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Design, Fabrication and Performance Analysis of 400W Solar-Wind Hybrid Systems for Rural Applications

A Project Report

Submitted by

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BONAFIDE CERTIFICATE

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Sri Amman Home Appliancies

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Date : April 25, 2006

TO WHOM SO EVER IT MAY CONCERN

This is to certify that **Mr.K.Rajesh Prabhu, Mr.P.Viknesh Ram** and **Mr.G.Sasi Kumar**, students of **Kumaraguru College of Technology, Coimbatore** have done their project titled "**Design, Fabrication and Performance Analysis of 400W Solar-Wind Hybrid Systems for Rural Applications**", from **January 2006 - April 2006**. During this period, their performance is very good and satisfactory.

We wish them all success to their future endeavours.

For Sri Amman Home Appliances,

Mr.Selvaraj

(Chief Executive Officer)

ABSTRACT

The availability of non-renewable energy resources is constantly decreasing and the world has to face the situation in which renewable energy resources comes as a substitute for all the currently available energy techniques. The main aim of our project is to use the plenty available renewable energy resources such as wind energy and solar energy for the rural areas. The project must be cost-effective and at the same time efficient so as to cope up with the conditions available in the rural areas.

The wind turbines are used for converting wind energy into mechanical energy. This mechanical energy is then converted into electrical energy by the use of alternator. The turbine blades rotate due to the kinetic energy of the wind and this gives a rotary motion to the shaft. The shaft is coupled to an alternator through a belt and pulley. Hence the turbine blades act as a prime mover for the alternator. The output voltage from the alternator is stored in a battery.

The other energy which is cheap and available in plenty is the solar energy. The solar energy is directly converted into electrical energy by the use of photovoltaic cells. The output from the photovoltaic cells is the dc voltage is stored in a battery.

The battery supplies power to the rural areas. As the project depends on both the wind energy and the solar energy, there is continuous supply to the battery. As this method uses two energy resources, there is no need to depend on a single technology. As this project is cost effective, it serves as a substitute for the commercially available wind turbines.

In our project we are combining both solar and wind energy to produce a power about 400W, which could be useful to rural community by reducing the cost of aero generator. This system could be a decentralized one which is adaptable for rural areas.

ACKNOWLEDGEMENT

With deep sense of gratitude, we extend our earnest and sincere thanks to our guide senior lecturer **S.R.RAJABALAYANAN**, Department of Mechanical engineering for this kind guidance and encouragement during this project.

We are also grateful to the head of department **Dr. T.P.MANI** for his constructive suggestions and encouragement during our project. We would like to express our sincere thanks to our principal **Dr.K.K.PADMANABAN** for forwarding us to do our project and offering adequate duration in completing our project.

We thank **Mr. SELVARAJ,** CEO and the technicians of Sri Amman Home Appliances, Coimbatore for the opportunity they had provided us with to take up this project and for their guidance.

We shall be failing in our duty if we do not thank all the department staff, lab technicians and our friends for having encouraged us and supported us morally while doing the project.

Finally we thank one and all who co-operated with us in bringing out this project successfully.

DEDICATED TO PARENTS AND FRIENDS

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Electricity is one of the basic needs in each and every corner around the world. At present, the sources of producing electricity especially the raw materials such as coal, uranium etc that are taken from the earth are lagging every day in terms of percentage in every country. For example, the lignite which is taken from the underground in Neyveli town-ship is decreasing daily since the requirement to produce electricity is comparatively higher. So the tonnage capacity per unit MW required for the generation of electricity is really greater than the original. Hence, the future is going to depend basically on the non-conventionally sources of energy for the power generation.

1.2 OBJECTIVES

Non-conventional sources of energy such as, solar energy and wind energy are the two energies that will exist forever around the world. So, in order to compensate and overcome this net effect that can occur in the future, we have used these two non-conventional sources of energy in a combined hybrid system as a resulting project to generate the electricity. This project basically will satisfy the rural areas where the cost of electricity per unit KWHR is higher. Since the solar wind hybrid system works during day and night, continuous electricity will be generated throughout the whole day from the whole system. During night time, the expected outcome will be of around 350 watts and during day time, it will be of around 150 watts.

1.3 SEQUENCE OF THE REPORT

given site. Insight explanations are given about the wind power, its speed and site selection considerations. Then we have explained the design progress for all the components in the assembly of windmill. The Pro/E models have been developed before constructing the prototype. In this we have designed the components to meet the requirements of the wind turbine system. After developing the prototype of windmill, the solar panel is selected single crystalline silicon cell for about 17Watts. Then we have furnished the details of the fabrication methodology for each and every component of the wind turbine system. At the end of the documentation, the analysis of solar panel is made for five days and similarly for the windmill, the performance is done based upon the tower height. The results have been obtained for both solar and wind systems and also the graph for five days using solar cells and for various tower heights using the windmill.

1.4 NEED FOR THE PROJECT

The development has been stimulated by:

- The need for low maintenance, long lasting sources of electricity, suitable for places remote from both the main electricity grid and from people; eg satellites, remote site water pumping, outback telecommunications stations and lighthouses;
- The need for cost effective power supplies for people remote from the main electricity grid; eg Indigenous and non-Indigenous isolated settlements, outback sheep and cattle stations, tourism and travellers.
- The need for non-polluting and silent sources of electricity; eg tourist sites, caravans and campers.
- The need for a convenient and flexible source of small amounts of power; eg calculators, watches, light meters and cameras;
- The need for renewable and sustainable power, as a means of reducing global warming.
- The preference for many people in grid connected areas to obtain their

Together, these needs have produced a growing market for photo-voltaic which has stimulated innovation. As the market has grown, the cost of cells and systems has declined, and new applications have been discovered.

CHAPTER 2

2.1 INTODUCTION TO HYBRID SYSTEM

With advances in solar and wind technology, it just doesn't make sense today to design a stand alone system to use only wind or solar. Hybrids offer greater reliability than either technology alone because the remote power system is not dependent on any one source. For example, on an overcast winter day when PV generation is low there is likely sufficient wind energy available to make up for the loss in solar electricity. Wind and solar hybrids also permit use of smaller, less costly components than would otherwise be needed if the system depended on only one power source. This can substantially lower the cost of a remote power system. In a hybrid system, the designer need not size the components for worst case conditions by specifying a larger wind turbine and battery bank than necessary.

The hybrid concept is often carried one step further to include a fossil fueled back up generator for the same reasons. In effect, stand alone systems substitute the fuel and the maintenance of the back up generator for a larger solar and wind combination. Depending on the size of the back up generator and the power consumption at the time, the generator can top up discharged batteries and meet loads not being met by the combined wind and solar generation. The whole setup of the wind-solar hybrid system is shown in figure 2.1.

Despite advances by hybrid power systems in improving reliability and reducing the overall size of the power system, initial costs remain high. It behaves the potential user to reduce demand as much as possible to keep costs down. Advances in energy efficiency permit users to meet their energy needs from smaller, less expensive power systems than once possible. The development of compact fluorescent lights and energy efficient appliances now makes this possible with little sacrifice in lifestyle.

2.2 ADVANTAGES OF USING HYBRID SYSTEM:

A hybrid renewable energy system utilizes two or more energy production reliability of the system is enhanced a hybrid system uses a combination of energy producing components that provide a constant flow of uninterrupted power. The hybrid system above makes the use of wind, solar, and possibility a back up generator. Hybridization ensures that should any part of your system not be performing (solar -cloudy days, wind- no wind) for any reason, you will have a back up means of producing your own electricity.

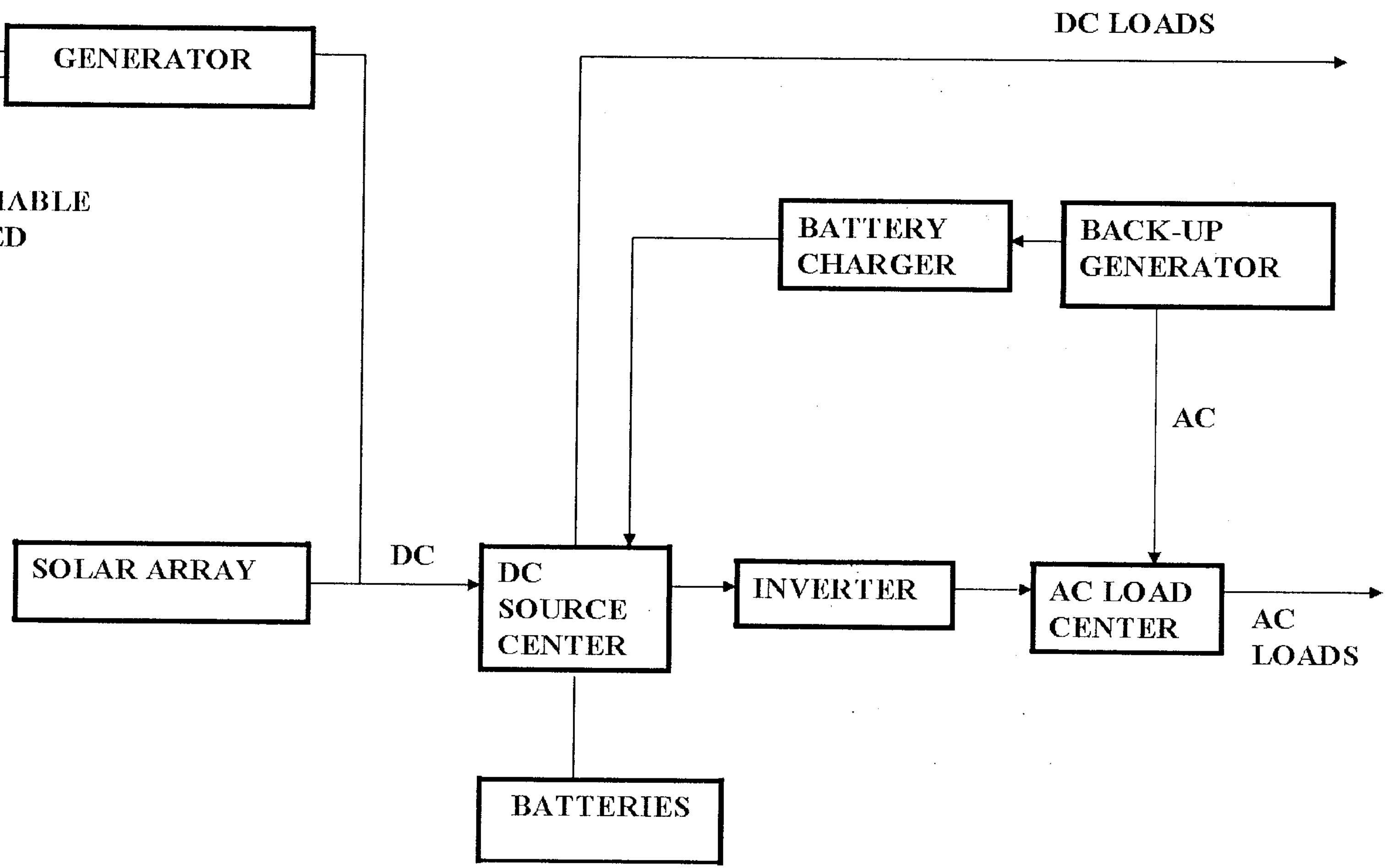


FIGURE-2.1 WIND-SOLAR HYBRID SYSTEM

CHAPTER 3

3.1 WIND-WHAT IS IT?

The atmosphere is a huge, solar-fired engine that transfers heat from one part of the globe to another. Large-scale convective currents set in motion by the sun's rays carry heat from lower latitudes to northern climes. The rivers of air that pour across the surface of earth in response to this global circulation are what we call wind, the working fluid in the atmospheric heat engine.

3.2 WIND POWER

Wind is air in motion caused by the rotation of the earth and the uneven heating of the atmosphere by the sun. Air rises as its particles spread out from being heated (making the air less dense and thus lighter.) Unheated or cool air comes in to take the place of the rising heated air.

This process is called convection. Wind patterns vary according to seasonal and landscape variability and due to changing wind patterns, physical obstacles, in the area, slope, etc. Wind power machines are classified as mechanical (without electric generators) and electrical. Mechanical are the ones focused on here, as they are mostly used in rural and remote areas for water pumping. Electrical windmills connect to a power grid and produce energy converted to electricity for heating, transportation, and other mechanized power.

3.3 NEED FOR WIND POWER

The wind power is a basic need for the rural areas electrification purposes and for other purposes namely,

- Power demand is growing with increased populations especially in developing countries where fossil fuel supplies are low.
- Wind Power can bring energy to remote areas outside the "electrical grid." It is cheaper in to start a wind power system than to bring in power lines or

- Wind is a renewable resource where as conventional methods such as coal, natural gas, and oil are limited (they have finite lifetimes.)
- Wind Power does not produce the greenhouse (carbon) emissions of conventional energy methods and thus will reduce these if used in their place.
- The price of installation, implementation, and maintenance has dramatically dropped in the past two decades making wind a more viable economic option even in developing countries. As technology advances, costs will continue to drop.
- Many countries could become energy independent if they used their available wind potential. For example, China has more wind power potential than it's current consumption.
- Wind power can be converted to other forms of energy (Wind Energy Conversion Systems - WECS): Electric - used for heating, light, transport, and running mechanical machines
- Utilization of wind power for heating and lighting will lesson local environmental degradation as it replaces mass collection of fuel wood (which causes deforestation and erosion/ watershed damage) as well as the usage of kerosene and animal dung for these purposes.
- Regular diurnal wind patterns in an area suggest that wind power will be an optimum choice for an energy system.
- Reliability of WECS is improving with increased technology.

3.4 WIND SPEED AND TIME

The wind is an intermittent resource: calm one day, howling the next. Wind speed and direction vary widely over almost all measuring periods. Because wind speed fluctuates, it becomes necessary to average wind speed over a period of time, usually over an entire year.

The average annual wind speed itself is not constant. It varies from year to average of 10 mph (5 m/s) is the norm. Meteorologists say that they gather 10 years of data or more before they feel comfortable that all the yearly cycles have been recorded.

3.5 BASIC PRINCIPLES OF WIND ENERGY CONVERSION

3.5.1 NATURE OF THE WIND

The circulation of air in the atmosphere is caused by the non-uniform heating of the earth's surface by the sun. The air immediately above a warm area expands; it is forced upwards by cool, denser air which flows in from surrounding areas causing a wind. The nature of the terrain, the degree of the cloud cover and the angle of the sun in the sky are all the factors which influence this process. In general, during the day the air above the land mass tends to heat up more rapidly than the air over water. In coastal regions this manifests itself in a strong onshore wind. At night the process is reversed because the air cools down more rapidly over the land and the breeze therefore blow offshore.

The main planetary winds are caused in much the same way: cool surface air sweeps down from the poles forcing the warm air over the tropics to rise. But the direction of these massive air movements is affected by the rotation of the earth and the net effect is a large countries clockwise circulation of air around low pressure areas in the northern hemisphere, and clockwise circulation in the southern hemisphere. The strength and direction of these planetary winds change with the seasons as the solar input varies.

Wind speeds increase with height. They have traditionally been measured at a standard height of 10meters where they are found to be 20-25% greater than close to the surface. At a height of 60metres they may be 30-60% higher because of the reduction in the drag effort of the earth's surface.

3.5.2 POWER IN THE WIND

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

They are as follows,

- Wind speed
- Cross section of wind swept by rotor and
- Overall conversion efficiency of rotor, transmission system and alternator.

No device, however well designed, can extract all of the winds 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 most that is possible is for the rotor to decelerate the whole horizontal column of intercepted air to about one-third of its free velocity. A 100% efficient aero-generator would therefore only be able to convert up to a maximum of around 60% of the available energy in wind into mechanical energy. The power in the wind can be computed by using the concept of kinetics. The windmill works on the principle of converting kinetic energy of the wind to mechanical energy. The energy available is the kinetic energy of the wind.

One of the most important tools in working with the wind, whether designing a wind turbine or using one, is a firm understanding of what factors determine the power in the wind. For the sake of thoroughness, we'll start right at the beginning. A gallon of air is similar to a gallon of water, but the gallon of air is lighter. It has less mass than that of water because air is less dense. It's more diffuse. This energy of motion gives the wind its ability to perform work.

When the wind strikes an object, it exerts a force in an attempt to move it out of the way. Some of the wind's kinetic energy is given up or transferred, causing the object to move. When it does, we say the wind has performed work. We can see this when leaves skitter across the ground, trees away, or the blades of a wind turbine move through the air.

The amount of energy in the wind is a function of its speed and mass. At higher speeds, more energy is available, in much the same way a car on the highway contains more energy than a car of equal size it passes. It takes more effort –energy-to stop a car driven at 70 mph than it does one at 50 mph. likewise, heavy cars contain more energy than light cars traveling at the same speed. This relationship between mass, speed and energy is given by the equation of kinetic

$$\text{Kinetic energy} = \frac{1}{2} m S^2$$

The air's mass can be derived from the product of its density d and its volume. Because the air is constantly in motion, the volume must be found by multiplying the wind's speed S by the area A through which it passes during a given period of time t.

$$M = dASt$$

When we substitute this value for mass into the earlier equation, we can find the kinetic energy in the wind.

$$\text{Wind energy} = \frac{1}{2} (dASt) S^2$$

$$= \frac{1}{2} dAtS^3$$

Power is the rate at which the energy is available, or the rate at which energy passes through an area per unit of time.

$$P = \frac{1}{2} dAS^3$$

Power P is directly proportional to air density, the area intercepting the wind, and wind speed. Increase any one of these factors and you increase the power available from the wind.

3.6 SCOPE OF WINDMILL

In India, wind power accounts for 71% of the total global installed capacity of renewable power. Tamil Nadu has a wind potential of 2000 MW out of 20,000 MW for the entire country. Edayarpalayam, a typical dry land tract in the state, 20 km east of Coimbatore city located close to the Palghat Pass, is naturally endowed with abundant wind potential. Rangamma Steels and Malleables was the first private industry to install four windmills during 1995–96 generator of 250 kW capacity requires a land area of 3–5 acres. The establishment of windmills has led to an increase in the land value from Rs.10, 000 in 1995–96 to one lakh rupees per acre now. Several changes are visible in the social and economic front.

3.7 WIND ENERGY

India ranks 5th in the world with a total wind power capacity if 1080 MW out of which 1025 MW have been established in commercial projects. In India the states of Tamil Nadu and Gujarat lead in the field of wind energy. At the end of March 2000 India had 1080- MW capacity wind farms, of which Tamil Nadu contributed 770-MW capacity. Gujarat has 167 MW followed by Andhra Pradesh, which has 88 MW installed wind farms. There are about a dozen wind pumps of various designs providing water for agriculture, afforestation and domestic purposes, all scattered over the country.

Realizing the growing importance of wind energy, manufacturers have steadily been increasing the unit size of the wind electric generators since the late 1980s. Another important development has been the offshore (i.e. in the sea) wind farms in some regions of Europe, which have several advantages over the on-shore ones. The third major development has been the use of new techniques to assess the wind resource for techno-commercial viability.

Five nations – Germany, USA, Denmark, Spain and India – account for 80% of the world's installed wind energy capacity. Wind energy continues to be the fastest growing renewable energy source with worldwide wind power installed capacity reaching 14,000 MW.

3.8 SITE SELECTION CONSIDERATIONS

The power available in the wind increases rapidly with the speed; hence wind energy conversion machines should be located preferable in areas where the winds are strong and persistent. Although daily winds at a given site may be highly variable, the monthly and especially annual average speeds are remarkably the most suitable sites for wind turbines would be found in areas where the annual average wind speeds are known to be moderately high or high.

Some of the main considerations are discussed below:

- High annual average wind speed
- Availability of anemometry data
- Availability of wind at the proposed site
- Wind structure at the proposed site
- Altitude of the proposed site
- Terrain and its aerodynamic
- Local ecology
- Distance to roads or railways
- Nearness of site to local center or users
- Nature of ground
- Favorable land cost

3.9 WIND ENERGY SCENARIO

The current trend of wind energy utilization in various parts of the country and also the regions in India are mentioned below as shown in the table 3.1 and the windmills located in the regions of India are shown in figure 3.2 and in table 3.1

TABLE 3.1 WIND POWER GENERATION AROUND THE WORLD

COUNTRIES	POWER (MW)
Germany	18100
Spain	9825
USA	8957
India	4,434
Denmark	3,129
Italy	1,570
Netherlands	1,186
U.K.	1,097
Japan	942
Portugal	791
China	765


INDIA

TABLE 3.2 WIND POWER, WIND SPEED FOR THE REGIONS SPECIFIED IN THE MAP

CLASS	50 M HEIGHT		INSTALLABLE MW	WIND POWER DENSITY (W/M2)
	WIND SPEED (M/S)	WIND POWER (W/M2)		
1	<5.6	<200		
2A	5.6-6.0	200-250	32,647	**RED**
2B	6.0-6.4	250-300	10,819	**VIOLET**
3	6.4-7.0	300-400	4,683	**GREEN**
4	7.0-7.5	400-500	395	**ORANGE**
5	7.5-8.0	500-600	17	**SKY BLUE**
6	8.0-8.8	600-800	-	**ROSE**
7	8.8-11.9	800-2000	-	**DARK BLUE**
		TOTAL	**48,561**	

CHAPTER 4

DESIGN OF WINDMILL

4.1 DESIGN OF 400W WIND ENERGY GENERATOR

The common wind turbine with a horizontal axis turbine system is simple in principle, but the design of a complete system, especially a large one that will produce electric power economically, is complex. Not only must the individual components such as the rotor, transmission, generator and tower be as efficient as possible, but these components must function effectively in combination. The design of each and every part are detailed as follows,

4.2 COMPONENTS OF WINDMILL

The various components involved in the whole fabrication of the windmill are detailed below.

- Rotor
- Windmill head
- Drive train
- Tower
- Yaw system
- Main frame
- Nacelle
- Alternator
- Dynamo
- Battery

4.3 MATERIALS FOR THE COMPONENTS

- ROTOR BLADE - ALUMINIUM
- NACELLE - SHEET METAL
- MAIN SHAFT - MILD STEEL
- YAW PLATE - MILD STEEL
- TOWER - GALVANISED IRON

4.4 DESIGN OF COMPONENTS

4.4.1 ROTOR

The rotor is directly mounted on a horizontal shaft and connected to an alternator by a means of a mechanical device known as pulley. These horizontal axis rotors are of lift devices type and these devices are preferred, since for a given swept area, high rotational speeds and more output power can be developed by lift then drag forces. In general, a drag device cannot move faster than the wind velocity while a lift device can. Thus a lifting surface can obtain higher top to wind speeds and consequently a higher power output is got.

Every rotor has an optimum tip-speed ratio at which its maximum efficiency is achieved and which also characteristics the rotor. The tip speed ratio is computed numerically as,

Tip-speed ratio (TSR) = V_{tip}/V

V -- Free wind speed

Based on the available wind speed, the performance of the rotor is characterized by plotting the curve which is discussed in the last section. For the three bladed propellers, the estimated tip-speed ratio is of around 5 to 8. Since the tip-speed ratio is relatively high, it needs less material. So the rotor is made totally from the light weight aluminum sheet metal with a good surface finish.

4.4.2 WINDMILL HEAD

The windmill head supports the rotor as well as it houses the rotor bush. It can be controlled to the suitable wind direction so as to face the windmill head perpendicular to the wind direction. This can be controlled manually by using the yaw system.

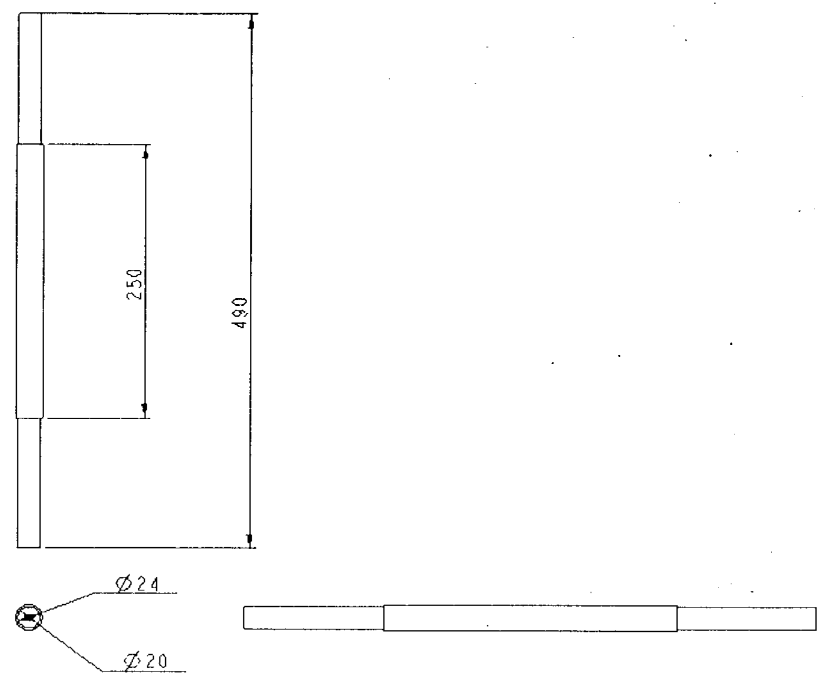
4.4.3 NACELLE

The nacelle is the top cover for the wind turbine housing which protects the wind mill components from corrosion. The readings of the direction of windmill are noted by using anemometer which is directly mounted over the top of the nacelle. It also reduces the emitted mechanical sound and gives the good look for the overall transmission system. Also the lightning arrester is placed over this to protect the windmill from thunder. It has two holes at both ends of the nacelle to allow the shaft to rotate freely from the input of wind energy. On larger Machines, it has a hole that it can be entered personal for inspector (or) maintains the internal components. The whole make of the nacelle is made from sheet metal which is hammered and bended using the sheet metal bending machine. Also the required size of the nacelle part is got by cutting process using the cutting

4.4.4 SHAFT

The shaft is a basic component in the whole assembly part of the wind machine for the transmission of power from the windmill head to the pulley to get the output directly from the dynamo or alternator. In this windmill, the one end of the shaft is directly mounted onto the fan hub using a 17mm internal diameter (ID) and 20mm outer diameter (OD) mild steel bush. To the other end of the shaft, the pulley of 19mm ID and 300mm OD is rigidly fitted and bolted onto it. The thickness and groove cut of the pulley is designed for an A-type belt. Bearings of double ball bearings type of 20mm ID are fitted rigidly to the both step cuts to sit properly in the plumber blocks. These bearings are also self alignment bearings which can adjust according to the vibrations that can develop in the shaft along a certain angle.the whole design of the shaft is shown in the figure 4.1

The whole design of the shaft is done based on the principle to rotate freely with the straight alignment of the shaft from the fan hub to the pulley. Its design is done by using the mild steel rod of 25mm diameter with a length of 1.5 feet. Then the length is reduced to about 490mm with the tolerance of ±0.5mm. After this, the diameter of the shaft is reduced to 24mm in the step part of the shaft for about 250mm. The other two ends of the shaft are reduced to about 20mm with the tolerance limit of ±0.9mm.



SHAFT	QTY -1
PART NO -3	
ALL DIMENSIONS ARE IN MM	
MATERIAL - MILD STEEL	

FIGURE 4.1 DESIGN OF SHAFT

4.4.5 MAIN FRAME

Each and every wind turbine system has the main frame for the initial design applications. Using the design application package, the whole assembly of the windmill is assembled depending on the main frame design. The Main Frame is a platform to which the other principle components such as shaft, plumber block, rectangular and circular plates are attached. It provides for proper alignment among those components and to maintain perfect balance during high wind speeds. To avoid corrosion, the primer paint is applied uniformly over the whole main frame body and the external paint is applied over the frame for better finish. It also provides for yaw bearing and ultimately tower top attachment. It is totally made from mild steel and cast iron metals.

4.4.6 YAW CONTROL

The area of the wind-streams swept by the wind is large when the blades get faced into the wind direction. This is achieved by control arrangement, in which when the wind direction changes a manual yaw control designed so that it can rotate slowly about the vertical axis (or yaw) axis so as to face the blades into the blade. The yaw control system falls into three categories namely,

- Fixed type
- Manual type and,
- Automatic yaw control type.

The fixed yaw system is a type where the wind turbine will be rigidly fixed about its axis and cannot be tilted to any axis normal to the direction of wind. The manual yaw system is used basically on the domestic purpose windmills where the yaw control is done manually to move the whole wind turbine. For the large type of windmills, the yaw system is controlled automatically using a yaw motor depending upon the anemometer readings. Since the design is done for the domestic purpose to benefit the rural areas, the manual system is the opt one to operate and relatively cheaper than the automatic control type. The characteristics of the yaw system are, it rotates the windmill about the vertical axis perpendicular to the wind direction, gives an excellent output power from the alternator and dynamo since if the windmill is not tilted there will be not be perfect rotation of the wind blades when the wind is not blowing perpendicularly to the wind blades, improves the efficiency and overall performance of wind turbine system. The whole design of the yaw system are shown in the figures 4.2 and 4.3..

The yaw control system can be effectively applied up to 270degrees about its own axis. This system is operated manually based upon the wind direction. Wind direction readings are directly noted from the anemometer which is mounted over the windmill. The yaw system consists of two plates namely, rectangular plate and circular plate for the effective operation. Its whole make is done by using the mild steel plates and its design is done on the pro e- modeling software as shown in the diagrams with the tolerance limit of ±0.3 mm.

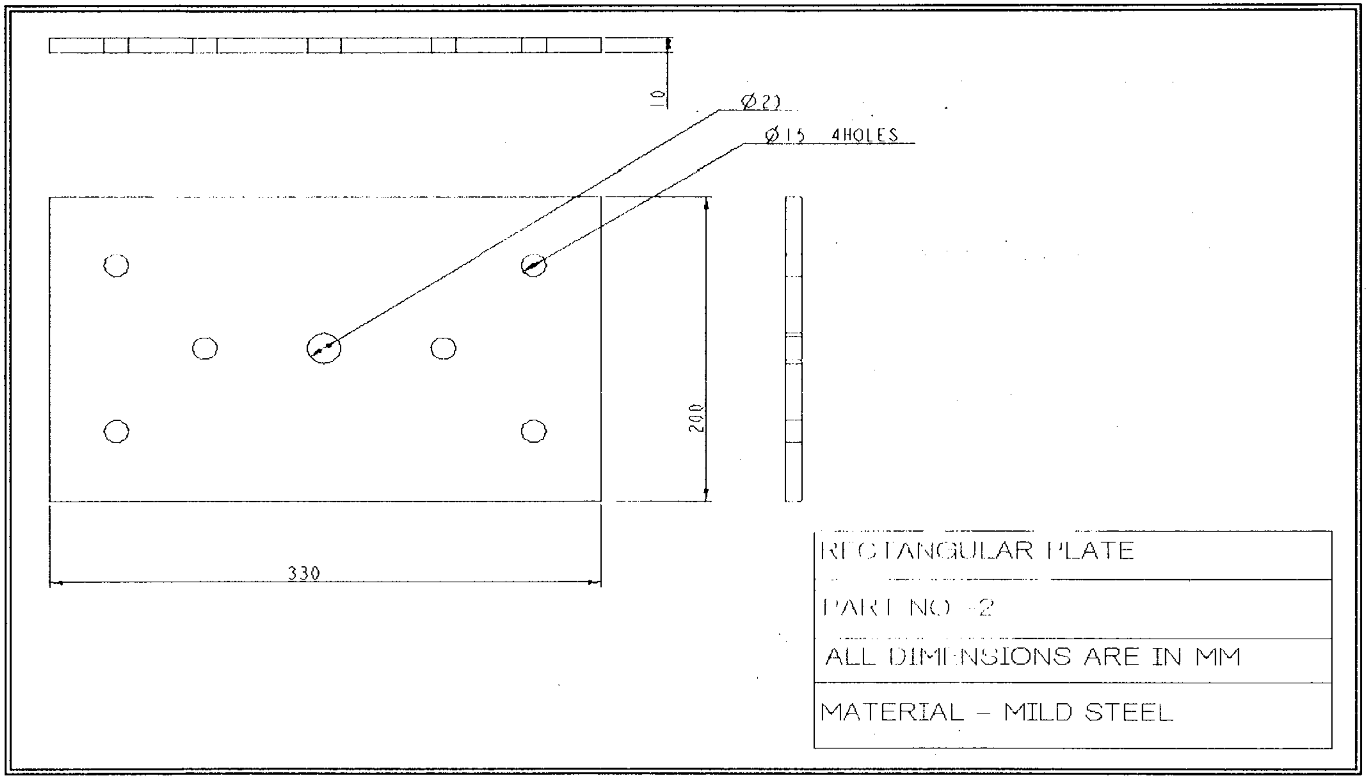


FIGURE 4.2 DESIGN OF RECTANGULAR PLATE

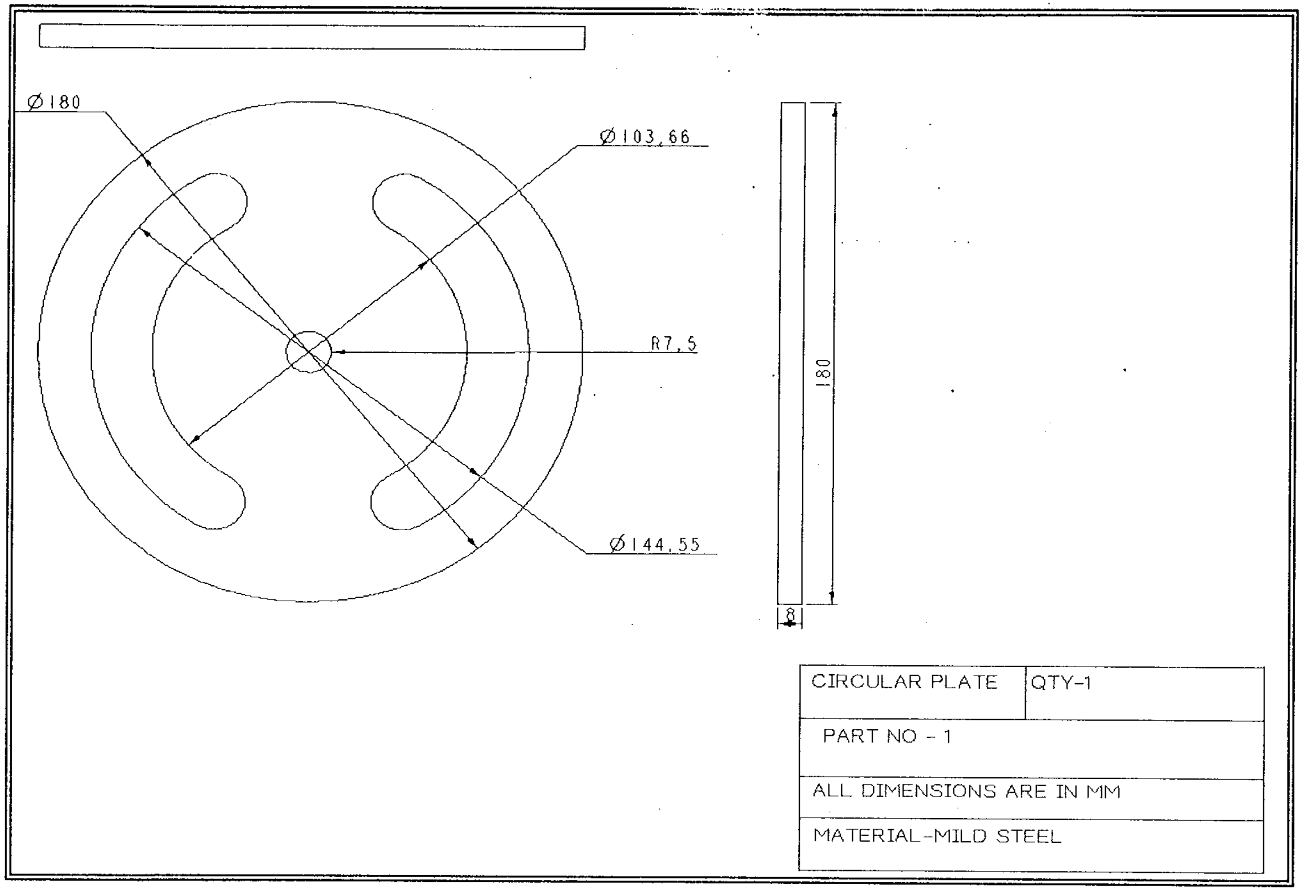


FIGURE 4.3 DESIGN OF CIRCULAR PLATE

4.4.7 TURBINE TOWER SYSTEM

The tower is made up of galvanized iron (GI) and above this pipe, the wind turbines are mounted and below this tower a circular plate is clamped to the ground so as to withstand the wind forces.

The tower is erected below the whole nacelle part of the windmill. Since the whole wind machine should be installed above the turbulence zone to perform well and to ensure long life. Our windmill is mounted over the roof top of the building to create its own turbulence. There may be a large wind force that can act upon the windmill. In order to withstand these forces, a circular plate is welded to the base of the tower in order to erect the windmill in a perfectly balanced position even if large wind forces act upon the whole wind machine.

The tower is made from a 2.5" diameter galvanized iron hollow pipe. In order to avoid the atmospheric effects such as corrosion etc, oil paint is applied over the pipe for better finish. Galvanized iron can withstand lot of weight and stresses that can act upon it. In order to reduce the overall weight of the machine, the hollow pipe is designed and welded to a base plate. Since there are lot of destructions such as buildings during the blow of wind, the height of G.I. pipe is extended up to 6feet.and then it is mounted over the top of the building (approx 30m)for better output from the windmill.

4.4.8 TYPES OF TOWERS

Towers fall into two categories namely,

- Free standing
- Guyed

Free standing towers or self supporting towers as they are known, are just that-free standing. They depend on a massive foundation to prevent the tower from toppling over in high winds, and must be strong enough internally to withstand the forces trying to bend the tower to the ground.

Guyed towers in contrast, employ several far flung anchors and connecting cables to achieve the same ends. Free standing towers are more expensive than guyed towers but take up fewer places. Since the wind turbine is done for domestic applications, free standing tower is the opt one that can support the overall weight for the components of the transmission system and cheaper than the other types of tower system.

4.4.9 TOWER FOUNDATION

The foundation of a wind turbine system must be sufficient to keep the turbine upright and stable under the most extreme design conditions. At most sites, the foundation is constructed as a reinforced concrete pad. Based on the above factor, the tower is designed for the windmill to withstand the net weight of the overall assembly.

4.4.10 PLUMMER BLOCK

The Plummer block holds and supports the shaft in a straight line along the horizontal axis. Inside the plummer block there is also a slight groove cut to seat the bearing inside properly and it has two parts so that they can be dismantled to place the shaft inside the bearing. The plummer block not only holds the shaft in a straight line but also will absorb the vibrations that can develop when the shaft tends to vibrate incase of overloading as shown in the figure 4.4.

The bearings are designed for the internal diameter of 20mm and width of 13mm to fit properly in the plummer block and the groove cut is made for the bearing width up to the diameter of around 33mm with the tolerance limit of around ±0.1mm.

In order to separate and join the two parts of the plummer block, the holes on either side are designed for the diameter of about 14mm with the tolerance of ±0.3mm. To fix the plummer block rigidly with the rectangular plate, two holes for 15mm diameter are designed at the two extremes of the plummer block. For these holes the bolts are designed accordingly with the appropriate length and diameter. The width of the whole assembly is designed for about 33mm and for a length of about 135mm with the negligible tolerances as shown in the model.

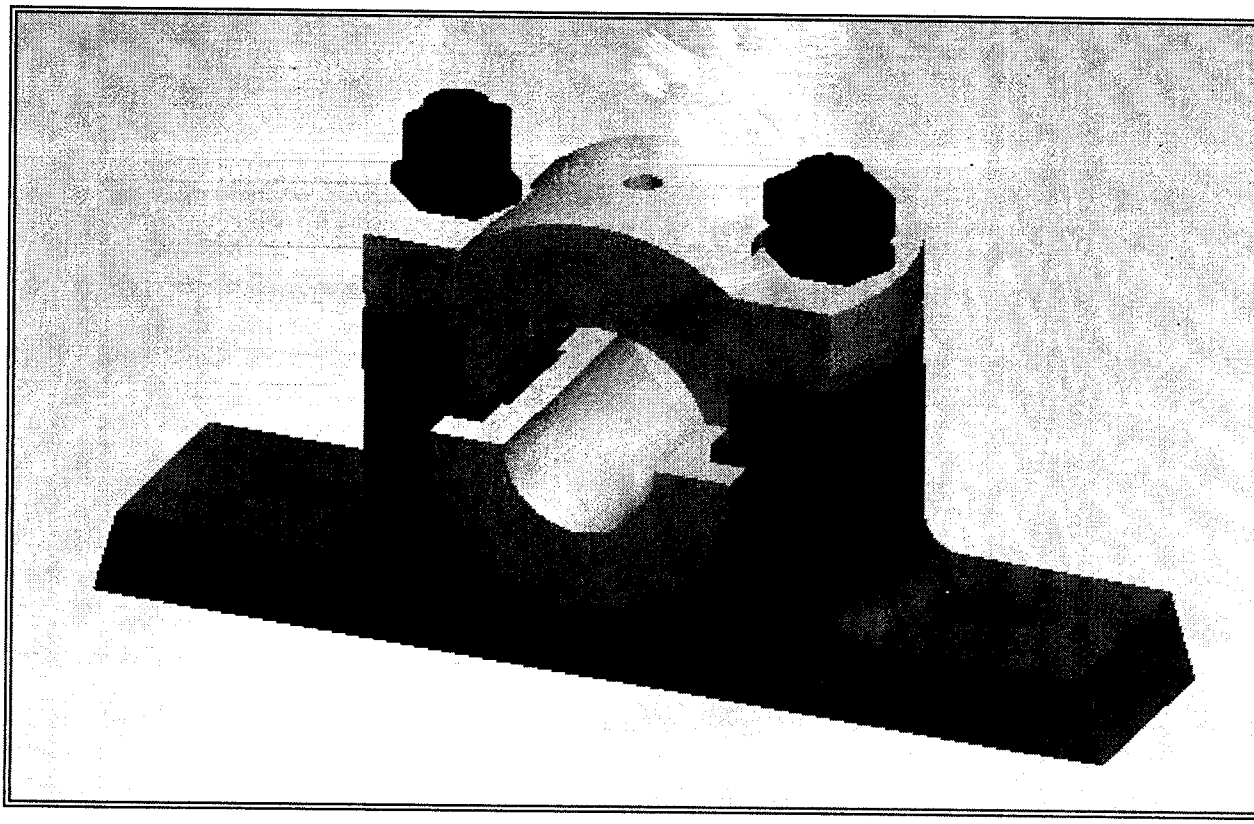


FIGURE 4.4 DESIGN OF PLUMMER BLOCK

4.4.11 BLADE DESIGN

Windmill blades can be easily made depending upon the type of metal while we use it for manufacturing. The blades are made of aluminium since it provides light weight and adequate strength for the electrical device to generate the electricity. They are slightly twisted from the root or the blade to reduce the tendency for the rotor to stall. Since the blades are narrower to the tip of the blade, better performance is obtained in the whole assembly. The windmill blades are directly attached to the hub to withstand various extraneous forces. These forces arise from wind turbulence, directional changes in the wind, variations of wind speed with height, gravitational forces, the pressure of the tower etc.

4.4.12 BLADES

Wind turbine blades are directly mounted on the hub and have a variable pitch. They are slightly twisted from the outer tip to the root by placing small nuts below the root of the fan hub. This is done to reduce the tendency for the rotor to small. Also at the tip of the blade of the wind turbine, the velocity is about six times the wind velocity. So, in order to overcome the above effect, the blades are set rather flat but at a small angle with the plane of rotation and almost at right angles to the direction of wind so that the effective wind properly approach from ahead of the leading edge. But at other parts of the blade, between the tip and the axle, the velocity and the ideal set of the blade is at a greater angle to the plane of rotation. One more advantage is tilting the blades of the wind turbines will lower the danger of fouling the supporting tower under severe wind conditions.

The blades are also constructed and attached to the hub in such a manner as to withstand the vibrational stresses resulting from rotation, several extraneous forces arising from wind turbulence, directional changes in wind, and variations of wind speed with height, wind gusts, gravitational forces, and finally pressure of the tower.

Although the wind power of a rotor increases with the swept diameter, there is a practical limit to the size. So, the blade's swept diameter is limited up to the size of 600mm. the blade is made purely in aluminum sheet metal so as to rotate freely even when the wind speed is low in certain circumstances during day and night. These blades are also designed to provide adequate strength to the fan hub to rotate and get the desired output from the alternator. Also the wind turbine has been built with the three bladed propeller, since it is the most common one that have been used in several wind machines in order to avoid the vibrations experienced with two bladed rotors. They cost less to fabricate the whole windmill and are capable of operating with a high tip speed ratio.

Blades are one of the most critical, and visible components of a wind turbine's rotor. Blades can me made from almost any material and have been. Wood has always been popular. Wood blades are built either from single planks of Sitka spruce or from wood laminates. The blades are then machined into the desired shape and coated with the tough weather resistant finish. Then the manufacturer covers the leading edge with fiber glass tape to protect the blades from wind erosion and hail damage. This tape is the same as that used on the leading edges of helicopter blades. It's resistant to ultraviolet light and abrasion.

Aluminum is lighter and for its weight, stronger. It's used extensively in the aircraft industry for this reason. We can fabricate aluminum blades with the same technique used to build the blades of airplane: form a rib and then stretch the aluminum skin over it. The blades on NASA's early Mod-OA were built this way. On smaller machines a simpler method can be used by stamping a curve into the leading edge, folding the sheet metal over the spars, and then riveting it in place.

Aluminum can also be extruded, eliminating all other fabrication steps. It was once thought that blades could be mass-produced this way, extruding blades in the same way we manufacture drain spouts ad window moldings by squeezing a hot piece of aluminum through a die.

4.4.13 NUMBER OF BLADES

The windmill rotor consists of three blades and this have been used in several windmill machines in order to avoid the vibrations experienced with two-bladed rotors. These vibrations are related to the turning (or yawing) of the rotor in order to face it into the wind.

CHAPTER 5

SELECTION OF PV MODULE

5.1 SOLAR ENERGY SCENARIO

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photo voltaic cells. When sunshine is incident on solar cells they generate dc electricity without the involvement of any mechanical generators. Energy conversion devices which are used to convert sunlight into electricity by use of photovoltaic effect are called solar cells. The solar cells should be distinguished from devices usually referred to as photo cells which detect light intensity by use of photo conductivity characteristics of materials. Photo cells are very sensitive to light, since their conductivities may change by many orders of magnitude with small variations of light intensity. They do not generate a voltage and thus require batteries for their operation.

Solar cells were developed during 1950s primary at the bell telephone and RCA laboratories. These cells proved to be the best power sources for extra terrestrial missions, and more than thousand satellites using solar cells where utilized during the 1960s and 1970s. In the mid 1970s, effects were initiated to make solar cells for terrestrial applications. Since 1975, most of the solar cells market has been for use on earth, although they remain the dominant source of power for space applications.

The photovoltaic effect can be observed in almost any junction of materials that have different electrical characteristics, but the best performance to date has been from cells using semi-conductor materials. Essentially all of the solar cells used for both space and terrestrial applications have been made of the semi-conductor silicon.

Photovoltaic solar energy conversion is one of the most attractive non conventional energy sources of proven reliability from the micro to the mega watt level.

5.2 SOLAR CELLS

Solar cells are devices which convert solar energy directly into electricity, The most common form of solar cells are based on the photovoltaic (PV) effect in which light falling on a two layer semi-conductor device produces a photo-voltage or potential difference between the layers. This voltage is capable of driving a current through an external circuit and thereby producing useful work.

5.3 CONSIDERATIONS FOR THE PHOTO-VOLTAIC MODULE SYSTEM

5.3.1 SOLAR ARRAY CONFIGURATION FACTORS

Solar cell panels usually consist of series-parallel interconnected solar cells bonded to supporting substrates and encapsulated with transparent materials to provide environmental protection. Solar arrays consist of multiple panels appropriately deployed, supported and interconnected.

Solar arrays are electrically defined in terms of strings or circuits each of which contributes a portion of the total current output at some nominally specified array voltage. The diodes protect the string by preventing the possible back flow of current that might arise under certain shading of failure conditions.

Bypass diodes are another protective feature commonly used on solar arrays. These diodes are wired in parallel around segments of a string and serve to limit the level of back bias voltage that can be developed across segments as a result of inadvertent shading or cracked solar cells. They are also useful in permitting continued string operation in the event of open-circuit failures within the protected string segment. Such protective devices are essential for line-focusing concentrators that employ single cell strings. The solar array voltages are established on the basis of the application and the electrical insulation capabilities of basic panel or concentrator.

5.3.2 ATMOSPHERIC EFFECTS ON SOLAR RADIATION

On a clear day and when the sun is directly overhead,70% of the total manner after scattering from atmospheric molecules and particulates. The rest is absorbed or scattered back into space. Clearly, both the direct and scattered fluxes vary with time and location because the amounts of dust and water vapor in the atmosphere are not constant even on clear days. The commonly accepted set of solar fluxes for air mass one (AM1) are shown below. AM1 refers to the thickness of atmosphere a sunbeam passes through if the beam is normal to the horizon.

ABSORBED:

Ozone	-	2%
Upper dust layer	-	1%
Air molecules	-	8%
Water vapor	-	6%
Lower dust	-	1%

SCATTERED TO SPACE:

Total	-	3%

SCATTERED TO EARTH:

Total	-	7%

DIRECT TO EARTH:

Total	-	70%

5.3.3 TESTING THE SOLAR PANEL

Disconnect the solar panel from the voltage regulator, then in good day light conditions (or very strong artificial light) measure the voltage from the solar

solar panel. This is measuring the open circuit voltage (Voc) any voltage measured will indicate that the panel is producing power, in good conditions, the reading on the voltmeter should be around, 15-18volts DC. The data plate on the rear of the solar panel will state the Voc, but bear in mind this may vary with light intensity.

5.3.4 INVERTERS

There is no clear solution to running 240volt AC equipment; they have a high current consumption. (12v DC in 240v AC out, pay off is high current use)

Typically:

- A 150watt inverter at no load (AC) uses 0.44amps DC
- At 60watts load (0.25amps AC) uses 5.33amps DC
- At 100watt load (0.41ampsAC) uses 9.10amps DC

So it can be seen that an inverter may add to the problem of high current use and a solution to source highly efficient DC (Battery) appliance.

5.4 SOLAR TECHNOLOGY

Solar cells represent the fundamental power conversion unit of a photovoltaic system. They are made from semiconductors, and have much in common with other solid-state electronic devices, such as diodes, transistors and integrated circuits. For practical operation. solar cells are usually assembled into modules.

Many different solar cells are now available on the market, and yet more are under development. The range of solar cells spans different materials and different structures in the quest to extract maximum power from the device while keeping the cost to a minimum. Devices with efficiency exceeding 30% have been demonstrated in the laboratory. The efficiency of commercial devices, however, is usually less than half this value. Crystalline silicon cells hold the largest part of multicrystalline material, rather than from the more expensive single crystals. Crystalline silicon cell technology is well established. The modules have long lifetime (20 years or more) and their best production efficiency is approaching 18%.

A cheaper (but also less efficient) type of silicon cells, made in the form of amorphous thin films, is used to power a variety of consumer products. You will be familiar with the solar-powered watches and calculators, but larger amorphous silicon solar modules are also available. A variety of compound semiconductors can also be used to manufacture thin-film cells (for example, cadmium telluride or copper indium diselenide). These modules are now beginning to appear on the market and hold the promise of combining low cost with acceptable conversion efficiencies.

A particular class of high-efficiency solar cells from single crystal silicon or compound semiconductors (for example, gallium arsenide or indium phosphide) are used in specialized applications, for example, to power satellites or in systems which operate under high-intensity concentrated sunlight. The operation and applications of these devices will be reviewed elsewhere.

5.5 WORKING PRINCIPLE

Sunlight enters the semiconductor and produces an electron and a hole-negatively charged particle and a positively charged particle, both free to move. These particles through the semiconductor and ultimately encounter an energy barrier that permits charged particles of one sign to pass but reflects those of the other sign. Thus the positive charges are collected at the upper contact and the negative charges at the lower contact. The electric currents caused by this charge collection flow through metal wires to the electric load as shown in the figure 5.1

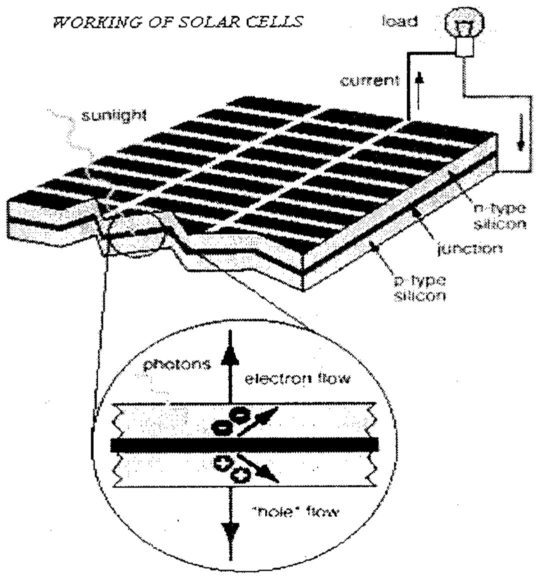


FIGURE 5.1 WORKING OF SOLAR CELLS

The current from the cell may pass directly through the load, or it may be changed first by the power-conditioning equipment to a.c at voltage and current levels different from those provided by the cell. Other sub-systems that may also be used include energy-storage devices such as batteries and concentrating lens or mirrors that focus that focus the sunlight onto a smaller and hence less costly semiconductor cell.

Photovoltaic generation is a technology that directly converts solar energy to electric energy through the use of cells with monosilica and polycrystalline surfaces that act as semi-conductors. It can probably supply the limited energy demands of remote and rural areas in the near future. The technological advances appearing day after day in developed countries have reduced the cost of energy produced by photovoltaic panels by five times since 1976; therefore, production has increased, the products are of better quality, and their manufacture is now automated and uses less expensive materials.

5.6 TYPES OF CELLS

There are mainly five types of solar cells which are explained as follows:

- **SILICON AMORPHOUS CELLS** have been used extensively for integrated circuits. Its technology is well developed and it is a natural choice for use in solar cells now, while other approaches are being developed. The whole layout of the silicon amorphous cell is shown in the figure 5.2.

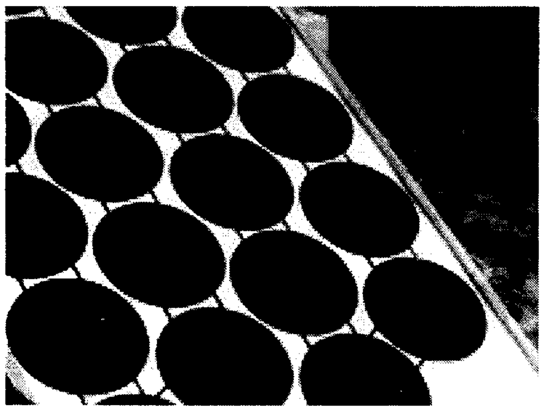


FIGURE 5.2 SILICON AMORPHOUS CELL

- **AMORPHOUS SILICON CELLS** are made of thin film from amorphous silicon. Amorphous silicon has a much higher absorption constant over wavelengths of importance in the solar spectrum than does crystalline silicon. As a result, a much thinner layer of amorphous silicon is needed to absorb solar photons. The cells are made from layers having a thickness < 1 μm.

- **POLYCRYSTALLINE OR THIN FILM CELLS** instead of single crystal cells requires extensive heating and careful crystal growth and slicing which may be economical in terms of both monitory cost and energy expended in the production process. Its layout is shown in the figure 5.3

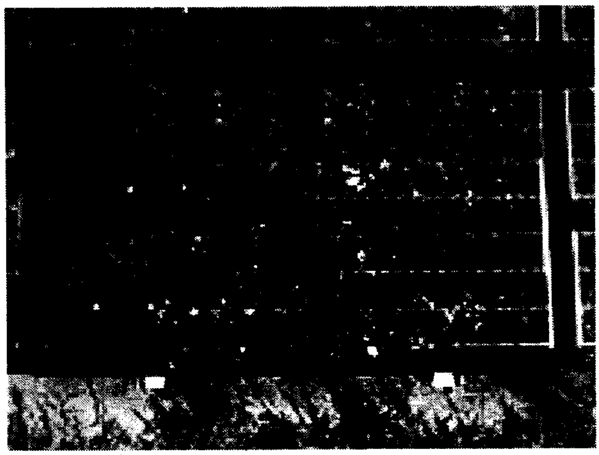


FIGURE 5.3 POLYCYRSTALLINE FILM CELL

- Focusing lens and mirrors cost much less per unit area than most semiconductors. It can be cost effective to use concentrator systems in which sunlight is focused on to relatively **SMALL SEMI CONDUCTOR CELLS.**

- Since cells can be designed to work particularly with light of one wavelength, it may be economical to split the spectrum and direct different portions on to cells optimized for those spectral components **(SPLIT SPECTRUM OR MULTI COLOR CELLS).**

- Since both available sunlight and demand for energy fluctuate, cells providing inherent energy storage by electrolysis within the cell may be attractive **(PHOTO ELECTRO CHEMICAL CELLS)**

Among these, the most economical one to develop the power from the solar cells is the single crystalline amorphous solar cell.

5.7 SILICON SOLAR CELL

The silicon solar cell has been the most developed and used cell to date. Silicon is the most common element on earth and is usually obtained from sand (SiO2). Experiments have demonstrated that silicon cell could convert about 15 % of the terrestrial sunlight into the electricity. At present large crystals of silicon or other semi-conducting material are grown and then sliced into thin cells for further processing into p-n junctions. Recently techniques have been evolved for producing thin sliced directly. But the cost of the silicon cells is still too high for solar cell arrays to become viable for large scale power generation. There are a variety of approaches being investigated that are aimed at developing cheaper silicon cells by using poly-crystalline silicon. Past cells that have been made of polycrystalline materials have had relatively low efficiencies, e.g. 2 to 3 %. Grain boundaries inhibit electron flow and recombination results. However, if the grains can be made much larger than the thickness of the cell, it may approach the characteristics of a single crystal cell. Processes such as chemical vapor deposition are being investigated that would deposit silicon large sheets very in extensively. Numerous techniques and subtracts are being used, to enhance large grain deposition. Re-crystallization after deposition may be possible with the use of techniques such as electron beam scanning stress strain growth, or even hot rolling.

5.8 IMPORTANCE OF SOLAR CELLS

There are three main reasons to think about the solar cells for being an important component in the world energy picture of the next few decades. They are as follows:

- One must not judge significance solely on the basis of total power output. Even a 100 watt solar cell power supply in any one of the several million villages in the world could be of enormous importance to the villagers, for whom it would provide power for water pumping, refrigeration, and communication with the surrounding world.
- Photovoltaic power generation is relatively free from the problems facing fossil-fueled or nuclear power plants-escalating fuel costs , disposal of waste , disposal of heat , major concerns over safety and potential modification of weather due to release of carbon dioxide.

Photovoltaic systems are modular and can be installed near points of use and put on line quickly as the demand for the electricity rises. These inherent advantages, plus the experience and expectations of a steady reduction in solar cell system cost, lead to the prediction that solar cell systems can make a significant contribution to the world energy supply.

CHAPTER 6

FABRICATION

6.1 FABRICATION OF THE COMPONENTS OF WINDMILL

The fabrication of each and every component of the windmill are described briefly as shown below,

6.1.1 SHAFT

First the shaft is machined using the lathe to perform the step turning, facing operations by means of lathe and the surface finish accuracy is improved by using the external cylindrical grinding machine. A lathe is one of the oldest and perhaps most important machine tools ever developed. It was basically developed to machine cylindrical surfaces. The job to be machined is rotated (turned) and the cutting tool is moved relative to the job. The operations carried out using lathe are as follows,

6.1.1.1 FACING OPERATION

FACING is the operation of machining the end of a work piece to make the end square with its own axis and that of the lathe. The tool moves perpendicular to the axis of the lathe. Initially the facing operation is done by using the live centre only for the two faces of shaft and then the holes are drilled at the two faces of shaft to hold using the both centers.

6.1.1.2 TURNING OPERATION

TURNING is the operation to remove the material from the outside diameter of a work piece to obtain a finished surface. The finished surface may be of continuous diameter, stepped, tapered or contoured. The feed of the tool for

The stepped turning operation is carried out by using both live centre and dead centre of the lathe because when we machine the shaft for a length of 490mm without using the dead centre, surface finish accuracy will be too low due to vibrations in the shaft. Firstly, in order to machine the shaft for a rough cut process the gear is engaged to medium speed gear in the gear box of the lathe. After engaging the medium speed gear in the gear box, the diameter of the shaft is reduced slowly in a gradual manner to obtain the diameter of 22.5mm for the entire length. The final touch for machining the shaft to reduce to 22mm is done automatically in a gradual manner for every 0.25mm by automatic feed engagement of the carriage to the lead screw and this is performed by using the slow speed gear in the gear box assembly. Secondly, the diameter is further reduced to 20mm for a length of 120mm at the two extremes of the shaft in a similar manner. Finally, the sharp corners at both ends of the shaft are contoured by tilting the tool post with a certain acute angle.

6.1.1.3 GRINDING OPERATION

GRINDING operation is a method of machining work pieces by the use of a rotary abrasive tool called "grinding wheel". Such wheels are made of fine grains of abrasive materials held together by a bonding material called a "bond". Each individual and irregularly shaped grain acts as a cutting element (a single point cutting tool). The grinding operation is generally carried out by using,

- Cylindrical grinding machine
- Internal grinding machine
- Centreless grinding machine
- Surface grinding machine and,
- Special grinding machine

The grinding operation is performed by using the cylindrical grinding machine since its surface should be machined externally. This machine uses a plain grinder, which is a general purpose production machine for the grinding of axles, shafts, splines etc. The methods that can be applied most extensively in this machine are traverse grinding, plunge-cut grinding and full-depth grinding.

The shaft is machined by rotating between the centres in the same manner as is done in a centre lathe to a tolerance limit of ±0.01mm. After this, the shaft is slightly reduced to the internal diameter of fan bush at one end of the shaft for a small length using the lathe and in a similar manner at the other end of the shaft, it is machined to the internal diameter of the pulley.

6.1.2 YAW SYSTEM

The yaw control system consists of a rectangular plate and circular plate to work in an effective manner. The operations carried out on the rectangular and circular plate are as follows,

6.1.2.1 GAS CUTTING OPERATION

GAS CUTTING is based upon the ability of certain metals to burn in oxygen with evaluation of a great deal of heat thereby melting the metal and forming oxides. The torch for flame cutting is similar to the welding torch. As the metal is burnt and eroded away, the torch is moved steadily along the path of cut. The thickness of the metal that can be cut is up to 1.5m.

The excess length of the rectangular plate is removed and also the fillet cuts at each corner of the plate are eroded out by using the gas cutting machine to avoid the sharp corners at each and every corner of the plate. The arc slot in the circular plate is also removed in the same fashion by using the gas cutting machine.

6.1.2.2 DRILLING OPERATION

DRILLING process is an extensively used machining operation by which through or blind holes are cut or originated in a work piece. The drilling tool is called a "drill" which is multi-point cutting tool. The hole is produced by axially feeding the rotating drill into the work piece which is held on the table of the drilling machine.

The rectangular plate is made from a 330mm length, 200mm breadth and 10mm width mild steel plate. Holes on the rectangular plate are drilled by using the drilling machine using the 20mm drill bit and 15mm drill bit. The hole at the centre of the rectangular plate is drilled by using 17mm drill bit. Similarly for the center part of the circular plate, a hole is drilled to same diameter.

6.1.2.3 TAPPING OPERATION

TAPPING is the best and the simplest way to cut internal threads with a tap. The hand tap is held firmly along with tool bit and after inserting it into the required hole to be tapped, it is rotated manually with both forward and backward rotations.

The holes around the four corners of the plate of diameter are tapped by using the 15mm tap bit and the other two holes of the plate near are tapped by using the 20mm tap bit.

6.1.3 NACELLE

This part of the windmill is made totally from the sheet metals. About two metal sheets have been taken and are removed and bended based upon the size of shaft and plumber block. It is bended using the sheet metal bending machine and removed by using the sheet metal cutting machine. After this, the two sheet metals are welded by using the spot welding machine with equal gap between the welding spots to get a completed structure of nacelle.

To protect the transmission part of the wind turbine from corrosion, the primer paint is applied over the nacelle and to protect from thunder, the lightning arrester is directly welded onto the top of nacelle. Also, the anemometer is rigidly fixed over this to analyze the wind direction.

6.1.4 TOWER

The tower is finely finished by means of the grinding wheel machine especially the corners of the this hollow pipe are made flat so that it sets parallel to the bottom face of the rectangular plate. This is then set vertically to the bottom of the rectangular plate and is welded below it using the AC welding machine.

6.2 FINISHED MODEL

The assembly of the windmill is started with the assembling of the rectangular and circular plates by means of bush and the Plummer block is fitted rigidly to the rectangular plate with bolts. The double ball bearings are fitted tightly to the step cut at both ends of the shaft and after this the bush is attached at the centre hole of the fan hub to fit on the shaft to rotate properly without any slip. Then the blades are tilted to a certain angle by using small nuts behind the blades to get fitted onto the hub. To the other end of the shaft the pulley is fitted properly without any angle of inclination. The tower is welded to the base of the rectangular plate and to the base of tower; a circular plate is welded to withstand the high wind forces. Finally the alternator is placed along the straight line of the pulley by using a metal piece welded to the bottom extreme of rectangular plate.

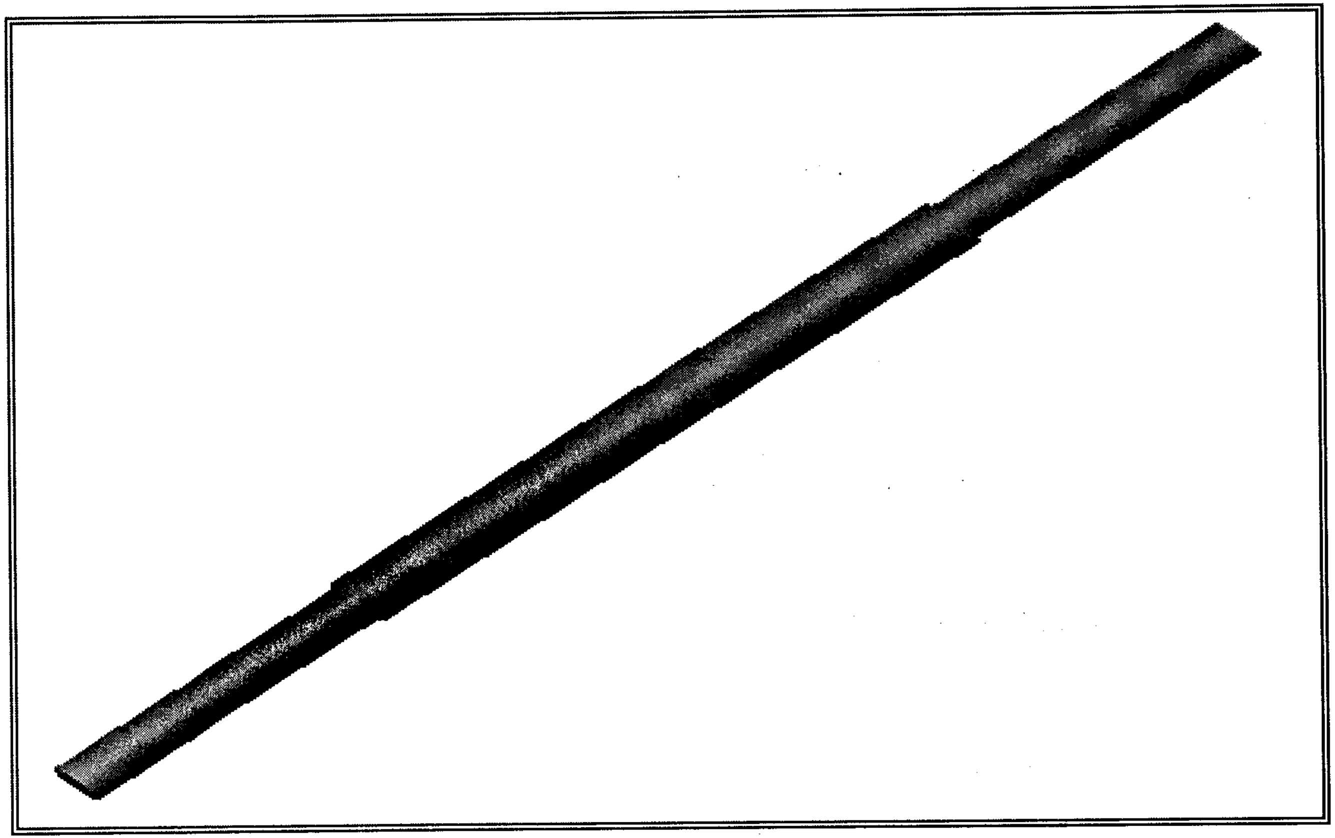


FIGURE 6.1 SHAFT

BASE PLATE

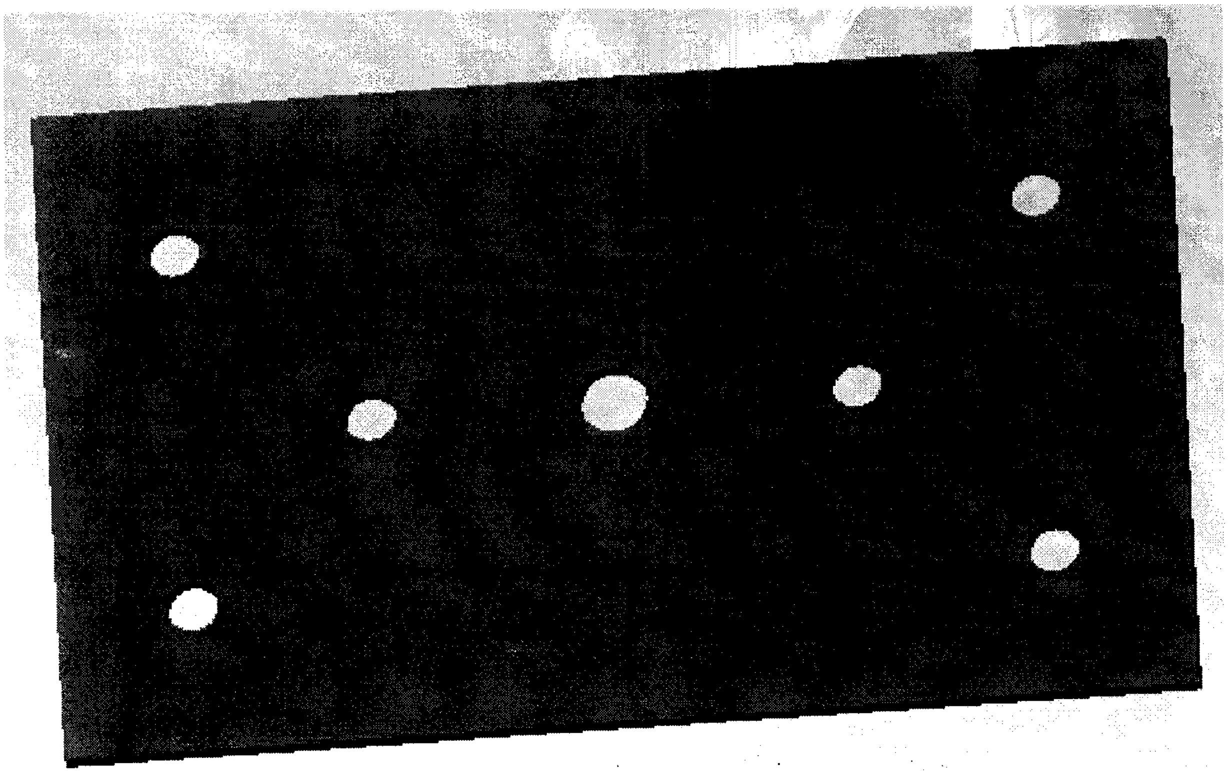


FIGURE 6.2 RECTANGULAR PLATE

YAW PLATE

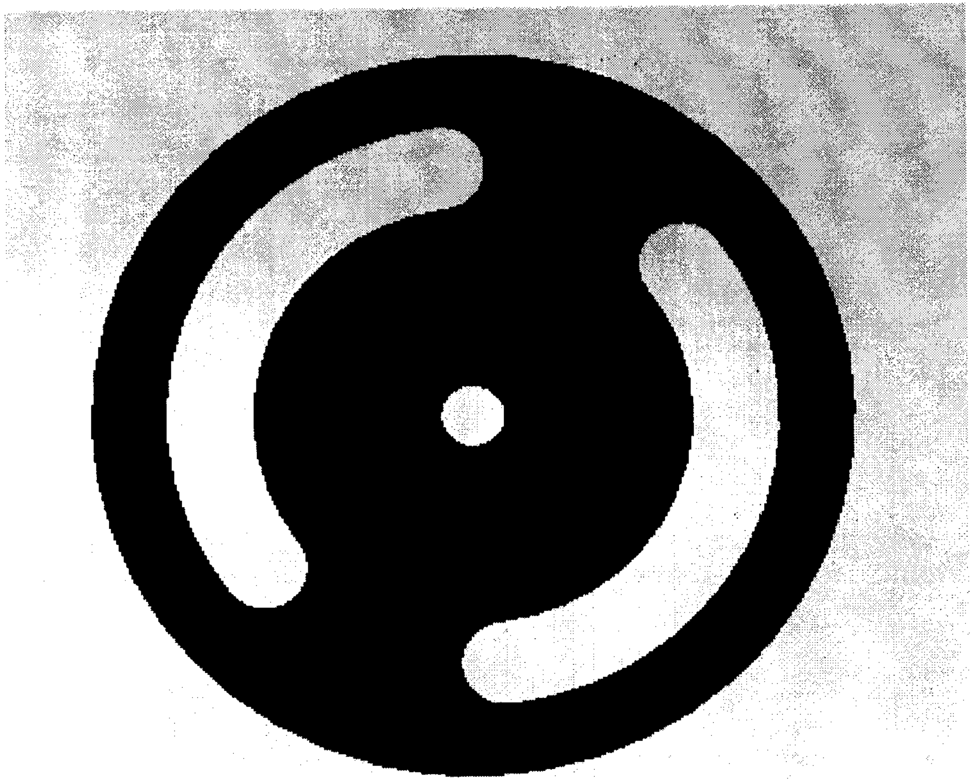


FIGURE 6.3 CIRCULAR PLATE

FIGURE 6.4 WIND SYSTEM IN PROGRESS

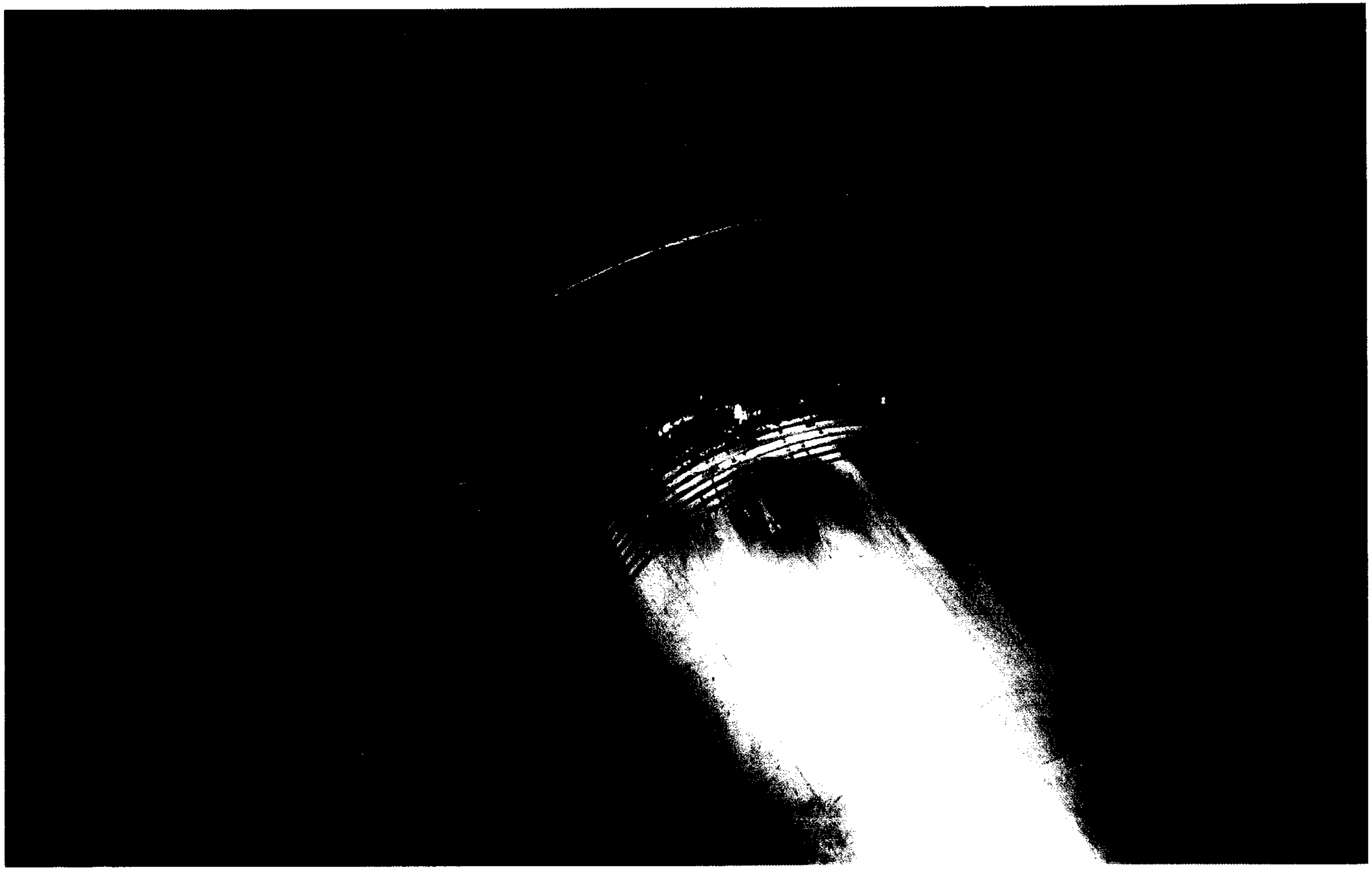


FIGURE 6.5 YAW SYSTEM

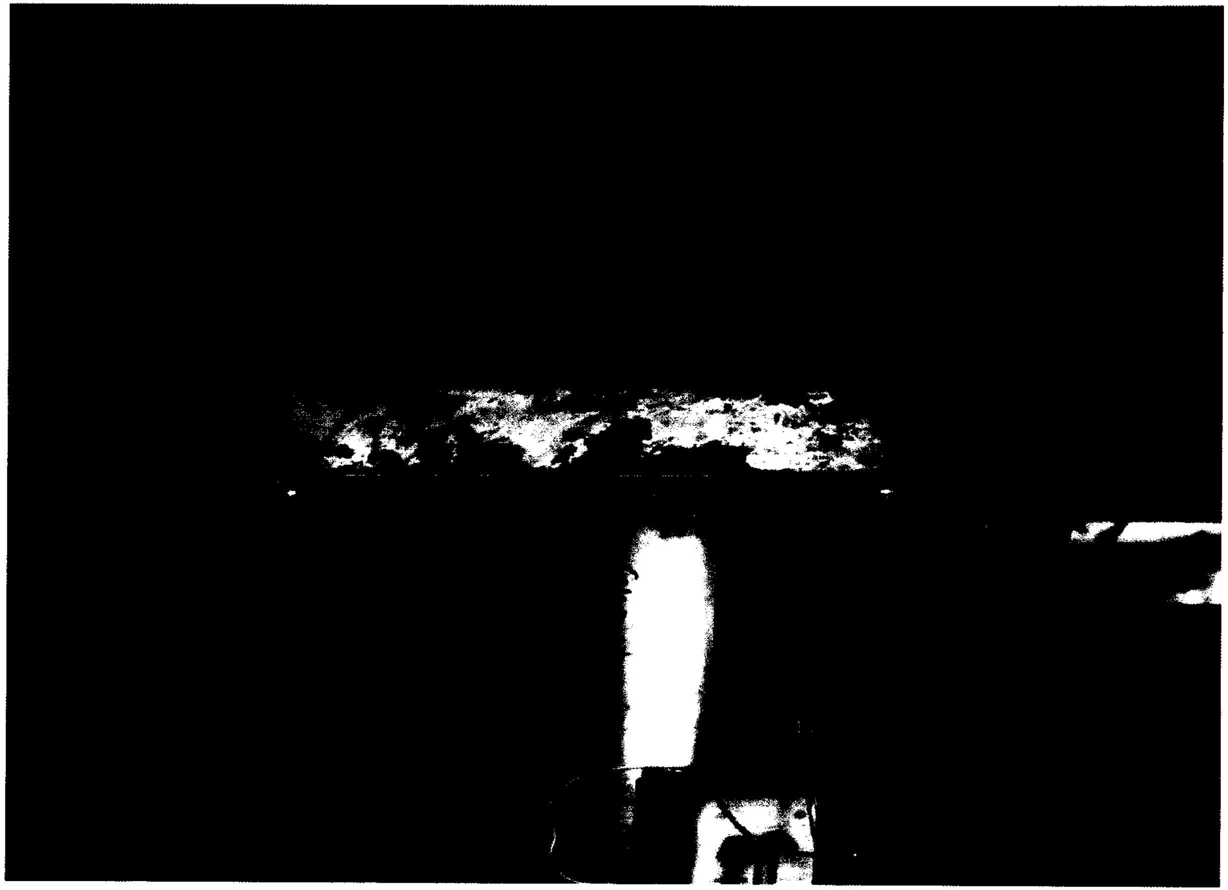


FIGURE 6.6 AEROGENERATOR ASSEMBLY

CHAPTER 7

PERFORMANCE ANALYSIS

OBSERVATIONS & GRAPHS

7.1 SOLAR PV MODULE

The observations of the solar radiation output are measured by using the multimeter by switching the knob of multimeter to the dc current and dc voltage. The intensity of solar radiation is measured by using the solar radiation intensity meter and for the corresponding input of solar radiations; a graph is plotted with the solar radiations (W/m2) as x-axis and the power (watts), voltage (volts) and current (amperes) as y-axes. Depending on these readings the performance of the solar photovoltaic module system is studied in a detailed manner from 12.04.2006 to 16.04.2006.

The readings from the solar photovoltaic system are tabulated as shown in the tables 7.1 to 7.5 and the corresponding graphs are plotted in a line graph as shown in figures 7.1 to 7.5.

7.1.1 PRACTICAL READINGS (ANALYSIS ON FIRST DAY)

TABLE 7.1 READINGS FOR 1ST DAY

SOLAR RADIATION (W/M2)	TIME (HOURS)	CURRENT (A)	VOLTAGE (VOLTS)	POWER (WATTS)
620	9:00	0.59	16.73	10
673	10:00	0.59	16.86	10
708	11:00	0.64	17.09	11
694	12:00	0.65	17.03	11
742	13:00	0.69	17.42	12
752	14:00	0.68	17.51	12
723	15:00	0.69	17.35	12
697	16:00	0.65	17.02	11

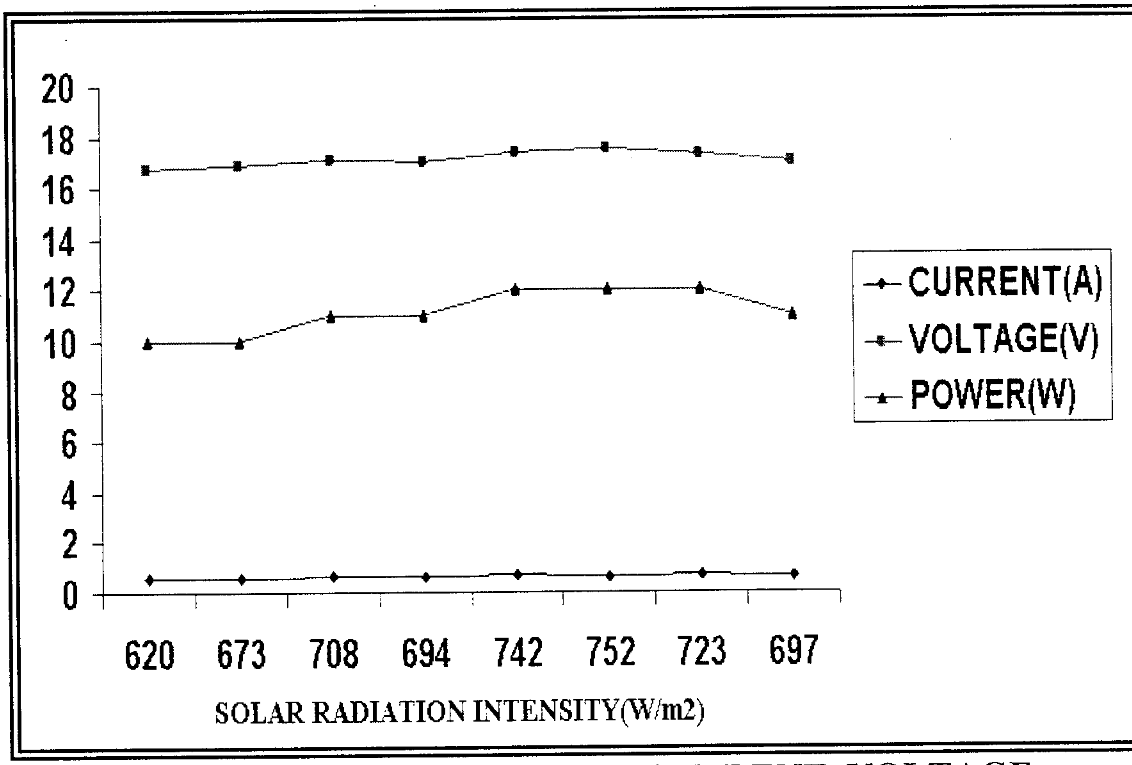
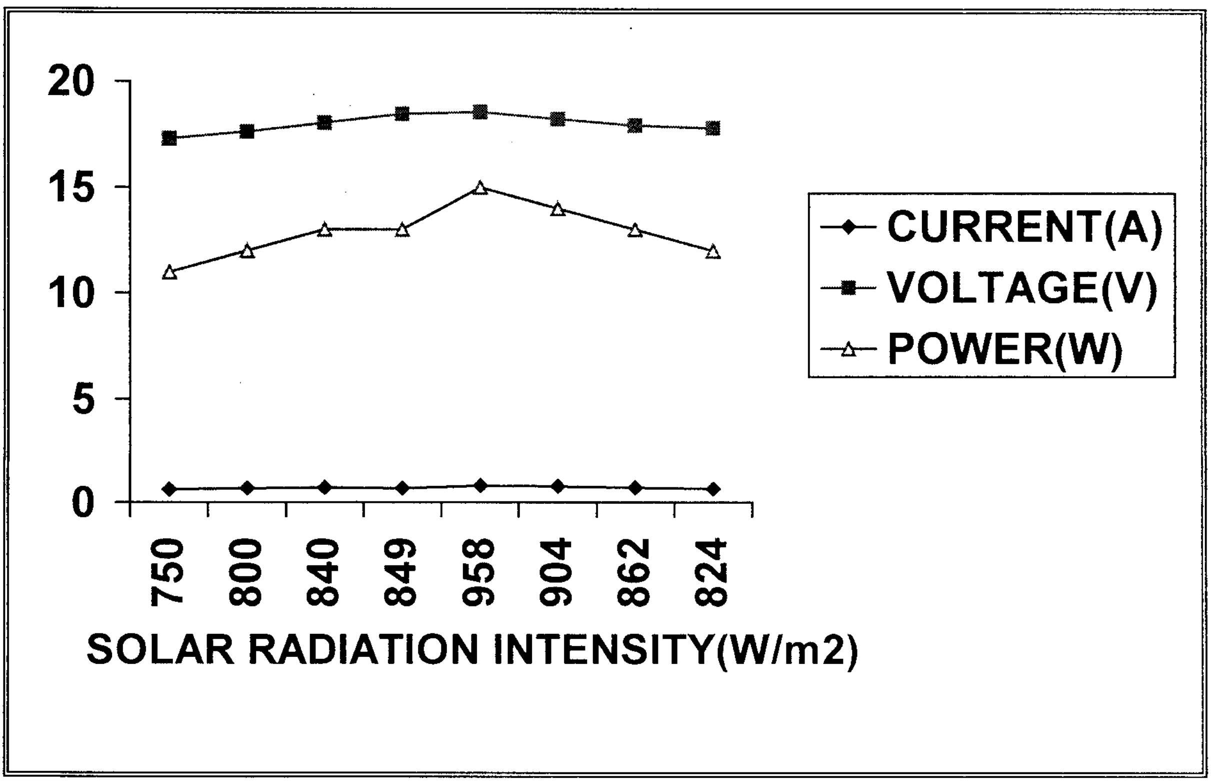


FIGURE 7.1 SOLAR RADIATION VS CURRENT, VOLTAGE & POWER (ANALYSIS ON 1ST DAY)

7.1.2 PRACTICAL READING (ANALYSIS ON SECOND DAY)

TABLE 7.2 READINGS FOR 2ND DAY

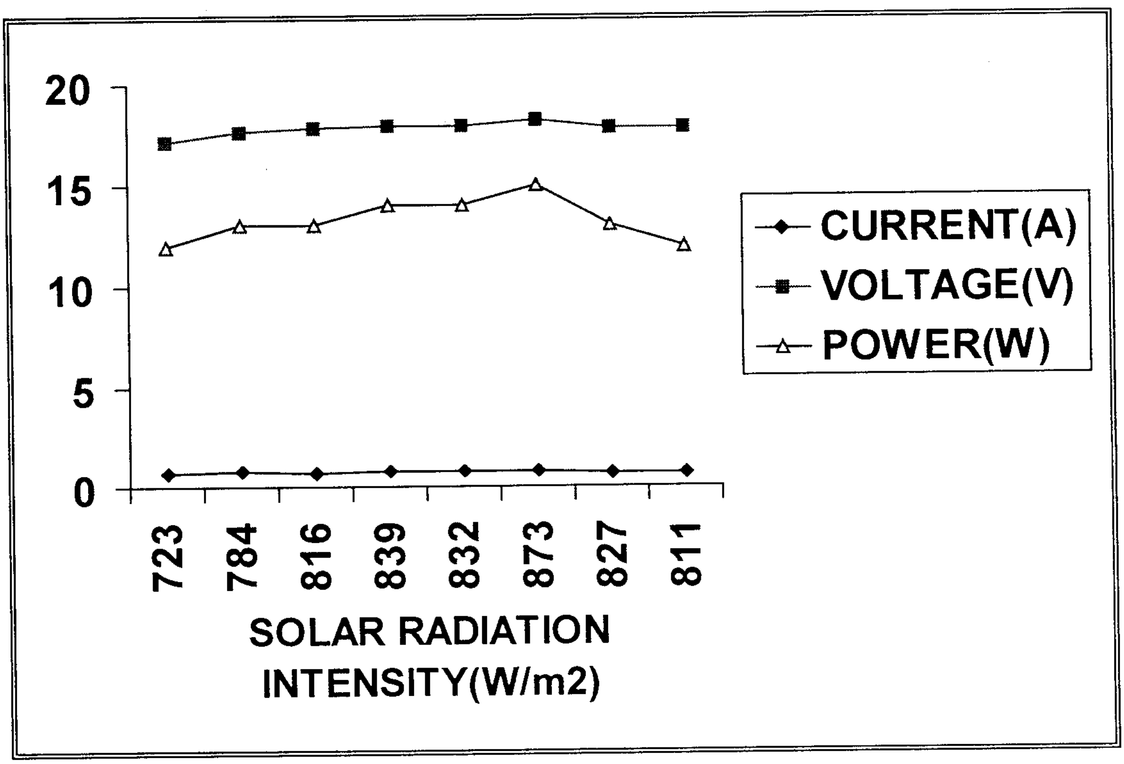
SOLAR RADIATION (W/M2)	TIME (HOURS)	CURRENT (A)	VOLTAGE (VOLTS)	POWER (WATTS)
750	9:00	0.64	17.30	11
800	10:00	0.68	17.62	12
840	11:00	0.72	18.04	13
849	12:00	0.70	18.46	13
958	13:00	0.81	18.55	15
904	14:00	0.77	18.22	14
862	15:00	0.72	17.94	13
824	16:00	0.67	17.80	12



7.1.3 PRACTICAL READING (ANALYSIS ON THIRD DAY)

TABLE 7.3 READINGS FOR 3RD DAY

SOLAR RADIATION (W/M2)	TIME (HOURS)	CURRENT (A)	VOLTAGE (VOLTS)	POWER (WATTS)
723	9:00	0.70	17.14	12
784	10:00	0.74	17.62	13
816	11:00	0.73	17.88	13
839	12:00	0.78	17.92	14
832	13:00	0.78	17.90	14
873	14:00	0.82	18.28	15
827	15:00	0.73	17.87	13
811	16:00	0.67	17.83	12



7.1.4 PRACTICAL READINGS (ANALYSIS ON FOURTH DAY)

TABLE 7.4 READINGS FOR 4TH DAY

SOLAR RADIATION (W/M2)	TIME (HOURS)	CURRENT(A)	VOLTAGE (VOLTS)	POWER (WATTS)
735	9:00	0.69	17.24	12
842	10:00	0:77	18.13	14
889	11:00	0.76	18.34	14
920	12:00	0.75	18.58	14
982	13:00	0.79	18.92	15
1010	14:00	0.79	19:02	15
957	15:00	0.80	18.84	15
933	16:00	0.74	18.75	14

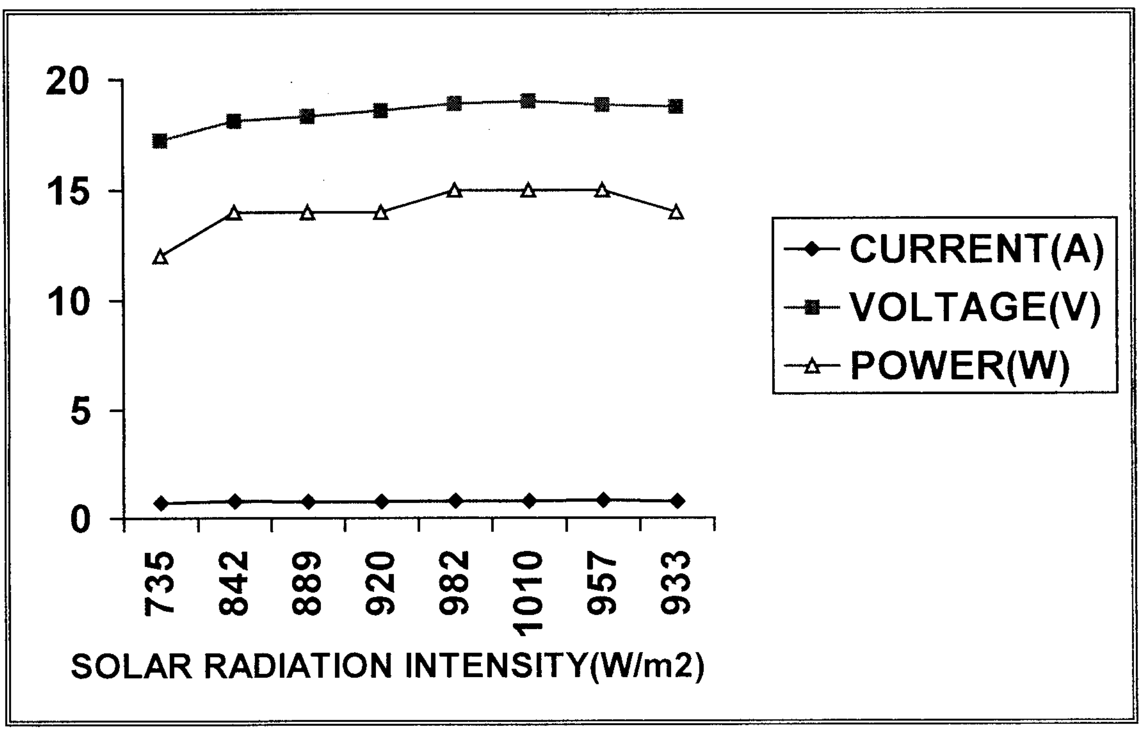


FIGURE 7.4 SOLAR RADIATION VS CURRENT, VOLTAGE &

7.1.5 PRACTICAL READINGS (ANALYSIS ON FIFTH DAY)

TABLE 7.5 READINGS FOR 5TH DAY

SOLAR RADIATION (W/M2)	TIME (HOURS)	CURRENT(A)	VOLTAGE (VOLTS)	POWER (WATTS
697	9:00	0.66	16.59	11
723	10:00	0.64	17.13	11
796	11:00	0.68	17.64	12
862	12:00	0.77	18.22	14
933	13:00	0.79	18.76	15
984	14:00	0.79	18.99	15
956	15:00	0.79	19.01	15
873	16:00	0.77	18.21	14

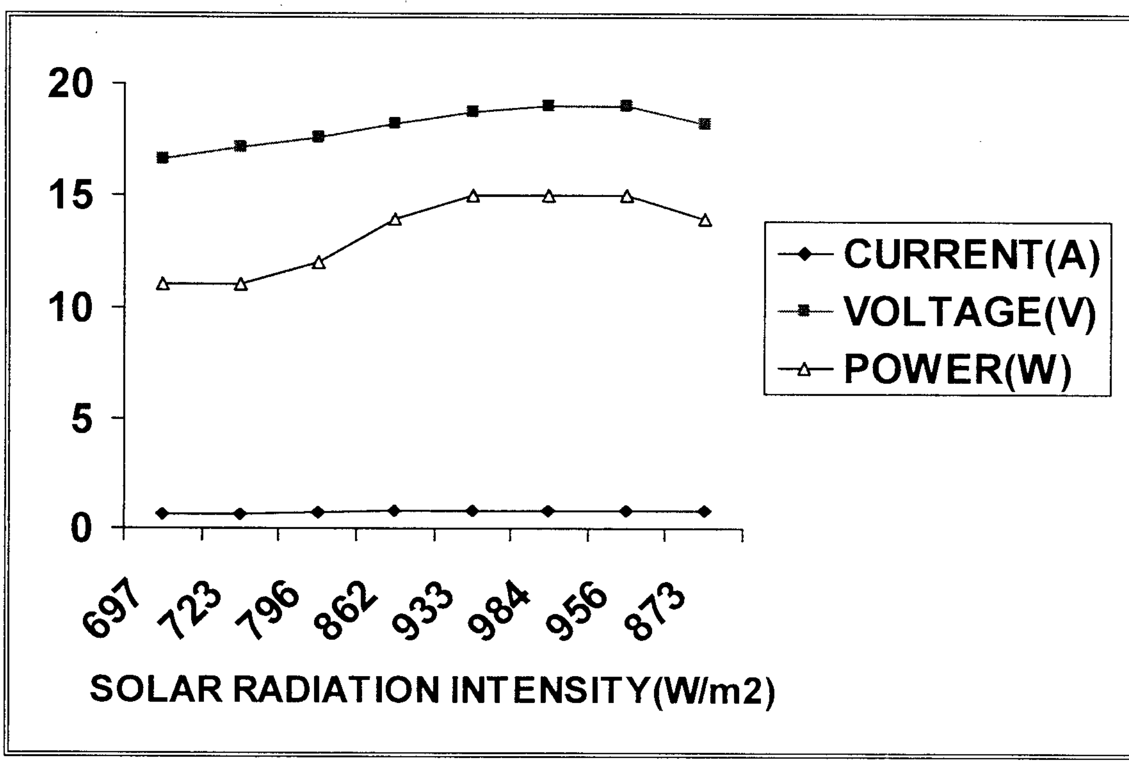


FIGURE 7.5 SOLAR RADIATION VS CURRENT, VOLTAGE

7.2 WIND TURBINE SYSTEM

The performance of the windmill is performed with the reference to the height of the tower. At the greater heights the wind speed will be greater than at the ground level because of obstructions of the tall buildings. Generally the tower height is increased by mounting the tower along with the whole assembly on the roof top of the building with the variations in its height. By varying the heights of mounting the tower over the building, the power output (%) from the alternator are plotted in a graph by taking it along y-axis and heights of the tower (feet) along x-axis.

7.2.1 ANALYSIS OF WINDMILL WITH RESPECT TO TOWER HEIGHT:

Each and every windmill is designed based upon the wind speeds. So the based upon the windmill site, the average speeds and maximum speeds for the windmill for the entire year are detailed below in the table 7.6. The performance of windmill with respect to the tower height is drawn in the graph 7.7.

TABLE 7.6 WIND SPEEDS ANALYSIS

MONTH	V_{AV} (m/s)	V_{max} (m/s)
January	5.08	23.32
February	4.71	19.78
March	4.29	18.94
April	3.58	20.03
May	5.75	26.30
June	5.96	29.80
July	5.33	24.20
August	5.96	20.40
September	4.79	17.70
October	4.17	15.90
November	3.79	14.50
December	[illegible]	[illegible]

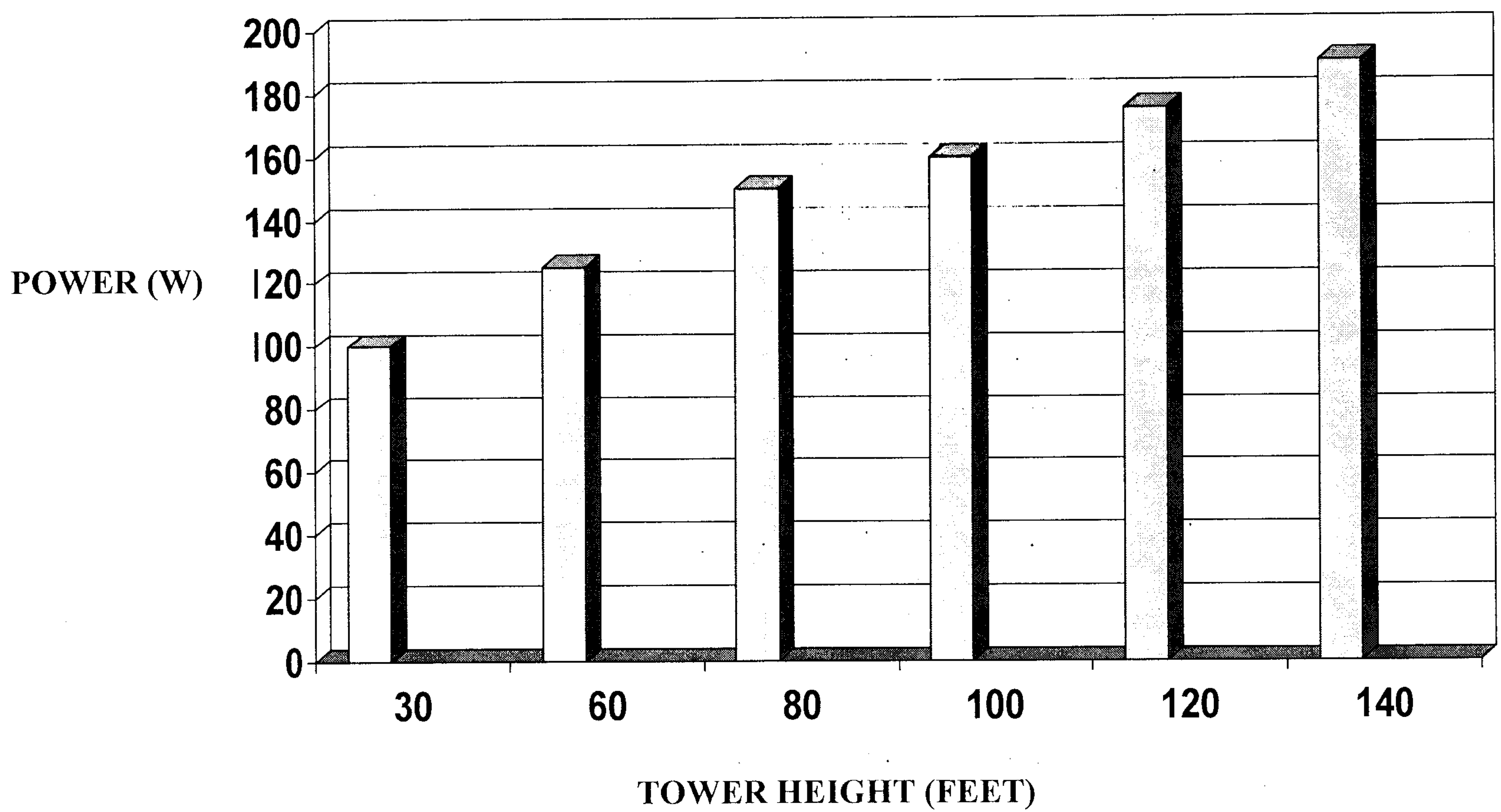


FIGURE 7.7 PERFORMANCE OF WINDMILL

CHAPTER 8

ECONOMICAL ANALYSIS

8.1 PAYBACK DETAILS

Pay back period is the period at which the overall cost which has been invested for the project or for any authority is got back within this period. This period is done for the sake of how long it has been used effectively and economically. The bill of materials for each and every component of the wind solar hybrid system are detailed as shown below in the table 8.1.

TABLE 8.1 BILL OF MATERIALS

COMPONENTS	PRICE (RUPEES)
Alternator	850
Base plate	170
Wire holder and bulbs	20
A-groove rope belt	25
Primer and external paints	170
Blades with hub	350
Yaw plates	275
Shaft	44
Plummer block	70
Double ball bearings	120
Gas cutting and cylindrical grinding operations	60
Tower	390
Labour expenses	1500
Electrician	30
Transportation cost	150
Project documentation	800
TOTAL COST	**5024**

If the windmill produces about 500KW per day for about 10 hours, it will produce about 5000 KW-hr. So, about 5 units will be generated per day approximately.

For **1 unit**, if the Electricity Cost	=	Rs.2.
For **5 units**, the Cost	=	Rs.10 only per day
For **1 month**, Cost	=	30*10
	=	Rs.300 only

If the windmill works for about 10 months efficiently and the remaining two months takes for maintenance work per year,

Expected Electricity Cost	=	10*300
	=	Rs.3000 only per year.
Pay-Back Period	=	5024/3000
	=	**1.7 years.**

CHAPTER 9

CONCLUSION

9.1 CONCLUSION

Solar cells offer a potentially attractive means for direct conversion of sunlight into electricity with great reliability and low maintenance as compared with solar thermal systems. Apart from this, the free availability in nature of such forms of energy, they are also pollution-free and can lend themselves to use in a de-centralized manner, reducing the cost of transmission and distribution of power. The cost of generating electric power with solar cells can be reduced by using concentrator to focus sunlight on to the cell. Loads can be reduced through conservation or by installing modular sources of generation such as photovoltaics and small wind turbines. Also, our project meets the growing demand at lower cost than by traditional methods of expanding the distribution system. This project yields the maximum power output over the low hill areas at the maximum power output of 400W.

9.2 LIMITATIONS

The limitations of the wind-turbine solar system are listed below,

- Photovoltaic systems need more efficient energy storage equipments.
- For a sunless day the power got from the solar cells cannot increase beyond the average power output.
- Wind turbine system cannot work in the areas where the wind speed is below 3m/s.

9.3 IMPLEMENTATION

The Solar PV system has been tested successfully. Due to unavailability of wind in Saravanampatty area, the performance of aero generator is not completed. This will be installed at Paruvai areas where the wind speed is 4m/s-10m/s and it could be useful for the rural community.

9.4 FUTURE WORK

Our project is going to be tested in the other areas across tamilnadu and going to be implemented in the paruvai panchayat to benefit the whole electricity demand. In this region, the wind speed ranges from 4 m/s to 10 m/s.

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