

# Fabrication & Experimental Analysis of Wind belt for small power generation

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**Abstract:** As we know that in the world the demand of power or electricity is continuously increased, so the dependency for generation of power is shifted from nonrenewable to renewable sources. The world has become increasingly dependent on renewable energy sources such as solar, wind, biogas etc. We chose to work on wind energy for this research project. This paper investigates the efficiency of wind speed integrated with an aero-elastic-flutter based, energy harvester machine known as Wind Belt. Flutter phenomenon has been used to change wind flow energy into mechanical vibration, which is then altered into electrical power. However, aero-elastic flutter initiates only when the wind speed is over a certain flutter commencement speed and the wind flow direction is nearly perpendicular to the flutter, which limits continuous power generation.

**Keywords:** Frame, Flutter, Wind energy, mechanical vibration etc.

## Introduction: -

As we know that in the world the demand of power or electricity is continuously increased, so the dependency for generation of power is shifted from nonrenewable to renewable sources. The world has become increasingly dependent on renewable energy sources such as solar, wind, biogas etc. We chose to work on wind energy for this project.

In this framework we are paying attention on developing a Machine or product that can generate electricity using the kinetic energy of the wind. All the conservative wind mills have a simple phenomenon of doing the same. General machines which generate power/electricity with help of wind power known as wind mill has a rotating device called “turbine” which rotates when wind flows over it. The shaft is attached to a dynamo and thus electricity is generated. This procedure sounds pretty good. But, when we try to implement it on a small scale level, like lighting a LED or charging a mobile phone etc., there are lots of troubles involved. Rotation-based wind turbines don’t balance down well due to friction and lesser energy of poorer wind speeds. So, there is a need to develop a new improvement or innovation which does not use rotary components, to achieve the mandatory targets at the small scale requirements.

## Purpose:-

The purpose of this research project is to evaluate the relationship between aero-elastic flutter and an induced electric current to generating the electric power for small scale level, like lighting a LED or Charging a Smart phone etc.

## Background study: -

Energy harvesting has been an energetic research area as demands for renewable energy sources increase. Energy harvesting systems refer to devices that capture and transform energy from the environment into electricity. Unlike conventional, large-scale renewable energy generating systems such as wind turbines, thermal generators, and solar panels, energy harvesting devices mostly target on powering small electronic devices.

The Wind belt is a wind power harvesting device invented by Shawn Frayn in 2004 for converting wind power to electricity. It consists of a flexible polymer ribbon stretched between supports transverse to the wind direction, with magnets glued to it. When the wind blows across it, the ribbon vibrates due to aero elastic flutter, similar to the action of an aeolian harp. The vibrating movement of the magnets induces current in nearby pickup coils by electromagnetic induction. [1]

## Shawn’s Wind Belt: -

Now days a lot of research is being done to the efficiently harvest wind energy. Several designs for wind turbines have come up that improves the efficiency, but not to significant values. Aim of this shifts to develop a better use that can face the winds and effectively harvest wind energy. Effectiveness here stands for efficiency of the combined system in conjunction with the cost of the device. Shawn Frayne in 2007 developed a Wind Belt [2].

Shawn Frayne, an MIT graduate was the first person to discover this idea and he created something called “Wind belt”. He started a company by the name “Humdinger” which sells these Wind belts. Inspired by him, we tried out working on the same principle in this course.

## Objectives of wind belt design:-

The detailed design of this project research is based upon a slightly different set of the objectives than its predecessors. For this work, the ultimate goal was to be creating a prototype that could be easily replicated by almost anyone at a very low cost. Construction would be require the little building skill and would be consist of mostly recycled parts. Power & efficiency are not

aim of this work; rather, it will be serve as a way for the people to learn about Wind belt design by getting hands-on experience by building one themselves.

The hope is that this model will help build a bigger base of people who are working to perfect the Wind belt design. Though larger the Wind belt prototypes can be daunting & expensive for average individual, the design of this specific Wind belt allows interested hobbyists to get their foot in the door and expand upon their original design later. Additionally, some new Belt materials will be tested as there are yet few feasible options. [2]

#### Advantages of a Wind belt:-

- The Wind belt is a light weight, low cost, portable, easy-to-use device.
- It can also be used for lighting bed lamps.
- A Wind belt can be kept on a moving car and the output can be used to charge phone while travelling.
- A Wind belt can be placed on poles in high wind zones and used for street lighting.
- An array of Wind belts placed side by side can form a “Wind cell” and it may be used to light up an entire room!

#### Working Principle:-

The Wind belt is based on the 3 main principles.

**1. Aero elastic Flutter:** - Aero elastic Flutter involves aerodynamic forces acting on a structure to result in a self-feeding high energy oscillation. Flutter has the potential to occur in any object subject to wind. If there is positive feedback in the structure between the aerodynamic forces and its natural vibration, flutter will occur. This means that the vibrational oscillation of the object, coupled with wind, will drive the object to move farther or faster.

**2. Electromagnetic Induction:** - The second principle behind the Wind belts design is that of Michael Faraday’s electromagnetic induction. Electromagnetic induction is the production of voltage across a conductor in a changing magnetic field. Faraday found and stated that the „induced electromotive force or EMF in any closed circuit is equal to the time rate of change of the magnetic flux through the circuit. Faraday’s law is:

$$E = -N * \Delta\Phi / \Delta t$$

Where,

N = the number of loops of a conductive coil

$\Delta\Phi$  = the change of electromagnetic flux.

In practice, a changing magnetic field applied through a conductive wire in a closed circuit will generate electricity. The current produced in the Wind belt is an alternating current, with a frequency typically between 20 and 30Hz depending on the wind speed and construction dimensions for the unit.

**3. Vibrations due to air flow:** - Vibrations deal with behavior of bodies under the influence of oscillatory forces. These forces are caused frequently by dynamically unbalanced masses in rotating machines or by the motion of the body itself. Vibrations can be used the way wind, say, we use for making the belt flutter. In our case, as we are trying to harness energy from vibration, high amplitudes will actually be beneficial. Higher the amplitude, more the belt will flutter, and more will be the output of the system. [3]

#### Study area:-

To make proper use of wind energy, proper site selection and wind speed availability are to be considered first. The wind speed and its duration are the key factors to design and to determine the use of wind energy. Therefore, to generate accurate and more reliable wind Speed data, the wind speed data monitoring system must be carried out before going to take any plan to implement either comprehensive or pilot plant in this regard. With a view to evaluating the actual pattern of wind energy, a typical location is chosen and wind speed is continuously monitored.

#### Top 4 types of wind patterns on earth surface:-

Type 1: Inter-Tropical Convergence Zone (Doldrums)

Type 2: Trade Wind Pattern

Type 3: Subtropical High Pressure (Westerlies Belts)

Type 4: Polar Easterlies [4]

#### Reasons for recognition of need of wind belt:-

1. Wind power must still compete with conventional generation sources on a cost basis. Depending on how energetic a wind site is, the wind farm might not be cost competitive. Even though the cost of wind power has decreased dramatically in the past 10 Years, the technology requires a higher initial investment than fossil-fuelled generators.

2. Good wind sites are often located in remote locations, far from cities where the electricity Is needed. Transmission lines must be built to bring the electricity from the wind farm to the city. However, building just a few already-proposed transmission lines could significantly reduce the costs of expanding wind energy.

3. Wind resource development might not be the most profitable use of the land. Land suitable For wind-turbine installation must compete with alternative uses for the land, which might be more highly valued than electricity generation. [5]

**Proposed solution for above Reasons:-**

Though conventional windmills produce relatively little power at low wind speeds, wind Belts can take advantage of the areas low average wind speeds. After doing a detailed Analysis of the above mentioned theories and specifications of wind & methods of its Harvesting in form of electricity, this solution is very commonly known as Wind Belt/Harvester.

**Component used for fabrication of Wind belt:-**

The following makeup the basic components of a Wind belt:

1. **Wooden Frame:** - Wind belt are exposed to the elements and are subject to UV radiation, temperature change, moisture, and variable wind speeds. Therefore, the frame must be durable. This means the frame should be as strong as possible. Consideration should also be taken as to how the Wind belt will stand or be mounted. High winds can create a lot of torque upon the Wind belts mounted and can damage the Wind belt or the structure it is attached to if the mount breaks. A piece of wood at least 6" wide and 2-3 feet long will be used for the frame. Just about any piece of wood fitting this description will do, but a thinner piece of wood will be easier to work with. For this project, we used 1/2" thick door panelling and cut it to 2.5 feet.
2. **Belt:** - The Belt must be lightweight and thin so it acts like an aerofoil when wind blows across it. It must be fairly rigid, as too much elasticity will disrupt the vibration of the Belt. The Belt will be taut and subjected to potentially high wind speeds, so the material must have a high tensile strength.
3. **Magnets:** - Permanent magnets are used to induce current in the coils when vibrating in and out of the coil. The magnets must be fairly lightweight so as not to disrupt the aero elastic flutter of the Belt. Neodymium magnets are the most commonly used.
4. **Coil:** - The coils must be made of a conductive metal. Copper is by far the least expensive of metals that conduct well. Coils can be wound by hand, lessening the cost.
5. **Electrical Connection (WITH LED 0.2-0.5 WATT):-** Electricity produced by Wind belt is of inconsistent voltage. Voltage is relative to wind speed, and so voltage must be regulated for use. Small Wind belt systems are capable of supplying power to standard USB ports, while larger systems can supply power for 12V DC circuits. Even larger arrays have the potential for grid-tied AC systems, but these are still in the experimental phase. Here we have used an LED of 0.2-0.5 Watt.

**Model Fabrication:-**

The Wind belt consists of a taut membrane of Camera Film roll, Neodymium magnets, Copper coil and a frame to hold these equipment. Apart from this, it consists electrical of Unit that gives the desired output power.

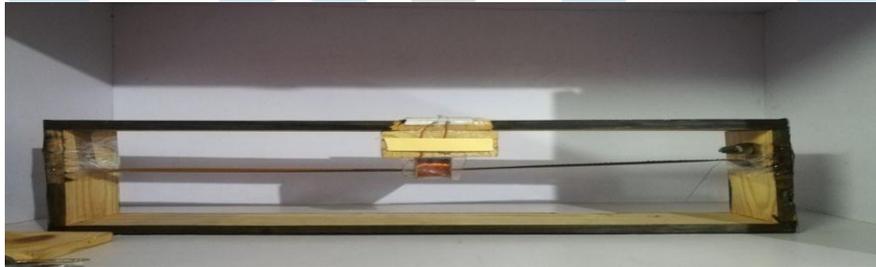


Figure 1:-Photograph of our Project

**Analysis of Wind Belt:-****1. Dimensional Analysis**

Table 1:- Dimensions of Model

SR. NO.	PARAMETERS	LENGTH (IN CM.)
1.	LENGTH	60
2.	HEIGHT	15
3.	TOTAL WIDTH	10
4.	BELT WIDTH	2.5

**2. Analysis of Model**

Analysis carried out under 3 specific conditions:

1. Carried out at Room Condition
  2. Carried out under Blower/Cooler (Assuming Wind on Highways)
  3. Carried out under Large Pedestal Fan of 2800 RPM (Assuming Wind in Coastal Areas)
- Calculation is carried out on 3 different positions of belt, moving the coil along with magnet on the belt at 25%, 50% & 75% on the length of belt in all the 3 above mentioned cases and output voltage in mill-Volt is noted.
  - This gives us a brief idea about the variation in output which we get at different wind speeds in different geographical conditions

**A. CARRIED OUT AT ROOM CONDITION (under a fan): Position of Coil and Magnet (on length of Belt)**

Table 2:- Table of Output at Room Conditions

Position	1) 25%	2) 50%	3) 75%
Voltage (In Mill-Volt)	0.2	0.5	0.2

- Output in form of voltage is obtained but not sufficient enough to glow the LED, will have to connect no. of belts in parallel in order to get sufficient output at room conditions.

**GRAPH:**

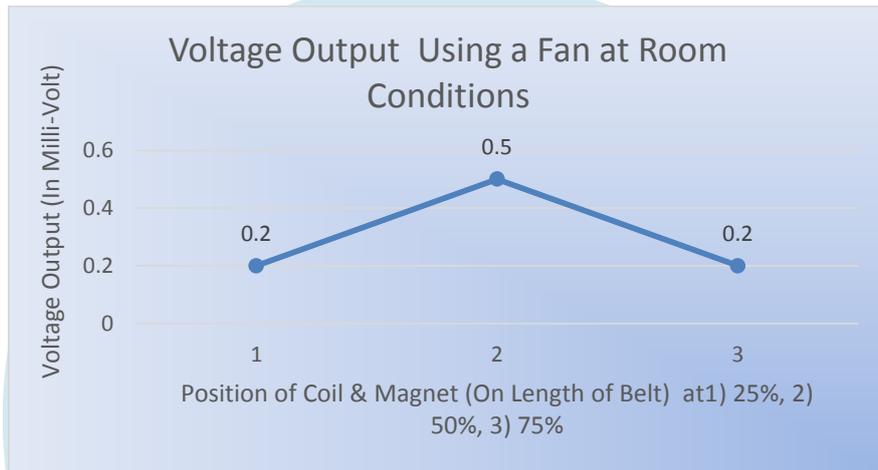


Figure 2:- Graph of output at room condition

**B. CARRIED OUT ON BLOWER (assuming wind on highway):**

Table 3:- Table of output on blower/cooler

Position Of Coil And Magnet (On Length Of Belt) Position	1) 25%	2) 50%	3) 75%
Voltage (In Mill-Volt)	3.1	5.5	3.2

- Output in form of voltage is obtained and sufficient enough to glow the LED, we can combine several units in parallel and place it on moving vehicles such as trucks etc. or at any fuel station and use it for basic electronic use.

**GRAPH:**

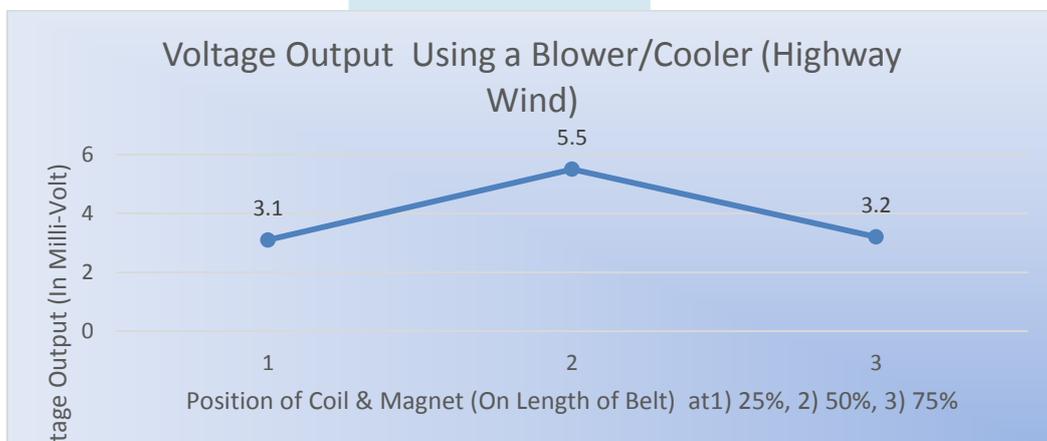


Figure 3:- Graph of output on blower/cooler

**C. CARRIED OUT LARGE PEDESTAL FAN (2800 RPM)(Assuming coastal area wind): Position of Coil and Magnet (on length of Belt)**

Table 4:- Table of Output on large pedestal fan

Position	1) 25%	2) 50%	3) 75%
Voltage (In Mill-Volt)	85	114	97

- Output in form of voltage is obtained and sufficient enough to glow the LED. This model is gives out its best output in this case and specifies that this model will be best suited in areas with higher wind velocity (such as coastal areas).

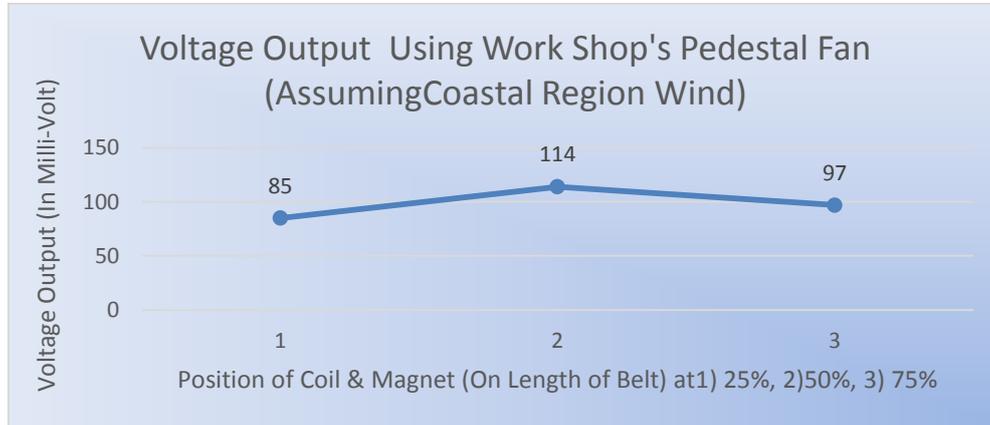
**GRAPH:**

Figure 4:- Graph of output on large pedestal fan

**Result:** - Wind belt offers an alternative for small scale wind power generation dispensing with the turbine altogether while producing power at a (claimed) efficiency of 10-30 times greater than that of a similarly rated wind turbine.

Table 5:- Result Analysis

**Position of Coil and Magnet (on length of Belt)**

Carried on Condition	25%	50%	75%
Room Condition	0.2 mV	0.5 mV	0.2 mV
Blower/Cooler (Assume Highway Wind)	3.1 mV	5.5 mV	3.2 mV
On Large Pedestal Fan(Assume Coastal Wind)	85 mV	114 mV	97 mV

From the above table we can conclude that with change in the position of coil and magnet there is variation in the voltage output. In all the above 3 cases we can observe that we are getting the maximum output at the centre of the length of belt i.e. at 50% position on the length of the belt.

**Future scope: -**

- An array of Wind belts placed side by side can form a “Wind cell” and it may be used to light up an entire room!
- There is a lot of scope for improving the design of the Wind belt for a better performance.
- One straightforward improvement in performance efficiency would be to use magnets of higher strength, coils with more number of turns and belt with optimum tension and length to be in resonance.
- The number of magnets and coils used can also be increased for a higher output.
- A series of Wind belts can be used to form a Wind cell, so that we can get output for medium scale appliances as well.

**Future Modifications and Proposed Applications of Wind Belt:-**

Wind Belt system can also be put to the following implementations:

- The Wind Belt system can also be used for auxiliary applications such as powering up of Wi-Fi outdoor routers and switches.
- Powering up of traffic lights on crossings.
- Powering up of radar speed guns to monitor over speeding.
- Powering up of SOS call booths located at desired locations on highways.
- Powering up of aviation beacon on the telecommunication towers located in the vicinity of the Wind Belt array.

## References

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