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PIEZOELECTRICITY INDUCED BY TURBULENT AIRFLOW FOR CLEAN AND RENEWABLE ELECTRIC POWER GENERATION

Rômulo Mourão Pires
Marcelo Mendes Vieira
Aguinaldo Soares de Oliveira
Universidade Federal de Mato Grosso, Rondonópolis, MT, Brasil
asoares@ufmt.br

Abstract. *The objective this paper is the demonstration of electric power generation capacity using piezoelectric patches, these being excited by a flow of turbulent air simulating a stream of natural air flow. Demonstrating and explaining the generation of electricity through the oscillation of a flexible plate coupled to the piezoelectric patches when subjected to a turbulent air flow. Using the turbulent flow as a mechanical movement, the piezoelectric patches coupled to a flexible plate will be subjected to a mechanical stress, thus generating an electric moment of intensity proportional to the stress applied to the metal plate by the turbulent flow of the air flow. Thus, through the mechanical efforts generated by the flow of air in the plate, it is possible to generate electric energy through the piezoelectric patches*

Keywords: *Piezoelectricity, electric power generation, clean and renewable energy.*

1. INTRODUCTION

The search for technologies related to electric power generation always had great interest, seeking to improve existing methods and discover new ways of obtaining it. A large part of the studies today are geared towards improve a piezoelectricity technology.

Although piezoelectricity technology is still in development, it is a viable alternative to generate clean and safe energy for a society that needs this type of energy. This energy clears due to the ability of some crystals to generate electrical energy when subjected to a mechanical effect applied, direct effect of piezoelectricity, (Oliveira, 2008) and (Maio, 2011).

The use of a turbulent air flow generated by a wind tunnel so as to deflect a metal plate with attached piezoelectric patches will be discussed in this paper. The efficiency of the device to undergo an elastic deformation due to the mechanical stress generated by a turbulent flow on a metal plate containing piezoelectric patches is studied.

2. EXPERIMENTAL PROCEDURE

The In order to obtain the turbulent air flow, an existing wind tunnel was used in the Flow Machines laboratory of the Federal University of Mato Grosso, Campus of Rondonópolis (UFMT-CUR), its measurements being 3400 *mm* in length and 0.082 m^2 of area. The exit duct of the wind tunnel had a certain internal roughness, which was not removed to aid in obtaining turbulent flow. The piezoelectric patches used for the paper were taken from electronic boards of microwave appliances, containing 12.7 *mm* in diameter each, where they are used as buzzers

The test bench was created from an existing metallic structure, but adapted to promote support of a metal plate with dimensions of (300x155) *mm* (height x width). The main objectives of the structure were to provide support to the system, and that there was no loss of vibration from the system to the structure, in order not to generate a reduction of the efficiency of the project in the generation of electric power through the vibration of the sheet metal, figure 1 and figure 2 (TICHY, 2010), (PERLIGEIRO, 2016) and (SANCHES, 2015).

Figure 1: (a) Front view of wind tunnel ; (b) Installation of piezoelectric patches.

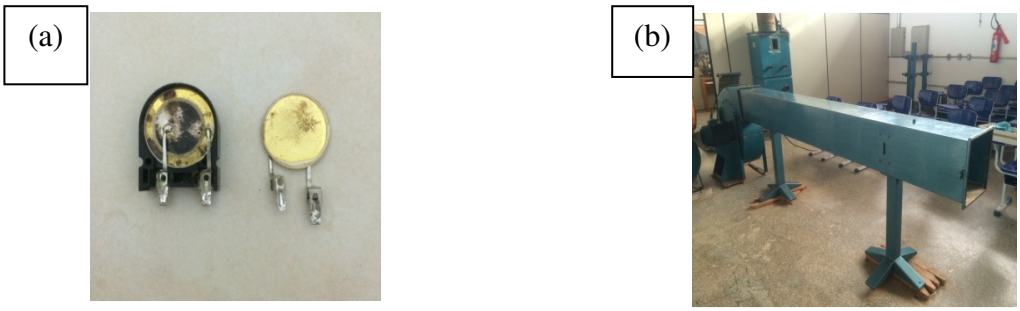

Figure 2: (a) Details of piezoelectric patches; (b) Isometric view of the wind tunnel.

The air flow was generated through a wind tunnel, and airflow flow control was performed through an adaptation in the turbine air intake nozzle using a 10 *mm* thick hardwood plate, figure 3, containing a channel approximately 10 *mm* wide, using a bolt with nut and washer to adjust the nozzle opening, thus allowing for gusting of winds with variable speeds between 0 and 34 *m / s*. To measure the wind speed used in the tests, an anemometer was used according in the figure 4.

Figure 3: Adaptation carried out on the suction nozzle of the wind tunnel to control the air suction flow, indicating open section and closed section

Figure 4: Anemometer used to measure wind speed during tests

According to CRESESB (2017), the power generated by the flow of the fluid can be described by the following equation:

$$P = \frac{1}{2}\rho A v^3 \tag{1}$$

Where:

The ρ is the air density at room temperature and considering the altitude of Rondonópolis-MT (227 *m* above sea level) is 0.9974 Kg/m^3, *A* is the metal plate area (m^2), *v* is the air speed (*m /s*) and *P* is the power of air flow (*W*).

The area used was the wind tunnel exit nozzle, which is 8,215x10-2 m^2.

The velocities used were collected during the tests, thus generating a table 1 with the values of power generated by the air flow in each test.

Table 1 - Values obtained for power of the air flow in the bench tests.

	Speed	Nozzle area	Air density	Power of air flow
UNIT	(m/s)	m^2	(kg/m^3)	(W)
Test #1	0	0,08215	0	0,0000
Test #2	2,9	0,08215	0,9974	0,5656
Test #3	4,7	0,08215	0,9974	2,4076
Test #4	6,7	0,08215	0,9974	6,9745
Test #5	8,3	0,08215	0,9974	13,2594
Test #6	9,1	0,08215	0,9974	17,4748
Test #7	9,8	0,08215	0,9974	21,8256
Test #8	12,4	0,08215	0,9974	44,2134
Test #9	14,5	0,08215	0,9974	70,6956
Test #10	16,6	0,08215	0,9974	106,0750
Test #11	17,2	0,08215	0,9974	117,9978
Test #12	20,4	0,08215	0,9974	196,8698
Test #13	21,5	0,08215	0,9974	230,4645
Test #14	22,6	0,08215	0,9974	267,6788
Test #15	23,4	0,08215	0,9974	297,1230

3. RESULTS

During the tests, data were collected on the velocity of the air flow incident on the metal plate (*m / s*), the voltage (*V*) and current (*mA*), generated by the piezoelectric patches undergoing deflection due to the flow of air through the metal plate during the tests in order to obtain the power (*mW*) that the piezoelectric patches produced. The data collected are presented in the figure 5.

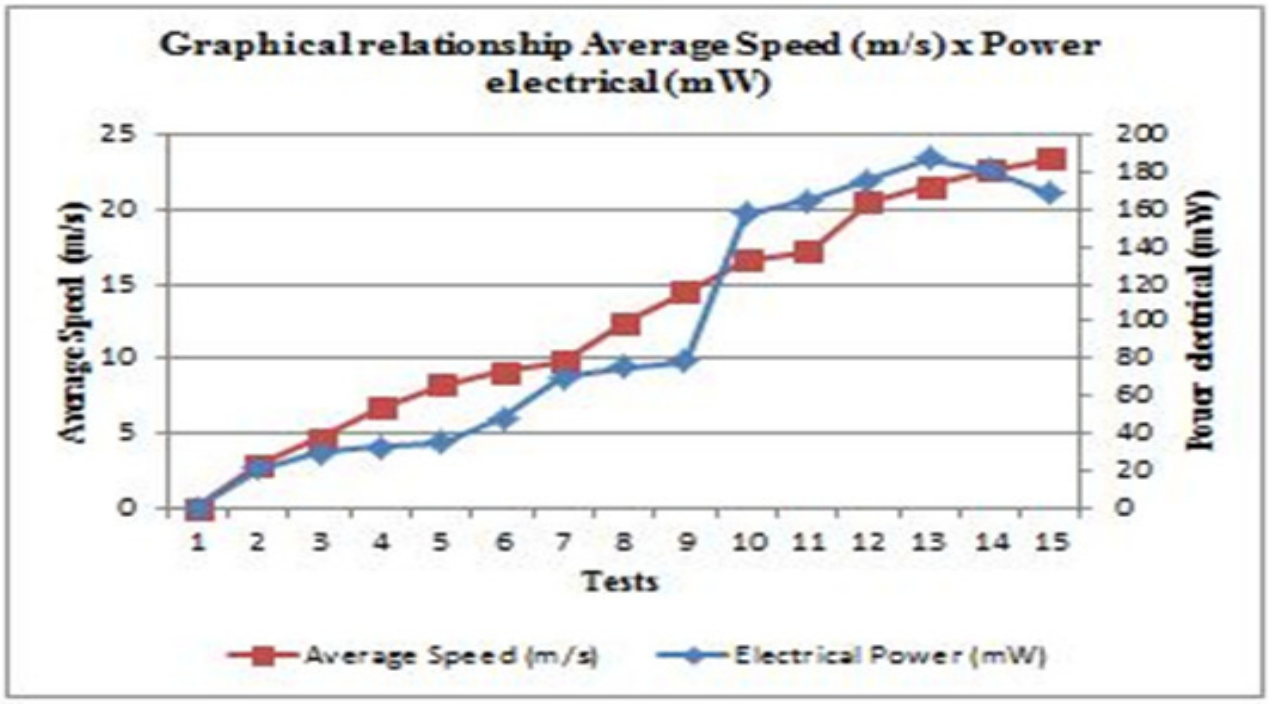

Figure 5: Speed X Power Graphic

4. CONCLUSIONS

The experimental work showed that a flow of turbulent air can generate, through the direct piezoelectric effect, clean energy and sufficient power to be used as an alternative source of energy.

5. ACKNOWLEDGEMENTS

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