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Design Optimization of WECS to charge Cell phones

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ABSTRACT

This paper describes about the development of optimized design of a windmill prototype, using‘c’ language. The wind turbine generator developed based on this design is used to generate electrical energy as the output from the atmospheric wind. The wind energy available from atmospheric wind flowing between the blades of prototype wind millis converted into mechanical energy. This mechanical energy is used to run a stepper motor. This Stepper motor, which acts like a generator converts mechanical energy into electrical energy. This Electrical energy is regulated using an electronic circuit. The regulated Direct Current can either be stored in a rechargeable battery or can be used directly to charge the cell phones.

KEYWORDS: Wind Turbine generator, Stepper motor, Zener diode, Optimization, ‘C’ language, Battery, Cellular phone.

1. INTRODUCTION

In the present era, we have mastered the art of consuming electricity and also l, l our responsibilities being taken care of by our fondly used electric and electronic appliances that run solely on electric power. However when it comes to the generation of electricity, we have little options and we always depend upon the age old methods. We have several alternative sources of energy that we see and feel every day and everywhere, but sadly they are awfully unexploited like solar and wind energies. The most nearly inexhaustible source of energy is yet available to us, is the Sun. It bathes the earth with radiation and derives its strength directly from this energy. Wind results from air in motion and air in motion arises from a pressure gradient. Wind possesses energy by virtue of its motion. This kinetic energy of wind can be utilized either to perform work or to generate electricity with the aid of a wind energy conversion system, which are also known as wind mills. Wind mills enhance both the earth’s beauty, without ever polluting the air, water or soil.

Theory of Wind Mill: For determining power extracted from wind by wind mill, we have to assume an air duct with velocity of wind at the inlet of the duct is C_1 and velocity of air at the outlet of the duct is C_2. If ρis the density of flowing air, then the available wind power,

$P_a = 0.5925 \times ½ \rho A C_1^3$

Hence, theoretically maximum power extracted from the wind is in the fraction of 0.5925 of its total kinetic power. This fraction is known as power coefficient or Betz Coefficient. The power coefficients the ratio of power wind rotor to power available in wind.

Design and development: It is very important to calculate the best loading value to create a good blade design. Hence, we need to specify the chord width and blade setting angle β at each of a series of stations along the span of the blade as shown in figure.1. At each station we will create the right shape of the blade to produce the right loading.

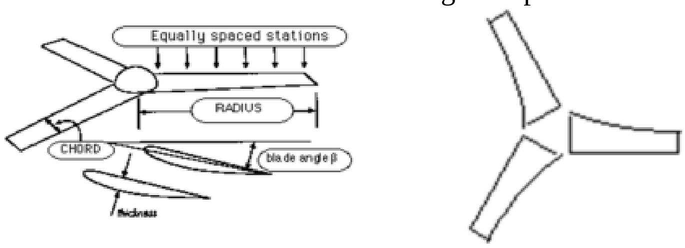

Figure.1. wind blade details

The bit of the blade at radius ‘r’ sweeps a fraction of the total swept area, and has the job of slowing this by the right amount of wind to satisfy the Betz coefficient. The area of wind it sweeps will be 2ЛrΔr. Its headwind will be (r/R)λv where λ is the tip speed ratio at which the prototype of wind mill would like to work. These specifications are shown in theFigure.2.

The apparent wind which a blade sees is altered by its own speed through the air. This headwind adds to the real wind to give the apparent wind, which creates the lift and drag forces. The head wind rotates the direction of the forces on the blade. The drag force opposes the blade’s movement. The lift force assists the blade’s movement. Both forces also push the blade downwind and slow the wind down. These details are shown in figure.3.

To satisfy Betz criterion, the wind in each part of the swept area of the rotor must be slowed down to 1/3rd of its upstream velocity, and this slowing is done by the THRUST force, which is very closely related to the lift force. This is shown in figure.4.

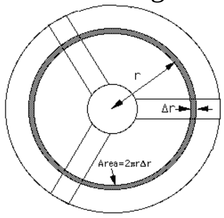

Figure.2.Specifications of Wind turbine blade

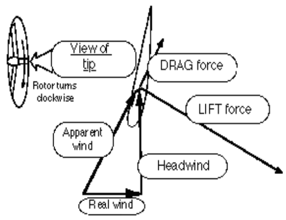

Figure.3. Details of wind forces

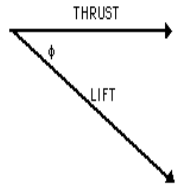

Figure.4.Lift and Thrust forces

This leads to a rough expression for the chord width c which will produce the right amount of thrust to meet the Betz condition. Where B is the number of blades, C is the chord width, at radius r, v is the free wind speed. BCΔr is the area of blade used to produce lift at radius r. The wind turbine part diagram drawn with the aid of CAD software is shown in figure.5 and the relationship between blade angle and tip speed ratio is shown as graph in figure.6

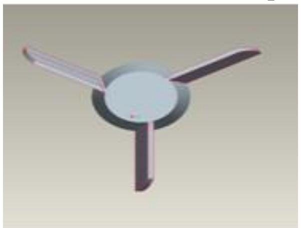

Figure.5 Wind Mill part diagram

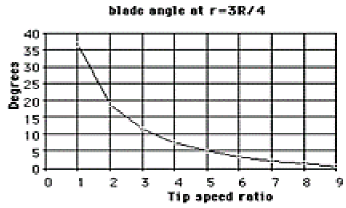

Figure.6. Graph drawn between blade angle and tip speed ratio

Design Calculations

- Wind mill outer diameter,D_2=0.55 m
- Head of air in water column P=31.5mm
- Head of air in water column at no load condition P0=31.5*1.33=42mm of water
- Rotational speed of windmill Rotor,N =1000 rpm=16.67 rps
- Maximum volume flow of air V_m=0.6 m^3/s
- Velocity of windmill at inner diameter C1=16.6m/s
- Velocity of windmill at outer diameter C_2=3.14*0.55*16.67=28.8 m/s
- Area at the outlet of windmill A_2=0.6/(0.42*28.8)=49.4*$10^{-3}$$mm^2$
- Coefficient of utilizationK =0.5,
- Blade width b =49.4*10^{-3}/(0.92*3.14*0.55*0.5)=62.2mm
- inner diameter (hub) of prototype windmill D_1=16.6/(3.14*16.67)=317mm
- o/p – output power produced by prototype windmill = 92watts,p=v*i =20v * 4.6amps
- tip speed ratio $\lambda = n/v_{m,}\lambda$=5 for 3 number of bladed prototype windmill
- Torque produced =10.95N.

Design solution using 'C': C is the language of choice for programming embedded and mechatronic systems with hardware interfaces. Writing computer programs is essential to solving complex science and engineering problems. The wind mill design calculations are written in 'C' programming language. This is given below.

```
#include<stdio.h>
#include<math.h>
#include<conio.h>
main()
{
int z, no,n;
float d2,v,vm,c2,a2,b,p,p0,c1,d1,op,eff,k,pi;
clrscr();
printf("enter values for d2,v,z,n,k,eff");
scanf("%f%f%d%d%f%f",&d2,&v,&z,&n,&k,&eff);
pi=1*3.14;
vm=2*v;
c2=pi*d2*n;
```

```
a2=vm/(0.42*c2);
b=a2/(0.92*pi*d2*k);
p=v*v*z;
p0=1.33*p;
c1=sqrt((c2*c2)-(p0/0.075));
d1=c1/(pi*n);
no=(pi*d2)/(1.25*b);
op=9.81*((p*v)/eff);
printf("\n max volume flow of atm air=%f",vm);
printf("\n speed of prototype windmill at o.d=%f",c2);
printf("\n area of outlet=%f",a2);
printf("\n blade width=%f",b);
printf("\n head of air in water column=%f",p);
printf("\n head of air in water column at no load=%f",p0);
printf("\n speed of  prototype windmill at i.d=%f",c1);
printf("\n inner dia of prototype windmill=%f",d1);
printf("\n no of blades=%d",no);
printf("\n op power from prototype windmill =%f",op);
getch();
}
```

This will generalize the design of prototype wind energy conversion system (WECS).

Stepper motor theory: There are four coils of wire located inside a stepper motor, which are 90 degrees away from each other and in the middle is the rotor which spins and has permanent magnets fitted around its circumference. As the rotor spins each magnet in turn approaches, passes, and moves away from each of the four coils in turn. A magnet passing a coil of wire causes electricity to flow through that coil and so each of the four coils will have different amounts of electricity flowing through it either one way or the other. When the four-phases are brought together and rectified into direct current (DC), the total electricity generated therefore has a near constant voltage and current. In contrast to other generators stepper motor produces a large induced voltage even at low rotational speed. The type used here with a dc resistance of 120ohms per winding can generate more than 20volts when turned by hand without any gearing. A supplementary circuit stores the energy. Two bridge rectifiers each made up of four IN4148 diodes charge the 4700micro farad capacitor. The output is driven either via 390ohms resistor or via 22k ohms resistor in series with 390 ohms. When cranking dynamo in the bright setting it is possible to exceed the rated current of 20milli ampere, and the rated voltage of 25volt. The photo of stepper motor and its circuits are shown in figure.6.

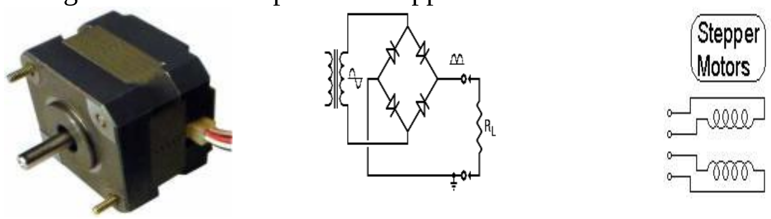

Figure.6. Stepper motor and its circuits

Voltage regulation: The simplest way to get started to connect each of the four live wires to a diode, connecting the other ends of the four diodes together. This will act as the DC positive output, and the common wires when connected together act as the DC negative output. Zener diode is used to regulate the voltage which is possible by operating Zener diode at its reverse breakdown voltage region. The Zener diode is like a general-purpose signal diode. When biased in the forward direction it behaves just like a normal signal diode, but when a reverse voltage is applied to it, the voltage remains constant for a wide range of currents. There is a limit for the reverse voltage. Reverse voltage can increase until the diode breakdown voltage reaches. This point is called Avalanche Breakdown region. At this stage maximum current will flow through the Zener diode. This breakdown point is referred as "Zener voltage". Thus output voltage is regulated as 6.8 D.C. voltage. The Zener diode is shown in figure.7.

Figure.7. Zener diode

Charging of cell phones: The voltage as per requirement of cell phones, irrespective of its type i.e. Nokia, Samsung, Sony, Reliance etc, has to be regulated based on the design of wind mill blades and the wind flow. The voltage range of cell phones charging generally varies from 3.7 V to5.25 V. Charging of many Cell Phones at a time is also possible using Multi charge insertion Pins. This is a project designed and developed by students under the guidance of the professors. The photographs of the prototype are shown in the figures.8

Figure.8. Photos of Wind Mill prototype project kit

2. CONCLUSION

In the present scenario, this project kit can be used in train or bus journeys. In this way, the energy can be conserved and mobile phones can be chargedin day to day life. Design and fabrication of prototype windmill for charging cell phones using wind energy is improved in performance than the usual systems being used in these days. The Size of the Prototype Windmill can be reduced further; When Stepper Motor of appropriate smaller size is designed to produce the required EMF. The Output Voltage can be increased by increasing the number of Blades, but this will add the Weight of the Windmill Rotor. Another effective way of increasing the Output Voltage is by increasing the number of Rotors, Whose Weight can be equally distributed uniformly along the extended Shaft.

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