MTEG
Mylar and Turbine Electric Generator
Nilay Chavan, Sunit Anchan, Saurabh Jadhav
Dept. Mechanical Engineering SLRTCE, Mumbai, India
nil45.nc@gmail.com
sunitanchan@gmail.com
saurabhjadhav16193@gmail.com

Abstract — Mylar-Turbine Electric Generator (MTEG) that utilize solar energy to generate electricity. The resulting designs are cost efficient and can be used as an alternative for solar panel. The energy producing efficiency of MTEG is higher than conventional solar panel. The setup requires less area and is easily mobile. It consists of three main components Mylar parabolic reflector, steam turbine and electric generator. Mylar parabolic reflector is used to concentrate the solar rays on the water tank, the steam generated from this water is used to run the turbine which generates electricity. The idea behind this concept is to provide affordable electric generator to the people living in rural areas.MTEG is an eco-friendly idea and a leading innovation to the future.

Index Terms— Mylar Parabolic Reflector, Boiler, Steam Turbine, Electric Generator

I. INTRODUCTION

Mylar-Turbine electric generator is a setup which can be used in rural areas and Equatorial region to generate electricity. The setup is designed in such a way that the components are easily available in the market and is mobile. Considering economic and energy crisis in certain areas, the setup is cost efficient and easy to use. Availability of Solar rays and water are certain requirements that have to be satisfied. The process is very easy to understand and can produce enough electricity to meet the daily electric consumptions in these areas. In comparison to solar panels, the setup is more efficient in terms of cost as well as electricity. The electricity is generated from a clean and a renewable source of energy.

II. COMPONENTS

The Mylar-Turbine Electric Generator is a setup which consists four of the following main components i.e. Parabolic Mylar Reflector, Water Boiler, Steam Turbine and three phase Induction Generator.

A. Parabolic Mylar Reflector

Mylar is often used to generically refer to polyester film or plastic sheet. However, it is a registered trademark owned by Dupont Tejjin Films for a specific family of plastic sheet products made from the resin Polyethylene Terephthalate (PET) [5]. The true generic term for this material is Polyester Film or Plastic Sheet. It is used for its high tensile strength, chemical and dimensional stability, transparency, reflectivity, gas aroma barrier properties and electrical insulation. The manufacturing process begins with a film of molten polyethylene terephthalate (PET) being extruded onto a chill roll, which quenches it into the amorphous state. It is then biaxially oriented by drawing. The most common way of doing this is the sequential process, in which the film is first drawn in the machine direction using heated rollers and subsequently drawn in the transverse direction, i.e. orthogonal to the direction of travel, in a heated oven. It is also possible to draw the film in both directions simultaneously, although the equipment required for this is somewhat more elaborate. Draw ratios are typically around 3 to 4 in each direction. Once the drawing is completed, the film is crystallized under tension in the oven at temperatures typically above 200 °C. The heat setting step prevents the film from shrinking back to its original shape and locks in the molecular orientation in the film plane. The orientation of the polymer chains is responsible for the high strength and stiffness of biaxial oriented Mylar film, which has a typical Young's modulus of about 4 GPa. Another important consequence of the molecular orientation is that it induces the formation of many crystal nuclei. The crystallites that grow rapidly reach the boundary of the neighboring crystallite and remain smaller than the wavelength of visible light. As a result, biaxial oriented Mylar film has excellent clarity, despite its semi crystalline structure. Biaxial oriented Mylar film can be metallized by vapor deposition of a thin film of evaporated aluminum, or other metal onto it. The result is much less permeable to gases and reflects up to 99% of light, including much of the infrared spectrum.

Mylar sheets are then glued to a rubber sheet for making durable and large parabolic membrane mirror. Parabolic reflectors are used to collect energy from a distant source and bring it to a common focal point. In this case the focal point is a surface of the water boiler.

B. Water Boiler

The surface of the water boiler acts like a focal point. The water tank has its outer surface coated in black. Black being a good heat absorber absorbs 99% of the reflected rays from the parabolic Mylar reflector. Inside the tank copper coils are placed for uniform heating. The process continues and water is heated to a temperature above its saturation point [2].

In this case salt is an additive which is used along with water. The boiling point of salt water is 102°C. It doesn’t
make a big difference but is enough to elevate the temperature as well as the pressure. According to Gay-Lussac's law, "for a given mass and constant volume of an ideal gas, the pressure exerted on the sides of its container is proportional to its temperature.'

\[ P \propto T \]  
\[ \text{Where } P = \text{pressure of the steam} \]  
\[ T = \text{temperature of the water} \]

The hot steam is then allowed to pass through a nozzle in the upper section of the boiler through a pressure valve [4]. The velocity and the pressure of the steam increases and this kinetic energy of the steam run the turbine blades.

**C. Steam Turbine**

A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency from the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible expansion process. The HP turbine is a pressure-velocity compounded, single axial flow, non-condensing impulse turbine [3].

Pressure-velocity describes the type of compounding. This refers to the use of blading which causes a series of pressure drops and a series of velocity drops as shown in Fig.1.

![Fig.1. Pressure vs. Velocity in Curtis stage.](image)

Type and division of steam flow: single axial flow simply means the steam flows in only one direction parallel to the axis of the turbine rotor. Steam enters the forward end of the turbine and exhausts through the after end of the turbine. On a dual flow turbine the steam enters in the center of the turbine rotor and flows both forward and after simultaneously.

Type of blading: The type of blading used on the HP turbine is impulse blading because it extracts more work from the high pressure steam than reaction blading. Impulse blading is in the shape of a half moon. As steam impacts the moving blade, it pushes the blade forward. This impact causes the steam to lose velocity without losing pressure. In order to efficiently extract the maximum amount of work out of the steam, two different types of impulse stages are used. The Curtis stage is the first stage of the HP turbine. The Curtis stage is designed to initially extract a large amount of work out of the steam as it enters the turbine. The remaining stages of the HP turbine are Rateau stages as shown in the fig (2). The Curtis stage is designed to be a power rotor, extracting a large amount of energy out of the steam. As main steam enters the HP turbine, it first passes through the nozzle block. The nozzle block contains the nozzles. The velocity of steam is increased and the pressure is decreased as the steam passes through these nozzles. On an impulse turbine, the only time a pressure drop occurs is when steam passes through a nozzle. After steam passes through the nozzles, it passes through the first set of moving blades. In the first set of moving blades, work is extracted from the steam causing the velocity to drop. After passing through the moving blades, the steam then passes through the non-moving blades. The only purpose the non-moving blades serve is to redirect steam from the first set of moving blades to the second set of moving blades. On an impulse turbine, non-moving blades do not have any effect on the pressure or the velocity of the steam passing through them. After leaving the non-moving blades the steam passes through another set of moving blades. This setup of a nozzle followed by a set of moving blades, non-moving blades, and moving blades makes up a single Curtis stage. After steam exits the nozzle there are no further pressure drops. However, across both sets of moving blades there is a velocity drop.

![Fig.2. Pressure vs. Velocity in Rateau stage](image)

The remaining stages of the HP turbine are a series of Rateau stages. A single Rateau stage consists of a nozzle diaphragm followed by a row of moving blades. The nozzle diaphragm separates the stages of an impulse turbine and provides support for the nozzles. The nozzles within the nozzle diaphragm serve the same purpose as the nozzles within the nozzle block. As steam passes through the nozzle, velocity is increased and pressure is decreased. After leaving the nozzle, steam then enters the moving blades where once again work is extracted from the steam. Even though there is a velocity increase and a velocity decrease in each Rateau stage, the overall velocity from the inlet of the first Rateau stage to the exhaust of the final Rateau stage is not changed. In contrast, there is a pressure drop in each Rateau stage, resulting in an overall pressure drop from the inlet of the first Rateau stage to the exhaust of the final Rateau stage. This overall pressure drop causes the Rateau staging to be considered pressure compounded.

**D. Electricity Generator**

http://www.giapjournals.org/ijsrtm.html
An induction generator or asynchronous generator is a type of alternating current (AC) electrical generator that uses the principles of induction motors to produce power. Induction generators operate by mechanically turning their rotors faster than synchronous speed. A regular AC asynchronous motor usually can be used as a generator, without any internal modifications. Induction generators are useful in applications such as mini hydro power plants, wind turbines, or in reducing high-pressure gas streams to lower pressure, because they can recover energy with relatively simple controls.

An induction generator usually draws its excitation power from an electrical grid; sometimes, however, they are self-excited by using phase-correcting capacitors. Because of this, induction generators cannot usually "black start" a de-energized distribution system.

An induction generator produces electrical power when its rotor is turned faster than the synchronous speed. For a typical four-pole motor (two pairs of poles on stator) operating on a 60 Hz electrical grid, the synchronous speed is 1800 rotations per minute (rpm). The same four-pole motor operating on a 50 Hz grid will have a synchronous speed of 1500 RPM. The motor normally turns slightly slower than the synchronous speed; the difference between synchronous and operating speed is called "slip" and is usually expressed as per cent of the synchronous speed. For example, a motor operating at 1450 RPM that has a synchronous speed of 1500 RPM is running at a slip of +3.3%.

In normal motor operation, the stator flux rotation is faster than the rotor rotation. This causes the stator flux to induce rotor currents, which create a rotor flux with magnetic polarity opposite to stator. In this way, the rotor is dragged along behind stator flux, with the currents in the rotor induced at the slip frequency.

In generator operation, a prime mover (turbine or engine) drives the rotor above the synchronous speed (negative slip). The stator flux still induces currents in the rotor, but since the opposing rotor flux is now cutting the stator coils, an active current is produced in stator coils and the motor now operates as a generator, sending power back to the electrical grid.

The generator system is best and less expensive. The best because this setup creates a pure sine wave, and no square wave like an ordinary inverter. The cheapest because of an used industrial 3 phase electric induction motor. It consists of a 3 phase induction generator.

III. PROCESS

The process requires sunlight as the main source of energy. Parabolic Mylar sheets are kept at a distance from the water boiler such that water boiler acts like the focal point of the parabolic reflector.

The parabolic mirror reflects the sunrays on the focal point in the concentrated form which act as a source of heating for the boiler. This concentrated heat boils the water above its saturation point thus producing steam at a temperature T and pressure P. Since the water in the boiler is at constant volume, as the temperature increases the pressure increases according to Gay Lussac’s law. Thus producing enough pressure to run the turbine. The pressure valve is an important part which regulates the pressure inside the water boiler thus acting as a control valve for the boiler system. The pressure valve includes a spring system which maintains the pressure within the boiler and when this pressure exceeds, it opens the valve and the steam passes through the nozzle and which runs the turbine.

The turbine system involves two stages i.e. the Curtis stage and the Rateau stage. The pressure and the kinetic energy of the steam is utilized to run the turbine. In the Curtis stage 1, the high pressure steam from the nozzle hits the moving blade. The steam expands and then is passed through stationary blades which direct the flow of steam to the next moving blades. Thus utilizes the maximum kinetic and pressure energy of the high pressure steam [3].

The next stage is the Rateau stage as shown in Fig.4. The exhaust steam energy of the Curtis stage is further utilized in the Rateau stage. The steam passes through a exhaust pipe which hits the turbine making it rotate. This rotational energy is utilized by the condenser. This condensed water can be recirculated to the boiler [3].
induction motor as a generator. The electricity generated is enough to satisfy the basic electricity consumption in the rural areas.

IV. EFFICIENCY

A key advantage of parabolic Mylar reflectors over just adding more collector area is that reflectors add to solar gain without adding to collector heat losses. A typical collector operating with a modest sun level of 500 watt/sq.m under winter conditions might have efficiency around 30%, but if you can boost the sun intensity to 1000 watts/sq.m with a reflector, the efficiency jumps up to more than 50%. The heat output goes from \((500 \text{ w/sq.m})(0.3) = 150 \text{ watts}\) up to \((1000 \text{ w/sq.m})(0.5) = 500 \text{ watts}\). A 3.3 time increase in heat output. You would have to more than triple the area of the collector to get this increase. Hence parabolic reflectors are recommended.

Blade efficiency can be defined as the ratio of the work done on the blades to kinetic energy supplied to the fluid, and is given by,

\[
\eta_b = \frac{\text{Work Done}}{\text{Kinetic Energy Supplied}} = \frac{2UV_w}{V_1^2}
\]

The kinetic energy supplied through the nozzle is less compared to that in reaction turbines, thereby increasing the efficiency of the Impulse turbine. The efficiency of a 3 phase induction generator is more than that of a 1 phase induction generator.

Table 1. Average power consumption per hour

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Appliance</th>
<th>Power Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standard TV</td>
<td>188</td>
</tr>
<tr>
<td>2</td>
<td>Ceiling Fan</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Well Pump (1/3-1 HP)</td>
<td>1200</td>
</tr>
<tr>
<td>4</td>
<td>25 watt compact fluorescent bulb</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>Cell Phone - recharge</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Computer</td>
<td>120</td>
</tr>
<tr>
<td>7</td>
<td>Portable Fan</td>
<td>100</td>
</tr>
</tbody>
</table>

V. ADVANTAGES

1. Electricity is generated using clean source of energy.
2. In comparison to solar panels MTEG is cost efficient.
3. Maintenance is low.
4. Easily mobile and durable.
5. Setup is easy to install.

VI. APPLICATION

The electricity generated is used to meet the daily electricity requirements for people in rural areas. Electricity generated by Mylar-Turbine Electric Generator can be used to pump water using electric pump.

REFERENCES

[1] N. Panickar “Thermodynamics” accessed on 15.2.2015, 10:35 AM.