International Review of Applied Engineering Research.
ISSN 2248-9967 Volume 4, Number 3 (2014), pp. 281-288

http://www.ripublication.com/iraer.htm

# Vibration Energy Powered Flaps

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## Abstract

Flying animals flap their wings to generate lift and thrust. The fundamentals of bird flight are similar to those of aircrafts. The difference in pressure produces lift, a force that acts roughly perpendicular to the wing surface and keeps the bird or airplane from falling. In this paper a conceptual idea of flaps powered by vibration-harvesting energy technology has been modelled. First of all this idea got evolved for the lift production, during helicopter rotor system failures. Number of accidents has occurred due to sudden power breakdown, of bird hit on the rotor blades etc. During such conditions the system can be switched on immediately so that the helicopter does not crash and land with an optimised speed. Ground Resonance intrudes number of complications causing system failure, which can be curtailed using this flap system for smooth landing. The system has been modelled in such a manner that the vibration energy produced due to rotary parts in the helicopter is given as input, to the piezoelectric vibration scavenging technology. A conceptual design of the flaps powered by large scale vibration has been devised here. The main reason for choosing piezoelectric technology is efficiency, compatibility and high voltage production, high coupling in single crystal etc. The Flaps not only provides additional lift but can be used in stabilising the helicopter due to high resonance. Moreover this design can be used not only in helicopters but also in other aerial vehicles, feeding the Input from some other source or methods. The idea of the system has been designed using AutoCAD software.

Keywords: Helicopter, Vibration scavenging energy technology, Piezoelectric, Flaps, AutoCAD.

## 1. Introduction

Kinetic energy generators convert energy in the form of mechanical movement (vibrations) into electrical energy. There are inertial spring and mass systems. Piezoelectric generators are inertial systems, which employs active materials that generate a charge when mechanically stressed. Kinetic energy harvesting requires a transduction mechanism to generate electrical energy from motion and the generator will require a mechanical system that couples environmental displacements to the transduction mechanism. Piezoelectric transducers can be utilized for this concept. Vibration energy is best suited to inertial generators. In this paper we have used piezoelectric vibration harvesting technology to power the flaps. When crystals were subjected to mechanical strain, they became electrically polarized and the degree of polarization was proportional to the applied strain. Conversely, these materials deform when exposed to an electric field.

$$d = \frac{strain}{appliedfield}$$

Piezoelectric generators rely on a compressive strain applied perpendicular to the electrodes. The power output achieved in the compressive mode can be improved by increasing the piezoelectric element's thickness or by using multi-layer stacks. Another important constant affecting the generation of electrical power is the electro-mechanical coupling coefficient, $k$. This describes the efficiency with which the energy is converted by the material between electrical and mechanical forms in a given direction. This is defined in equation where $W_i^e$ is the electrical energy stored in the, *i* axis and $W_j^m$is the mechanical input energy in the *j* axis.

$$k_{ij}^2 = \frac{W_i^e}{W_j^m}$$

## 2. Basic Postulations

- This concept is given for helicopter safety purposes but, the basic idea can be used for any other systems with light weight considerations like micro aerial vehicle etc.
- The light weight helicopter is taken into account for the flaps design considerations. Mainly focused for single engine helicopters.
- The problem of ground resonance consideration can be analysed only after development of the exact idea of the system, which was not done while formulating this paper.
- Currently flapping wings are used in miniaturized and micro aerial vehicles. But there are various light weight Nano materials like graphene, Bucky paper which are under development for a large scale usage. These materials are lighter than any other materials, which are presently being used in Aerial vehicles manufacturing. These materials can be used in the future for fabrication of flaps proposed in this paper.

- For the purpose of powering flaps and to support the vibration energy concept, we have proposed the usage of piezoelectric strips though it is presently being used for power generating in microwatts range.

## 3. focal Illustration

**Fig. 1**: Central Plot of the concept proposed.

## 4. Fundamental Idea

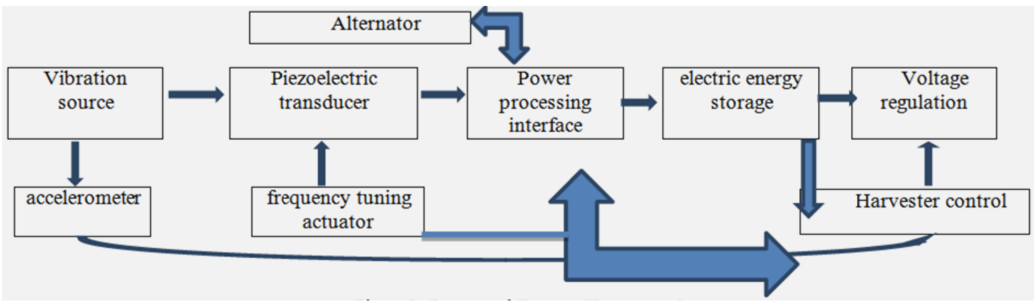


**Fig. 2**: Proposed Energy Harvester System.

The source in this system is taken to be the vibrations that are generated by the main rotor blades. Helicopter vibrations primarily have its source from the main rotor. Severe vibrations tend to ensue mostly in two conditions. One is during high speed flight and the other is low speed transition flight. The piezoelectric transducer used here are the piezoelectric strips^ [1] which has been developed by 'MIDE engineering smart technologies'. This strip has been used here to prove our concept. A connection can be given from the main rotor blades to the power processing interface. Here we have also used alternator for power generation which can also be connected to the power processing interface. Then the power is stored in a storage device. Whenever flaps are used voltage regulation is done, which in turn will power the flaps leading to production of lift.

## 5. Flap Design

The conceptual design of flaps is shown as below which can be fitted to the helicopter fuselage. The flap design showed here is a retractable design.

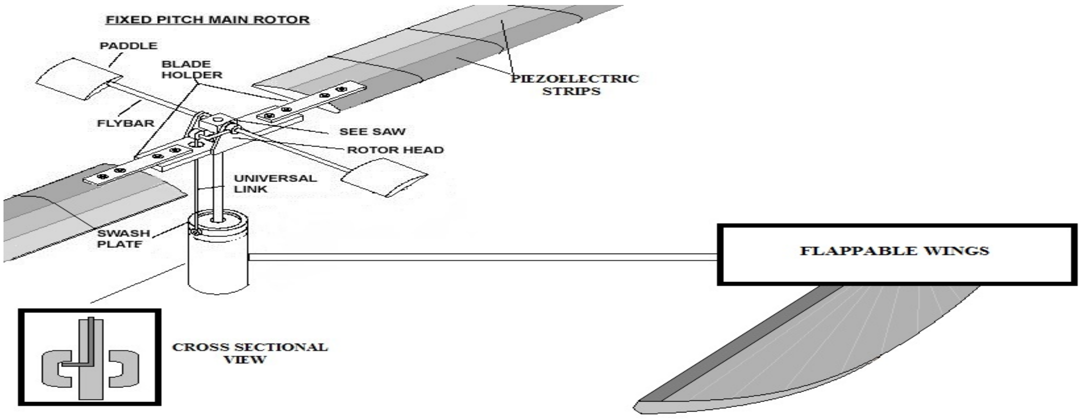


**Fig. 3**: Flap Design Integrated to the Piezoelectric strips.

## 6. Power Unit

The flaps can be powered by two power units.

- Piezoelectric strip concept.
- Alternator.

### 6.1 Piezoelectric Strip Concept

These strips have the capacity to generate power in the range of microwatts. By further research these strips can be modelled to suit our concept.

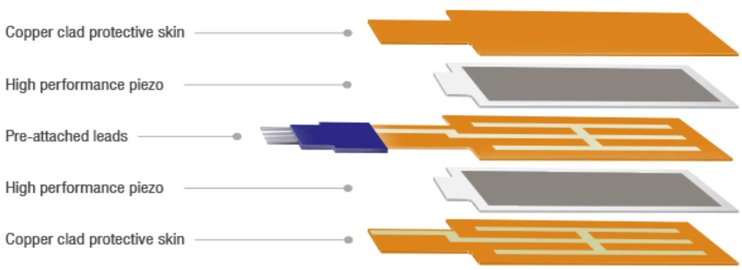


**Fig. 4**: The protective layer of the piezoelectric strip.

These strips are nothing but Piezo-ceramic wafers which are packed into a copper clad protective skin. This skin protects the normally brittle piezos, and protects them against harsh environmental elements. The copper clad skin also provides a high degree of electrical insulation, and enables pre-attached leads for easy connection.

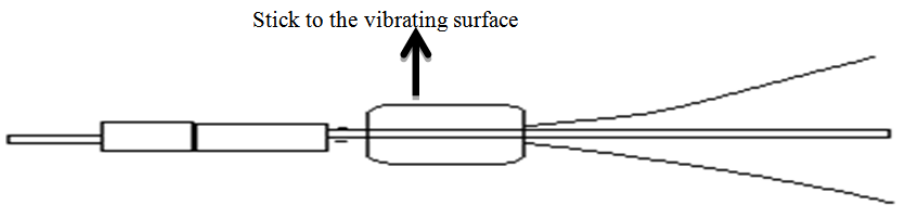


**Fig. 5**: Overview of a piezoelectric strip.

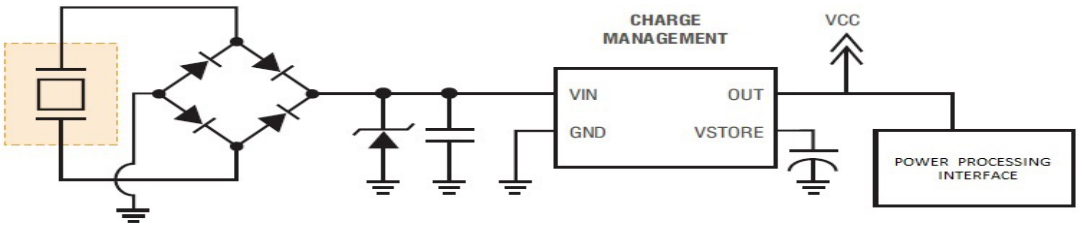


**Fig. 6**: Circuit diagram explains the usage of strips to our system.

Our idea is to 'integrate number of strips to the main rotor blades'. A connection can be made and it can be connected to the link. The following diagram explains the concept.

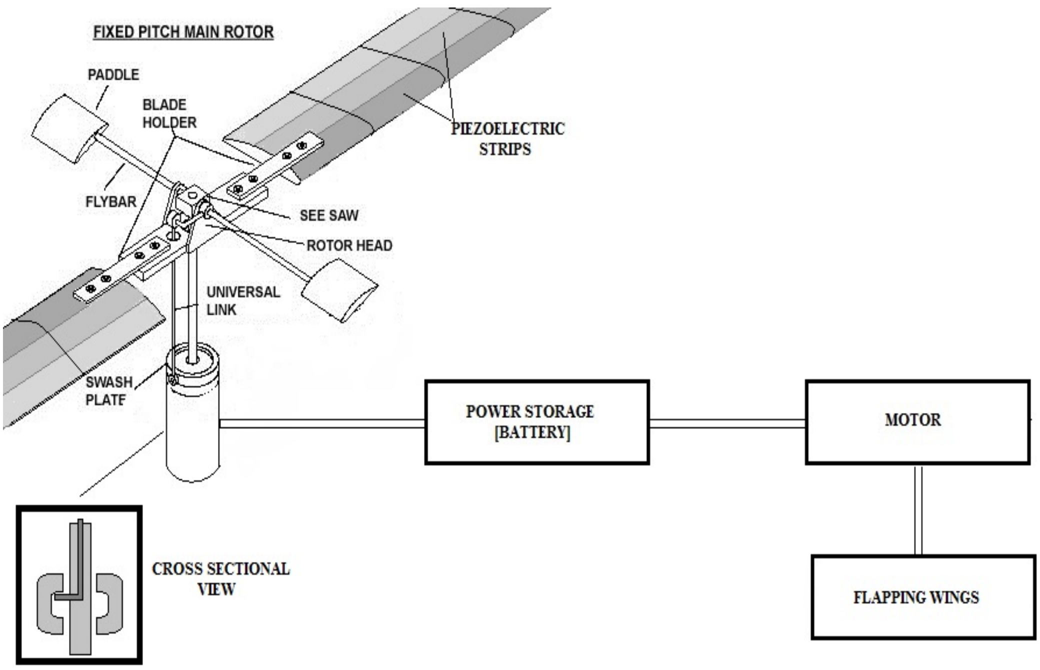


**Fig. 7**: Piezoelectric energy harvester connected to the Flaps

**Alternator:** An alternator is an electromechanical device that converts mechanical energy to electrical energy in the form of alternating current. The alternator can be coupled to the main rotor shaft using a simple gear mechanism as shown in the following diagram.

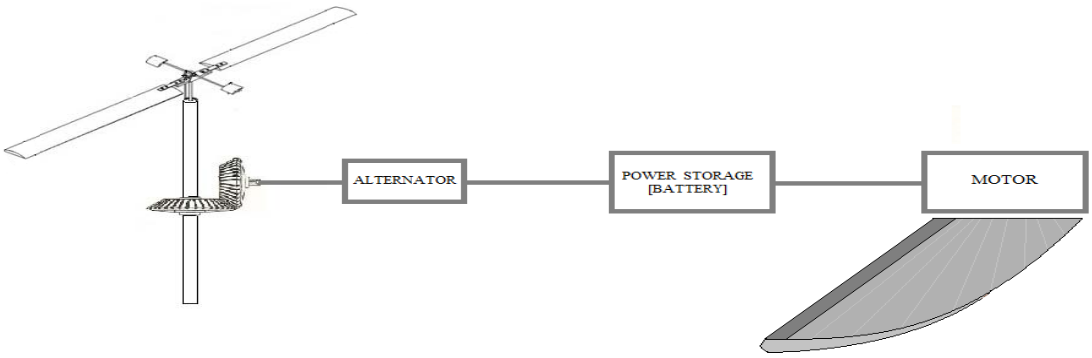


**Fig. 8**: Alternator power generator concept.

The power generated goes to the power processing interface. This was formulated as an additional backup to power the flaps.

## 7. Power Calculation

The calculations are done with few assumptions, which are stated as follows.

The main rotor RPM = 2700, Frequency of rotor = 45 Hz.

According to the frequency we have chosen Volture V22bl Piezoelectric strip with the following specifications,

Typical thickness = 0.031 inches. Max tip to tip displacement = 0.12.

**Table 1**: Relation between Mass and Natural Frequency.

| Tip Mass(gram) | Frequency | Amplitude | Open circuit Voltage |
|---|---|---|---|
| 0.5 | 45 | 0.25 | 6 |
| 0.5 | 45 | 0.375 | 8.5 |
| 0.5 | 45 | 0.5 | 11 |
| 0.5 | 45 | 1 | 17.5 |

From the table above amplitude is taken to be 1. Accordingly the output voltage = 17.5.

Usually has to be calculated as follows. —. But the experimental values obtained from the data sheet of volture products, is appropriate for the chosen case. Hence, from the graph shown below the = 0.75mW and $\Delta t$ = 10 seconds (assumed).

Therefore the Capacitance obtained from each strip is calculated as follows,

$$C = 2 * Pavg * \frac{\Delta t}{v^2}$$

$$C = 2 * 0.75 * 0.001 * \frac{10}{17.5^2},$$

Therefore C = 0.0000489 produced by one strip at resonance time interval of 10 seconds.

‘Along with this the Power obtained from the alternator also adds to the flap requirement’.

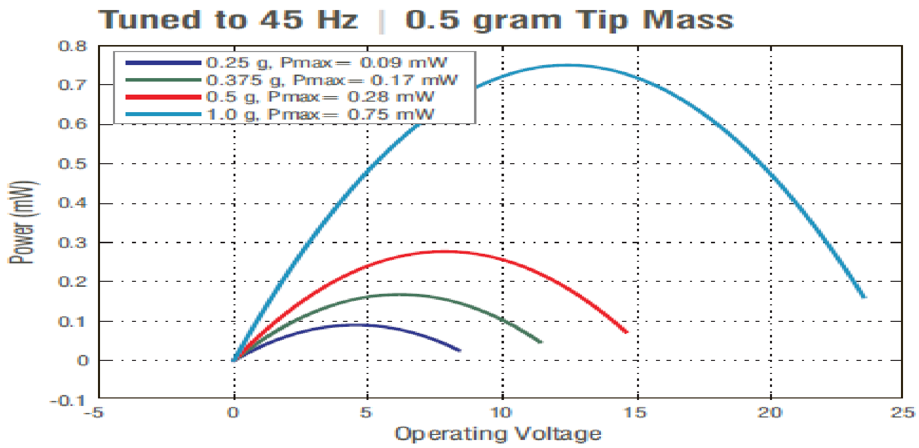


**Fig. 9**: Typical Power Characteristics.

## 8. Conclusion

The projected model explained in this paper purely conceptual. With further research this idea could be implemented practically in the helicopters. Helicopters are widely used in rescue operations especially during natural disasters. They are vulnerable to various unstable conditions, especially due to vibrations. Number of accidents has been recorded throughout the history. Hence, employing this idea will eventually save many helicopters and decreases the crash rates. Moreover the proposed idea can, not only be used in the helicopters but can also be used in other aerial vehicles.

## 9. Acknowledgements

Setting an endeavour may not always be an easy task; obstacles are bound to come in its way. Hence, we would like to thank our parents for a never ending support they have provided us through all our hurdles. For the rest of our lives, we are indebted for everything they have done to us.

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