WIND ENERGY HARVESTING FROM FLAPPING LEAF GENERATOR

Karthikeyan V
Assistant Professor,
Nehru institute of Engineering & Technology
Coimbatore,
anjkar11@yahoo.com

Dr. P. Maniiarasan
Nehru institute of Engineering & Technology
Coimbatore

Bharath Kumar M R
UG scholar,
Nehru institute of Engineering & Technology
Coimbatore
mrbharathee@gmail.com

Abstract- The increasing concerns towards depletion of non-renewable sources and development of innovative cost efficient technologies for the use of renewable energy sources are the driving factors for using wind energy for power generation. Wind energy is traditionally harvested by using wind turbines for generating power. The cost of typical 1kw wind turbine starts at 30k; moreover they produce noise and are huge in size, thus the initial cost for setting up a plant increases. This paper is on harvesting the wind energy using Piezo electric stalk attached with flapping polymer leaf. The flapping of the polymer leaf due to the wind produces pressure on the Piezo electric stalk, this vibration yields electrical energy. In order to meet the energy demand 1000's of leaves are parallelized thus result in Piezo tree. This Piezo electric stalk is made up of Polyvinylidene Fluoride (PVDF). The cost of setting up this prototype is very cheap compared to the traditional wind turbines. This paper details on the vertical stalk- horizontal leaf and horizontal leaf –horizontal stalk arrangement, Piezo tree, and the ways of harvesting the energy generated and the places it can be erected.

Keywords: Piezo electric, Wind Energy, PVDF, Renewable energy, turbine, polymer leaf.

I. INTRODUCTION

Renewable and sustainable energy research has attracted much attention with the increasing gap between the demands and supply of fuel in recent years. Researchers have been searching for a practical alternative to petroleum and coal for Electrical power. Hydroelectric power stations and wind turbines are two of the most successful solutions in this field; however, even compared to hydroelectric energy, wind power is much more environmentally friendly. Nevertheless, there are some limitations of traditional wind power generators, namely, that using a large rotational turbine to harvest energy from the air requires significant financial and infrastructure investment, large real-estate area and long term Commitment. The focus of this paper is on the principles and feasibility of the harvesting energy from the Wind in constrained spaces such as around buildings, as an alternative to conventional rotary wind turbines. The central Idea is to harvest energy from wind induced vibration instead of wind driven rotation. In the prototype, the flexible plate and film are driven to oscillate just as a flag or leaf might flap in the wind. The flapping motion is attributed to instability of the aero-elastic system. The flexible piezoelectric material Polyvinylidene Fluoride (PVDF) is the basic component, as it could withstand unpredictable wind strength. Compared to traditional rotary wind turbines and other piezoelectric vibration generators, this parallel vibration generator could have the following advantages:

(1) Light, scalable, robust structure
(2) Low cost
(3) Attractive bio-compatible design
(4) Easy installation, operation and maintenance
(5) Reconfigurable morphology
(6) Usability in a wide range of environments
(7) Broad response band to wind speeds and directions

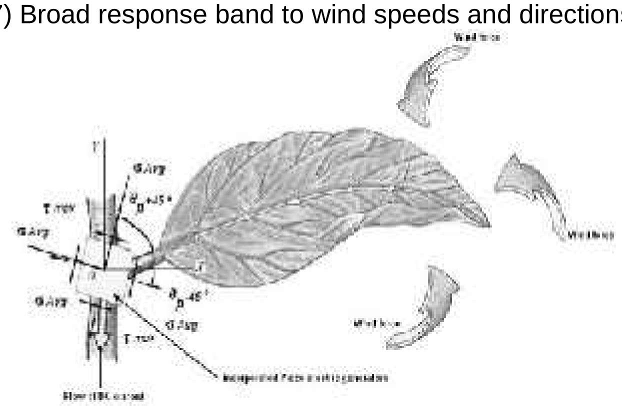


Fig.1. Conceptual sketch and realization of "Piezo-tree" generator

In this paper, we focus on the "Piezo stalk and leaf" which is the essential element of the plant-like generator. We present a single leaf made from piezoelectric materials, which is capable of generating electrical power through wind Induced vibrations. As Figure 1 shows, a five-leave tree as a wind energy generator prototype. Each vibrating element consists of a polarized PVDF “stalk”, a plastic hinge and a polymer/plastic “leaf”. The conceptual design and prototype device are both described in the following sections.

II. CONCEPT, THEORY AND MODEL

A. Original Idea

When a fluid passes a bluff body, it will alternately produce a vortex shedding on both sides of bluff body, leading to a classical “vortex street” configuration in the near wake. The fluctuating pressure forces then form in a direction transverse to the flow and may cause structural vibrations. We therefore expect to gain this kind of mechanical vibration Energy which we can convert to electrical power afterward. The theoretical background of the design is similar to the Aforementioned “eel”, however, we propose to harvest energy from wind rather than oceans or rivers.

B. Simplified Dynamic System Model

To understand the physical mechanism behind the design, we consider a simplified model of the flapping fluid-structure Coupled system which is abstractly treated as an aerodynamic instability driven cantilever-pendulum system (Figure 2). The attachment “leaf” is driven by the vortex induced periodic pressure through the bending force and moment of the PVDF stalk.

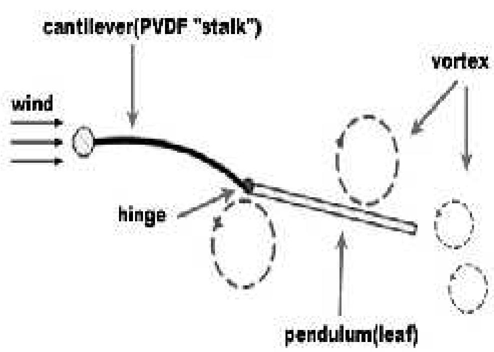


Figure.2. Top view of simplified system model (00000Horizontal-stalk leaf)

Theoretic Background

In this prototype, the flexible plate and film are driven to oscillate just as a flag or leaf might flap in the wind. The Flapping motion is attributed to instability of the aero-elastic system. There are two potential excitations that may be Responsible for the unstably periodic motion of a flexible body: first is the external harmonic forcing field caused by Vortex shedding from leading edge (bluff body); second is the unsteady force and moment induced by the vortex when Shedding from the trailing edge of the flexible plate or film, which is called a self-induced effect. Classical studies predict that the dominant exciter of this oscillation phenomenon should be the vortex shedding from the bluff body.

III. DESIGN AND IMPLEMENTATION:

A. *Basic Design and Experimental Solutions*

Considering of the unpredictable wind strength, the flexible and robust piezoelectric materials (PVDF) is the essential component of the device. The basic design is to clamp one edge of PVDF element to the bluff body and leave the other edge free. When the wind crosses this device, it will lead the aero-elastic instability and the periodic pressure difference will drive the Piezo-leaf to bend in the downstream of the air wake, synchronously. We collect the AC signal from the flapping Piezo-leaf, which is working on a periodic bending model, and store the electrical energy in a capacitor after rectifying it with a full-wave bridge.

B. *Horizontal-Stalk Leaf*

As Figure 3(a) shows, this design has a bluff body. The laminated PVDF is clamped in the horizontal direction of airflow, and a triangle shape polymer leaf attaches to the free end of stalk through a plastic hinge. The direction of the complete system looks like a minus shape. The leaf is attached to stalk by hinge.

C. *Vertical-Stalk Leaf*

As Figure 3(b) shows, this design has no bluff body. The laminated PVDF is clamped in the vertical direction of airflow, and a triangle shape polymer leaf attaches to the free end of stalk through a plastic hinge. The direction of the leaf is no longer the same as stalk, but it is still in the direction of the airflow, thus the new device looks more like an “L” shape; we Refer to this configuration as the “vertical-stalk leaf” hereafter. In this vertical configuration, the stalk twists as well as bends. The vertical-stalk leaves exhibit much more excitation performance than horizontal-stalk leaves. Vertical-stalk configuration of leaf has ore potential for wind vibration devices. In order to increase the power produced the configuration such as short single layer PVDF stalk, Long single layer PVDF stalk and double layer air spaced PVDF stalk are used based on requirement.

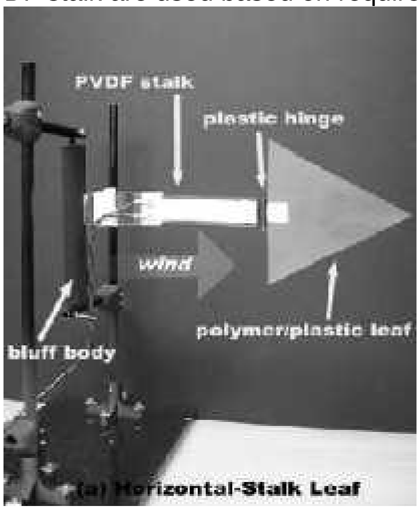


Fig.3.a.Horizontal stalk Piezo configuration

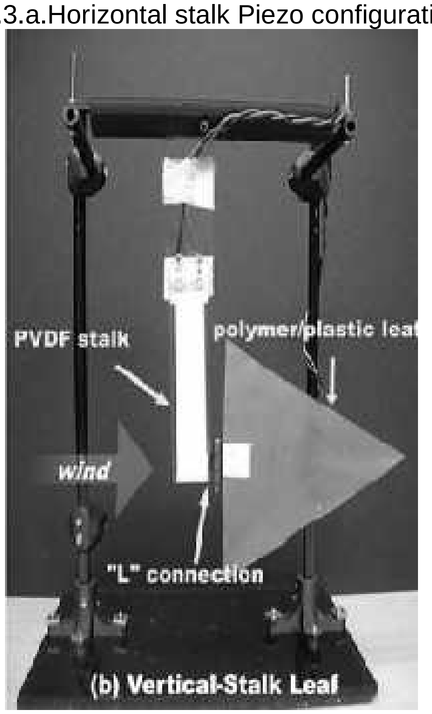


Fig.3.b.Vertical stalk Piezo configuration

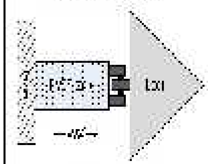
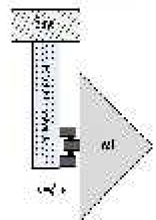
Configuration of Prototype	PVDF element	Max Output Power (Load=10 MΩ, Deviation ≈ 6%)
Horizontal-stalk leaf 	Long single layer PVDF stalk	17 μW (Wind speed = 6.5m/s)
Vertical-stalk leaf 	Short single layer PVDF stalk	296 μW (Wind speed – 8m/s)
	Long single layer PVDF stalk	76 μW (Wind speed – 5.5m/s)
	Long air-spaced double layers PVDF stalk	119 μW (Wind speed = 6.5m/s)

Fig.4. Experimental results achieved by researchers

IV. IMPLEMENTATION FOR COMMERCIAL POWER GENERATION:

The Implementation for commercial power generation can be done by parallelization for the Prototype Piezo trees i.e. several Piezo trees are connected to achieve the power demand . These Piezo trees each has about 100's to 1000's of Piezo leaves. When several of these trees are connected in parallel the required power can be yielded. These trees are not affected by the atmospheric and climatic conditions, they are simple and cost efficient and can be placed in any location with minimum wind speed. The below shown is typical implementation of the Piezo trees in parallelization in highway. In a highway there is movement of vehicles 24*7 thus movement of each vehicles creates some air pressure thus resulting in wind of a average speed just enough to vibrate the Piezo leaves. Thus when number of trees parallelized along highway can generate enough power that can be used to power the lams in the highways and even for tollgates. These trees also add beauty to the highway and attract the people attention. We also proposed a novel method for placing these Piezo trees in highways for powering the highway lights and tollgate. The potential advantage of parallel wind-vibration energy harvesting appears to be in their robust, simple and maintenance-free monolithic construction, their ability to scale from miniature sizes to large scales through parallelization, and their natural blending in urban and natural environments.

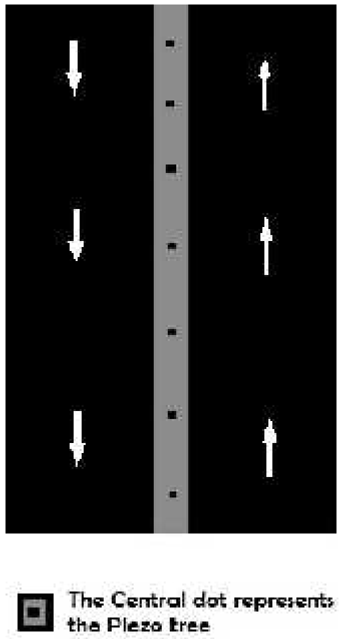


Fig.5. Piezo tree along a highway

V. CONCLUSION

In this paper we projected horizontal stalk Piezo and vertical-stalk Piezo-leaf generator which could convert wind energy into electrical energy by wind-induced flapping motion. The potential advantage of parallel wind-vibration energy harvesting appears to be in their robust, simple and maintenance-free monolithic construction, their ability to scale from miniature sizes to large scales through parallelization, and their natural blending in urban and natural environments. In near future we will see the Piezo trees replacing the wind mills.

VI. REFERENCES:

[1] Proceedings of the ASME 2009 Conference on Smart Materials, Adaptive Structures and Intelligent Systems, SMASIS2009, Oxnard, California, USA,Shuguang Li College of Astronautics, Northwestern Polytechnic University, Xi'an, Shaanxi, China Sibley School of Mechanical and Aerospace Engineering, Cornell UniversityIthaca, NY, USA Hod Lipson Sibley School of Mechanical and Aerospace Engineering, Cornell University Ithaca, NY, USA.

[2] Sodano, H.A., Park, G. and Inman, D.J., 2004, "A Reviewof Power Harvesting from Vibration using Piezoelectric Materials," *The Shock and Vibration Digest.*

[3] www.alternative-energy-news.info

[4] www.greenoptimistic.com