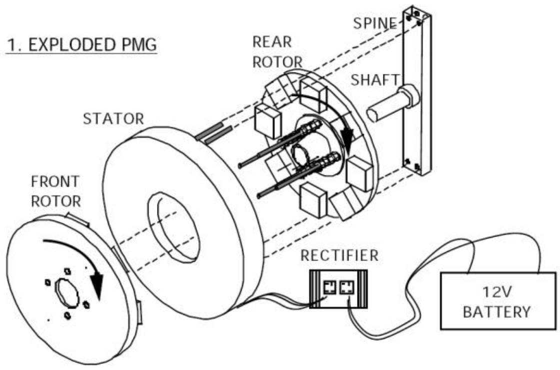

Fig.(7) Diagram of constructed generator.

The PMG (figure 7) consists of:-
- A steel spine and shaft.
- A stator containing coils of wire
- Two magnet rotors
- A rectifier

The stator contains six coils of copper wire, cast in fiberglass resin. This stator casting is mounted onto the spine; it does not move. Wires from the coils take electricity to the rectifier, which changes the AC to DC for charging the battery. The rectifier is mounted on an aluminum 'heat sink' to keep it cool. The magnet rotors are mounted on bearings, which turn on the shaft. The rear rotor is behind the stator, and enclosed within it. The front one is on the outside, fixed to the rear one by long studs which pass through a hole in the stator. The wind turbine rotor blades will be mounted on the same studs. They will turn the magnet rotors, and move the magnets past the coils. Magnetic flux passes from one rotor to the other through the stator. This moving magnetic flux is what produces the electric power. The PMG works at low rotational speed. The power output of the PMG, charging a 12 volt battery. At 420 rpm it generates 180 watts, which is 15 amps at 12 volts (15A x 12V = 180W). List of Materials and tools Materials for PMG described in following table.

Table (1) List of materials for PMG.

Materials for PMG	No. per PMG	Size	Total weight in gram.
Polyester resin			2700
Catalyst (peroxide)			50
Talcum filler powder			1200
Stainless steel wire		2mm×10meters	200
Grade 3 ferrite magnet blocks	16	20×50×50mm	4000
Winding wire		1.7 mm	3000
Flexible wire		Same size×6meter	
Bridge rectifiers	2	25A 200V single phase	
Heat sink rectifiers			250
Box section tube ('RHS') for spine	1	380 x 50 x25 x 4mm	1100
Magnet disk (or octagonal) plates	2	6mm x305mm Outer Diameter	6000
10mm threaded rod ('studding')		1000mm	500
10mm nuts	32		300
10mm washers	16		
8mm threaded rod		400mm	125
8mm nuts 5mm nuts	8		50
8mm nuts 5mm nuts and bolts for rectifiers	2	5mm× 20mm	
Shaft		25mm× 150mm	500
Bearing hub to fit shaft.	1		1250

Some coils for the stator The PMG stator contains six coils of copper wire as in figure below.

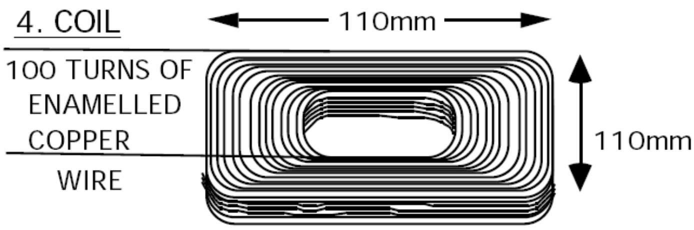

Fig.(8) The shape and dimensions of coil.

The magnet rotors are mounted on a bearing hub (see fig.9). The hub has a flange with holes in it. For example there may be four holes on a 102mm (4 inch) 'pitch circle diameter' (PCD). Or you may have some other arrangement. This will depend on what kind of hub it is [Hugh, 2001].

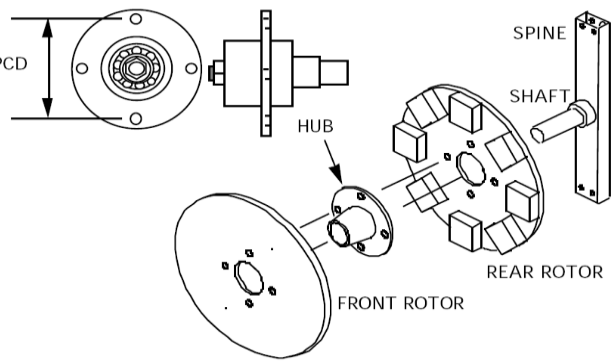

Fig.(9) Parts of PMG machine.

The holes must be marked and drilled very precisely. (See figure 9)
• Cut a square piece of steel plate 125mm by 125mm.
• Draw diagonal lines between the corners and mark the exact centre with a punch.
• Set your compasses at 51mm radius (or to suit whatever PCD). Draw a circle.
• The diameter of the circle is the PCD of the holes in the hub.
• Punch both places where one line meets the circle.
• Set your compasses at 72mm. Mark two points exactly this distance from thefirst two, on the circle.
• Drill four holes exactly 72 mm apart on the circle. Use a small drill first and thena larger one.
The shape of the completed wind turbine was worked and installed at the roof home shown in the following figure.

Fig.(10) Completed shape of worked wind turbine.

IV. Model of Permanent Magnet DC Generator:

The generator can be considered as an ideal generator with an internal resistance in series as illustrated in the figure. The torque T and rotational speed ω are input parameters. The current I and the voltage U are output parameters. The external resistance is noted as Ru. According to Faraday, the generated voltage is a linear function of the rotational speed (1) and according to Lorentz, the generated torque is proportional to the current (2):

$$U_g = \varphi_m . \omega \quad \ldots(1)$$

$$T_g = \varphi_m . I \quad \ldots(2)$$

In which φ_m is a constant which is proportional to the magnetic flux (φ_m in Wb).

The voltage *U* that is supplied at the generator clamps is equal to the voltage generated minus the voltage drop over the internal resistance, which is also equal to the generated current times external resistance.

$$U = \varphi_m . \omega - I . R_i \& \quad U = I . R_i \quad \ldots(3)$$

The torque required to drive the generator is equal to T_g plus the torque required to overcome losses (T_0).

$$T = T_g + T_0 \quad From\ Eq.(2)\ we\ get\ T = (\varphi_m . I) + T_0 \quad \ldots(4)$$

The efficiencyη is defined as the ratio of electric power generated and mechanical power required:

$$\eta = \frac{P_e}{P_m} \rightarrow \eta = \frac{(U.I)}{(T_g + T_0).\omega} \quad \ldots(5)$$

The losses *L* can be calculated as the sum of the power due to the lost torque and heat generated due to the internal resistance of the generator:

$$L = T_0 . \omega + I^2 . R_i \quad \ldots(6)$$

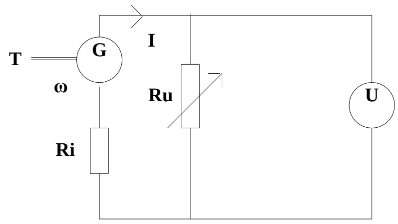

Fig.(11) Equivalent circuit of permanent DC generator.

Brush voltage

A brush voltage U_b is introduced which has the opposite sign as U_g. Formula (1) changes into:

$$U_g = \varphi_m . \omega - U_b \quad \ldots(7)$$

The value that has been used for U_b is 0.1 V.

Torque losses

The torque T_0 can be determined by measuring the torque as a function of the rotational speed at open circuit (I = 0 A).

Using the model, the characteristics of a DC permanent magnet generator can be determined accurately with a minimum of measurements. For instance, using a spring balance, a multimeter and RPM counter, the efficiency of a generator can be determined [Gerrit Jacobs, 1998].

Factors that Affect Power Output

Now that you have a wind turbine, let's start exploring what factors affect the amount of power your turbine produces. Here are a few places to start;

• ***Wind Speed***
• ***Generator Type***
• ***Blades***

V. Calculation the Power of Wind:

A simple equation for the power in the wind is described below. This equation describes the power found in a column of wind of a specific size moving at a particular velocity [Manwell and others, 2002].

$$\mathbf{P = 1/2\times \rho\times (\Pi\, r^2) \times V^3} \quad \ldots (8)$$

P = Power in the Wind (watts)
ρ = Density of the Air (kg/m^3)
r = Radius of your swept area (m)
V = Wind Velocity (m/s)
Π = 3.14

From this formula you can see that the size of your turbine and the velocity of the wind are very strong drivers when it comes to power production. If we increase the velocity of the wind or the area of our blades we increase power output. The density of the air has some impact as well. Cold air is denser than warm air so you can produce more energy in colder climates (as long as the air is not too thin!).

The following figures show the wind turbine power as a function of rotational speed with no load. Without correction for the brush voltage, and writing the current I as a function of the rotational speed in programming at MATLAB [Duane and Bruce, 1997].

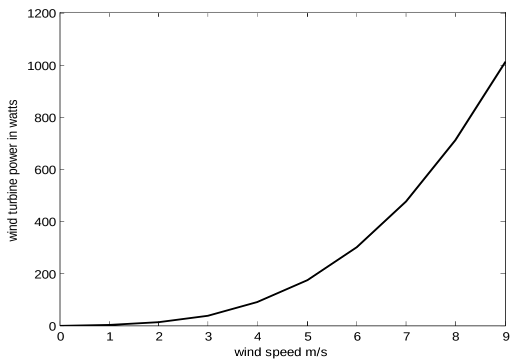

Fig.(12) Wind turbine power with respect to wind speed.

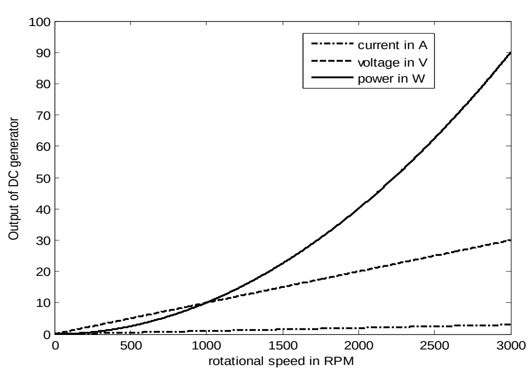

Fig.(13) Out put power from our dc generator with respect to rotational speed.

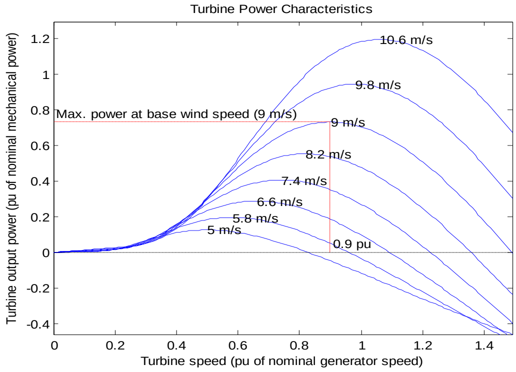

Fig.(14) Our wind turbine power characteristics.

How much wind power is coming from our constructed wind turbine?
V = 9 m/s (meters/sec)
ρ = 1.223 kg/m^3 (kilograms/cubic meter)
r = 0.85 meters
A = 2.2698 m^2 (Area of Circle = Πr^2)
Power in the Wind = $\frac{1}{2}\rho A V^3$
Power = $(0.5)(1.223)(2.2698)(9)^3$
= 1011.894 Watts
There are more than one kilowatts of wind power coming from constructed wind turbine. Can our little turbines capture all of this power?!

Table (2) Measurement of wind speed in Najaf city.

Date	Wind speed m/s	Time (GMT)	Direction in degree w.r.t North
2010/10/1	4	12	30
2010/10/2	5	10	360
2010/10/3	5	3	20
2010/10/4	4	20	350
2010/10/5	5	12	350
2010/10/6	4	18	20
2010/10/7	3	13	30
2010/10/8	5	23	360
2010/10/9	6	9	360
2010/10/10	3	9	360
2010/10/11	9	15	360
2010/10/12	6	8	360
2010/10/13	3	13	360
2010/10/14	4	10	360
2010/10/15	2	9	270
2010/10/16	2	6	240
2010/10/17	2	12	360
2010/10/18	0	0	0
2010/10/19	3	9	360
2010/10/20	5	12	350
2010/10/21	8	8	330
2010/10/22	6	12	360
2010/10/23	4	12	350
2010/10/24	0	0	0
2010/10/25	3	12	330
2010/10/26	7	13	310
2010/10/27	3	6	350
2010/10/28	4	12	330
2010/10/29	4	18	120
2010/10/30	6	8	330

VI. Conclusion:

From the analysis of this project, it can be summarizing that the output power will be increase when the value of radius blades increase. Small wind energy system suitable to use at home have the radius blades between 0.72-2 meters which can produce power output below 1 KW. In general, by using the real wind speed data, the output from small wind generator that can be applied in Iraq is 390 W until 2kW. From overall work, small wind system which has radius blades from 1 until 2 meter has good potential to install this system. This power stills not enough to supply all electrical instruments at our home. So, this small wind system can be used to supply low power equipment at home such as lighting, parking meter and wireless devices. For wind turbine which has radius blade larges than 5 meter, it is not practical to install for every house, maybe it more suitable to supply overall village for one wind turbine. After the analysis by using real data in Iraq, it can be conclude that this small wind system have potential to practice in this country in the future.

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