Implementation of Vortex Blade Less Wind Mill Power Generation System

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Abstract- *In this project we are generating electrical power as non-conventional method by simply running on the vehicle. The power is generated by the piezo-electric arrangement is fitted in the blade less wind mill. Non-conventional energy system is very essential at this time to our nation. Non-conventional energy using blade less wind mill needs no wind input power to generate the output of the electrical power. Piezoelectricity is the electric charge that accumulates in certain solid material (notably crystal, certain ceramic and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The aim of this research work is to make power generation more sustainable, economic and ecological by utilizing the advancement in the technology.*

I. INTRODUCTION

Man has needed and used energy at an increasing rate for his sustenance and well-being ever since he came on the earth a few million years ago. Primitive man required energy primarily in the form of food. He derived this by eating plants or animals, which he hunted. Subsequently he discovered fire and his energy needs increased as he started to make use of wood and other bio mass to supply the energy needs for cooking as well as for keeping himself warm. With the passage of time, man started to cultivate land for agriculture. He added a new dimension to the use of energy by domesticating and training animals to work for him.

1.1 VEHICLE SUSPENSION

In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. Without blade less wind mills, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement.

1.2 PIEZOELECTRIC

Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure. It is derived from the Greekpiezo or piezein, (which means to squeeze or press, and electric or electron, which means amber, an ancient source of electric charge. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie.

1.2.1 Discovery and Early Research

The piezoelectric effect, by which a material generates an electric potential in response to a temperature change, was studied by Carl Linnaeus and Franz Aepinus in the mid-18th century. Drawing on this knowledge, both René Just Haüy and Antoine César Becquerel posited a relationship between mechanical stress and electric charge; however, experiments by both proved inconclusive.

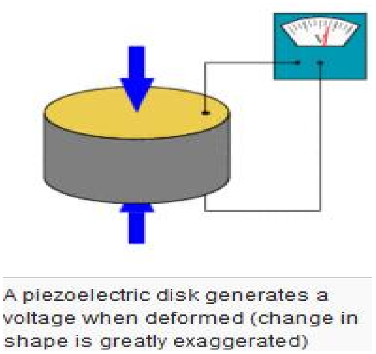

Fig. 1.1 A Piezoelectric Disk Generates a Voltage When Deformed

1.5.2 Mechanism

The nature of the piezoelectric effect is closely related to the occurrence of electric dipole moments in solids. The latter may either be induced for ions on crystal lattice sites with asymmetric charge surroundings (as in $BaTiO_3$ and PZTs) or may directly be carried by molecular groups (as in cane sugar). The dipole density or polarization (dimensionality [Cm/m^3]) may easily be calculated for crystals by summing up the dipole moments per volume of the crystallographic unit cell. As every dipole is a vector, the dipole density ***P*** is a vector field.

The change in ***P*** appears as a variation of surface charge density upon the crystal faces, i.e. as a variation of the electric field extending between the faces caused by a change in dipole density in the bulk. For example, a 1 cm^3 cube of quartz with 2 kN (500 lbf) of correctly applied force can produce a voltage of 12500V.

1.5.3 Piezoelectric Effect

Piezoelectricity is the ability of certain crystalline materials to convert mechanical energy into electrical energy and vice versa.

The direct piezoelectric effect is that these materials, when subjected to mechanical stress, generate an electric charge proportional to that stress. An example of the use of the direct effect is found in gas lighters. Piezoelectric sensors, like acceleration sensors and pressure sensors, also exploit the direct piezoelectric effect.

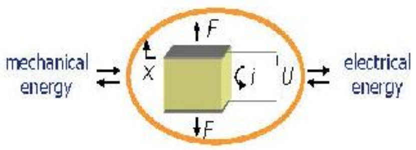

Fig. 1.2 Piezoelectric Effect

1.3 PIEZOELECTRIC MATERIALS

The piezoelectric effect occurs only in nonconductive materials. Piezoelectric materials can be divided in 2 main groups: crystals and ceramics. The most well-known piezoelectric material is quartz (SiO2).

1.6 QUARTZ SIO_2

The trigonal crystallized silica of SiO2 is known as Quartz and is one of the most common crystals on earth's surface.

Quartz shows a strong piezoelectric effect perpendicularly to the prism axis. Applying pressure on a quartz crystal generates an electrical polarization along the pressure direction. Alternatively, applying an electrical tension leads to a mechanical deformation of the crystal.

1.8 BARIUM TITANATE $BaTiO_3$

Barium titanate belongs to the group of electrical ceramics. It is an oxide of barium and titanium.

As a piezoelectric material, it is usually replaced by lead zirconate titanate (PZT).

It is used as a piezoelectric material for microphones and transducers.

- Crystal Structure: tetragonal
- Molar mass 233.192 g/mol

II. METHODOLOGY

The fundamental methodology we utilized in our undertaking is to convert the kinetic energy of air into physical-mechanical stress. After this, with the help of a piezoelectric sensor we covert that mechanical pressure into the alternating impulse of charge flow i.e. current. To saddle the active vitality of air, we use a vertical structure which is called the mast. At the point when air with high velocity makes an impact on the mast, it starts to vibrate with a certain amplitude and in a certain direction concerning the welded joint. As we know from the concept of resonance, every material has its natural intermolecular frequency. When that frequency matches the frequency of mast vibration, resonance occurs. Mast starts to vibrate with larger amplitude and after that we covert the large amplitude vibration into vertical stress on the piezoelectric sensors through a metal plate called Disc which is welded at fixed support of mast.

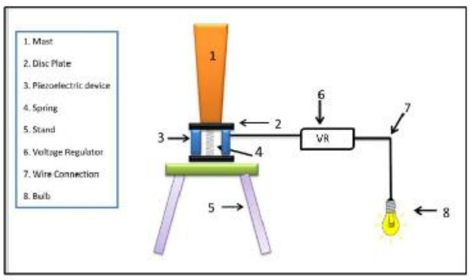

Fig. 2.1 Block diagram of Bladeless turbine

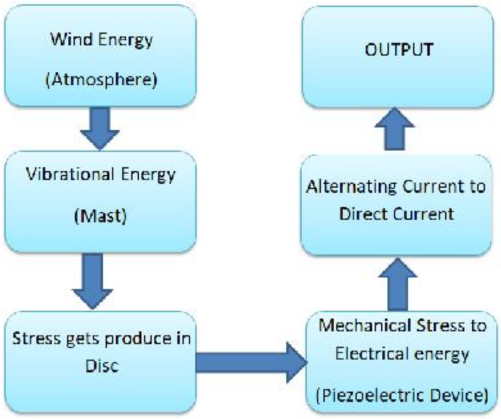

Fig. 2.2 Working of Bladeless turbine

III. COMPONENTS AND DESCRPTION

1. Battery
2. Frame
3. Piezo Electric Chip
4. Blade Less Wind Mill

3.1 Battery

In isolated systems away from the grid, batteries are used for storage of excess solar energy converted into electrical energy. The only exceptions are isolated sunshine load such as irrigation pumps or drinking water supplies for storage. In fact, for small units with output less than one kilowatt. Batteries seem to be the only technically and economically available storage means. Since both the photo-voltaic system and batteries are high in capital costs.

We use lead acid battery for storing the electrical energy from the solar panel for lighting the street and so about the lead acid cells are explained below.

3.2 Lead-Acid Wet Cell

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A. One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery for a 12-V battery.

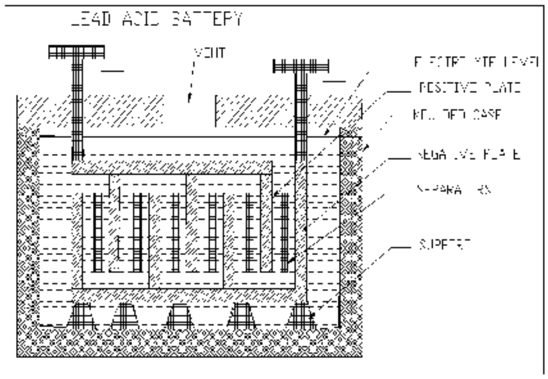

Fig. 3.1 Lead Acid Battery

As the discharge continues, the sulfate fills the pores of the grids, retarding circulation of acid in the active material. Lead sulfate is the powder often seen on the outside terminals of old batteries. When the combination of weak electrolyte and sulfating on the plate lowers the output of the battery, charging is necessary. On charge, the external D.C. source reverses the current in the battery. The reversed direction of ions flows in the electrolyte result in a reversal of the chemical reactions.

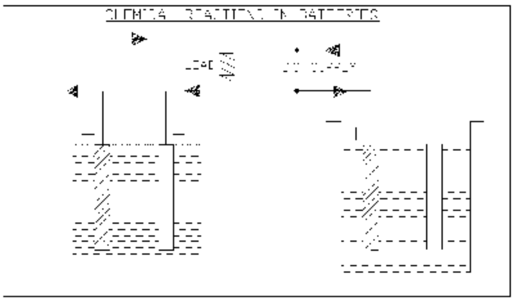

Fig. 3.2 Chemical Reaction in Batteries

Now the lead sulfates on the positive plate reactive with the water and sulfate ions to produce lead peroxide and sulfuric acid. This action re-forms the positive plates and makes the electrolyte stronger by adding sulfuric acid.
The chemical equation for the lead-acid cell is

Charge

$$Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$$

Discharge

On discharge, the pb and pbo_2 combine with the SO_4 ions at the left side of the equation to form lead sulfate ($pbSO_4$) and water (H_2O) at the right side of the equation.

One battery consists of 6 cell, each have an output voltage of 2.1V, which are connected in series to get an voltage of 12V and the same 12V battery is connected in series, to get an 24 V battery. They are placed in the water proof iron casing box.

3.2.1 Caring for Lead-Acid Batteries

Always use extreme caution when handling batteries and electrolyte. Wear gloves, goggles and old clothes. "Battery acid" will burn skin and eyes and destroy cotton and wool clothing.

The parts of the plates that become "sulfate" no longer store energy. Batteries that are deeply discharged, and then charged partially on a regular basis can fail in less than one year.

Check the electrolyte level in the wet-cell batteries at the least four times a year and top each cell of with distilled water. Do not add water to discharged batteries. Electrolyte is absorbed when batteries are very discharged. If you add water at this time, and then recharge the battery, electrolyte will overflow and make a mess.

On charge, with reverse current through the electrolyte, the chemical action is reversed. Then the pb ions from the lead sulfate on the right side of the equation re-form the lead and lead peroxide electrodes. Also the SO_4 ions combine with H_2 ions from the water to produce more sulfuric acid at the left side of the equation.

3.2.2 Current Ratings

Lead-acid batteries are generally rated in terms of how much discharge currents they can supply for a specified period of time; the output voltage must be maintained above a minimum level, which is 1.5 to 1.8V per cell. A common rating is ampere-hours (A.h.) based on a specific discharge time, which is often 8h. Typical values for automobile batteries are 100 to 300 A.h.

In cold weather, therefore, it is very important to have an automobile battery unto full charge. In addition, the electrolyte freezes more easily when diluted by water in the discharged condition.

3.2.3 Charging The Lead-Acid Battery

It may be of interest to note that an automobile battery is in a floating-charge circuit. The battery charger is an AC generator or alternator with rectifier diodes, driver by a belt from the engine. When you start the car, the battery supplies the cranking power. Once the engine is running, the alternator charges he battery. It is not necessary for the car to be moving. A voltage regulator is used in this system to maintain the output at approximately 13 to 15 V.

With proper care, lead-acid batteries will have a long service life and work very well in almost any power system. Unfortunately, with poor treatment lead-acid battery life will be very short.

3.3 FRAME STAND

Frame stand is made up of mild steel materials. The whole above mentioned parts are fixed in to this frame stand with suitable arrangement.

3.4 BLADE LESS WIND MILL

Vortex Bladeless S.L is a Spanish tech startup that developed a multi-patented wind turbine without blades. In 2014, Vortex Bladeless won The South Summit Award in the category of energy and industry for the best project.

Vortex's innovation comes from its unusual shape, where a fiberglass and carbon fiber mast oscillates in the wind taking advantage of the vortex shedding effect. At the bottom of the mast a carbon fiber rod moves inside a linear alternator that generates the electricity, with no moving parts in contact. Vortex has a small carbon footprint, is noiseless, has low centre of gravity and allows for small foundation dimensions, so more generators can be placed in an area, at twice the density of traditional turbines.

IV. EXPERIMENTAL ANALYSIS

4.1 FABRICATION PROCESS

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material. The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing.

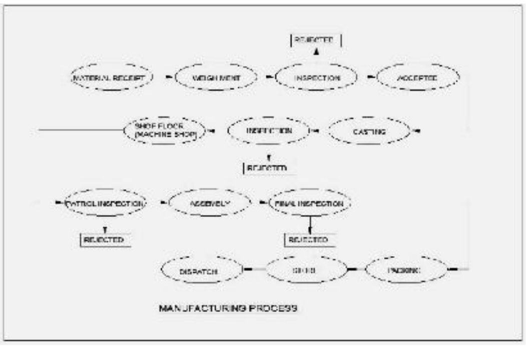

Fig. 4.1 Fabrication Flow Chart

4.2 METAL CUTTING

Metal cutting or machining is the process of by removing unwanted material from a block of metal in the form of chips.

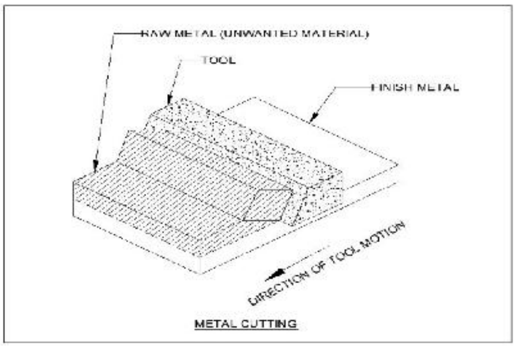

Fig. 4.2 Metal Cutting Process

Cutting processes work by causing fracture of the material that is processed. Usually, the portion that is fractured away is in small sized pieces, called chips. Common cutting processes include sawing, shaping (or planning), broaching, drilling, grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, the basic mechanism for causing the fracture can be understood by just a simple model called for orthogonal cutting.

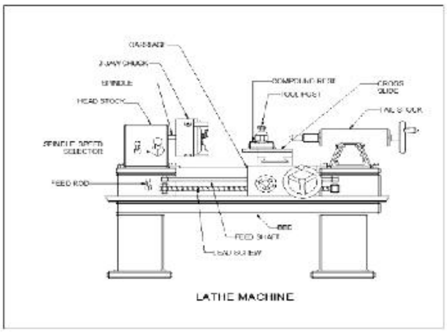

Fig. 4.3 Lathe Machine

In all machining processes, the work piece is a shape that can entirely cover the final part shape. The objective is to cut away the excess material and obtain the final part. This cutting usually requires to be completed in several steps – in each step, the part is held in a fixture, and the exposed portion can be accessed by the tool to machine in that portion. Common fixtures include vise, clamps, 3-jaw or 4-jaw chucks, etc. Each position of holding the part is called a setup. One or more cutting operation may be performed, using one or more cutting tools, in each setup.

4.3 SAWING

Cold saws are saws that make use of a circular saw blade to cut through various types of metal, including sheet metal. The name of the saw has to do with the action that takes place during the cutting process, which manages to keep both the metal and the blade from becoming too hot. A cold saw is powered with electricity and is usually a stationary type of saw machine rather than a portable type of saw.

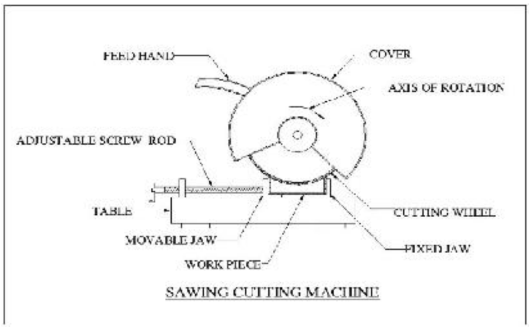

Fig. 4.4 Sawing Cutting Machine

Along with the high speed steel blades, a cold saw may also be equipped with a blade that is tipped with tungsten carbide. This type of blade construction also helps to resist wear and tear. One major difference is that tungsten tipped blades can be re-sharpened from time to time, extending the life of the blade. This type of blade is a good fit for use with sheet metal and other metallic components that are relatively thin in design.

5.4 WELDING

Welding is a process for joining similar metals. Welding joins metals by melting and fusing 1, the base metals being joined and 2, the filler metal applied. Welding employs pinpointed, localized heat input. Most welding involves ferrous-based metals such as steel and stainless steel.Weld joints are usually stronger than or as strong as the base metals being joined.

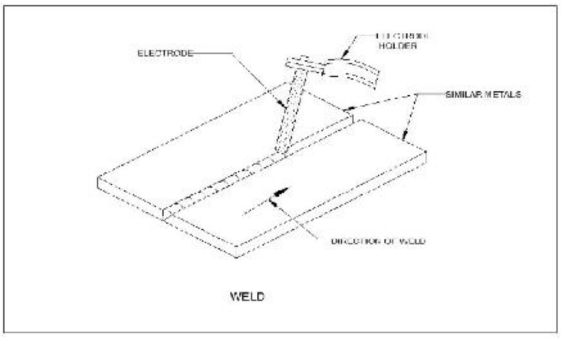

Fig. 4.5 Welding Process

4.5 NUMERICAL ANALYSIS

Larger radius of the mast
R1=0.20m
Smaller Radius of the mast
R2=0.05m
Height of the mast
L=1m

Lateral surface area of the mast

S= π x (R1+R2) x L
= 3.14 x (0.20+0.05) x 1
S=0.78539 $\mathbf{m}^2$
Average velocity of the wind V=30 to 40 km/h

Projected area of the mast exposed to wind

A= (R1+R2) x L
= (0.20+0.05) x 1
A=0.25 $\mathbf{m}^2$

Force by the wind on the projected area

F=ρ x A x $v2$ (Where “ρ” density of the air)
=1.225x0.25x8.34x8.34
= 21.30N

V. RESULT AND DISCUSSION

5.1 STRUCTURAL ANALYSIS

We have used CATIA V5 software for designing and stress analysis, and the numerical analysis was done by keeping in mind the structural figure. In this step, the designing of the Piezoelectric Bladeless turbine is done. All the dimensions are taken accordingly

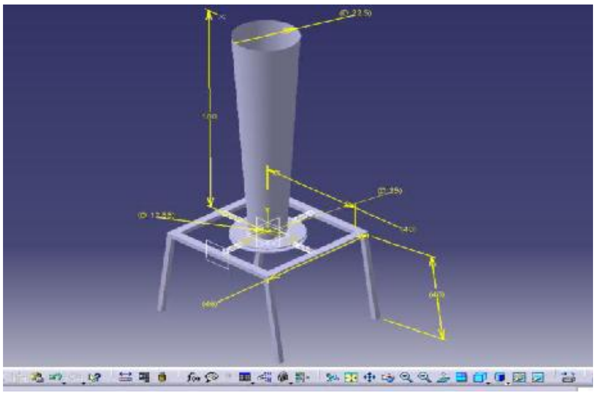

Fig. 5.1 Designing of Bladeless turbine.

As we know mast will behave like a cantilever beam so accordingly it is clamped from one end (end with smaller radius). Now using the result which we got from numerical analysis i.e. Force applied by the wind on the projected area = 11.93 N.This force is applied in the Z direction and it is considered that the applied force behaves like continuously varying load. In Figure 6, the arrow shows the direction of the applied force.

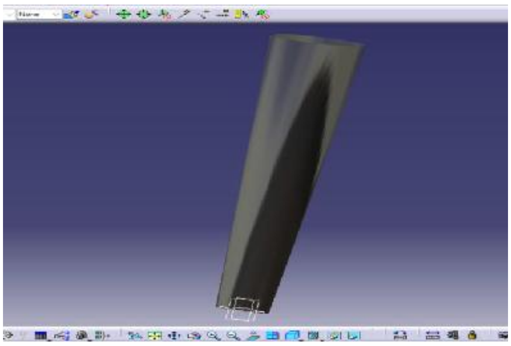

Fig. 5.2 Material Selection of Mast

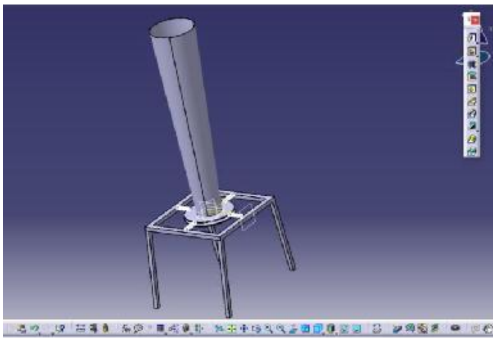

Fig. 6.3 Structural Analysis of Mast.

All we can say is that piezoelectric wind turbine has all the advantage to be the better alternative of the conventional wind turbine and with its installation in large numbers, overall efficiency can be increased.

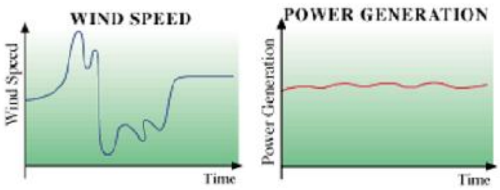

Fig. 5.4 Variation of Wind Speed and Power Generation with time

As shown in the above chart, variation in wind speed is very much, and due to this net force applied on the mast varies, generating oscillations of different frequencies. Due to these random oscillations, stress applied on the piezoelectric chips is of varying magnitude, which later generates an alternate current. So, for steady power output, we have used a full-wave rectifier, which helps in producing this steady power flow as shown in the above figure.

Also, by our structural analysis, we came up with a conclusion that maximum stress is generated by the flowing wind at the lower end of the mast. But due to the geometry and material chosen of the mast, our structure can sustain this generated stress making in more economic than a conventional wind turbine.

5.2 WORKING MODEL

Fig. 5.5 Working Model

VI. CONCLUSION

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between institution and industries. We are proud that we have completed the work with the limited time successfully.

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