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Effect of eccentric mass on rotor dynamics as a source of harvesting energy vibration

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Abstract: This research focuses on the potential for vibration energy from the use of eccentric masses in dynamic rotors to become an electrical energy source. Prior studies on eccentric mass in dynamic rotors were primarily concerned with examining the rotor's vibrational characteristics; however, little research was done on converting vibrational energy into electrical energy. The purpose of this study is to ascertain the maximum amount of electrical energy that can be produced by dynamic rotor vibrations using an eccentric mass. Utilizing an electromagnetic energy harvester, an experimental study is the methodology used. With a rotor rotation speed of 450 rpm, the eccentric mass variations used are 6.5 grams, 8.5 grams, and 10.5 grams. Matlab is used in this research to process data. The highest energy, using an eccentric mass of 8.5 grams, was found to be 24.15 mV. Nevertheless, this study shows that while the eccentric mass has an impact on the amplitude, it has no effect on the voltage. In order to increase and improve the efficiency of the electrical energy produced, further research on the utilization of vibration energy from dynamic rotors can be guided by the findings of this study.

Keywords: Vibration; electrical energy; eccentric mass; rotor dynamic; voltage

1. INTRODUCTION

The process of gathering vibrational energy and converting it into electrical energy is known as "harvesting vibration energy" or "harvesting energy from vibrations." This harvester cannot be used directly because it generates very little electrical energy. Usually, the energy generated is first stored in a battery or other type of storage [1].

Vibrational energy harvesting is an intriguing and potentially useful technique for producing alternative energy. There are numerous vibrations that can occur; engine vibration is one of them. Certain tools or machines can cause mild, medium, or strong vibrations depending on the usage and circumstances. Energy can be harvested because of these vibrations, which stand for untapped energy. One of the most common forms of energy is mechanical vibration, or kinetic energy. This energy can be obtained from the environment through the operation of machinery, buildings, air and land transportation, and even from movements produced by the human body. It can also be converted into electrical energy through the use of a transduction system. appropriate electromechanical [2].

The qualities of the vibration source to be used have a major impact on how well vibration energy is harvested. the kind of transduction mechanism employed as well as the connection between the transducer and the mechanical system. The test frame has a mass fastened to it to produce vibrations. Electrical energy can be produced by movement (kinetic energy) of a transducer (piezoelectric, electromagnetic, etc.). Certain harvesters have been developed as resonant devices, depending on the source of vibration [3].

The dynamic rotor is the only vibration source that can be utilized to harvest energy. According to research [4], kinetic energy can be captured by developing a rotating energy microelectro mechanical system (MEMS) with guard electrodes on an eccentric rotor and a fan-shaped harvester. Vibration drive systems are designed to produce and induce vibrations based on research [5] Accelerometer and oscilloscope measurements are used to determine the acceleration of vibration motion.

Mercu Buana University has conducted numerous vibration-related research and testing projects, including vibration analysis on motorcycles [6] [7], FRF testing to detect taper bearing damage, and harmonic signals from cellphones that act as the excitation force [8]. Gear crack damage can be identified using the FRF method [9]. utilizing the FRF method to compare the engine and bearing properties of two-cylinder blocks in order to assess system sensitivity and make design modifications [10]. Tapered bearings cause higher vibration amplitudes than ball bearings [11]. FRF testing [12] and Sigra disc brake testing [13] can be used to ascertain the dynamic properties of a single-cylinder diesel engine. These tests can also yield information on the global and local vibration modes of the engine. Aside from that, you can use the bump test method [14]. To determine whether the Sigra disc brake has been damaged. The vibration method can be used to predict end mill damage on CNC machines during the production process [15]. The results of vibration testing on industrial machinery, which is used to identify the source of vibration that damages the screw compressor, indicate that the screw shaft has been damaged as a result of unbalance [16]. In the meantime, vibration testing using the Hilbert Transform method is used to predict damage in electronics testing of vehicle actuators. The FRF method is a useful tool for structure prediction. which is capable of identifying structural damage, fractures, and dynamic properties [17].

It is still uncommon to conduct research on how an eccentric mass affects a dynamic rotor's ability to harvest energy from vibrations, and a device is required to capture the vibrations before they are transformed into electrical energy. Consequently, this research will provide a more thorough explanation of the vibrational studies on the impact of eccentric masses on dynamic rotors as a source for electrical energy harvesting.

2. METHOD

To get successful research study outcomes, a research plan must be created. An experimental investigation was conducted for this research project. There are two methods for gathering data: harvesting energy vibration data with an oscilloscope and collecting vibration data with an FFT Analyzer. Matlab will be used to handle the test data before examining the current voltage resulting from the eccentric mass's effect on the dynamic rotor, as illustrated in Figure 1.

The steps of gathering vibration data and harvesting vibration energy are depicted in Figure 1, where the accelerometer sensor is mounted on the dynamic rotor frame. To find the size of the vibrations created, the accelerometer sensor is connected to an FFT analyzer, which is followed by an analysis using Matlab. The same procedure is applied to a vibration device that harvests energy, and the voltage that results is monitored with a handheld oscilloscope and examined with Matlab. 450 rpm is the stated rotational speed of the dynamic rotor. Eccentric mass variations of 6.5 grams, 8.5 grams, and 10.5 grams were used in this investigation. After that, the test results are processed and examined by contrasting the outcomes.

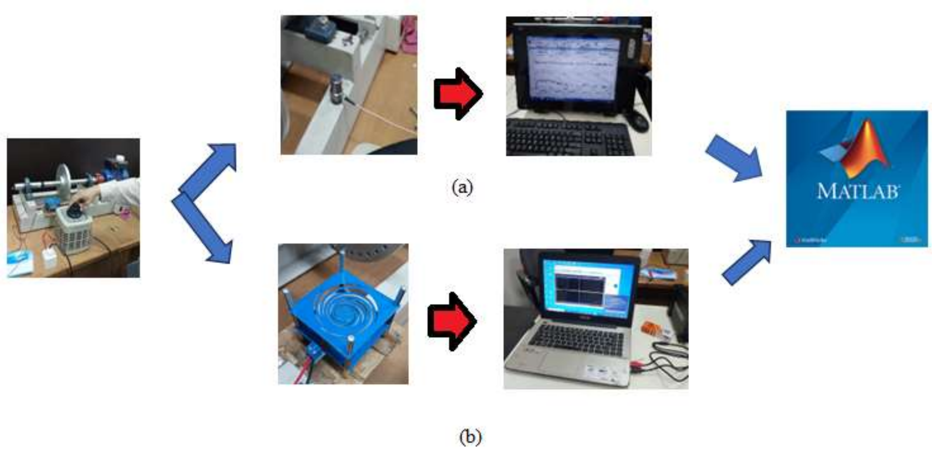

Figure 1. Illustrates the steps involved in gathering data: (a) measuring vibration sources experimentally; (b) gathering data to harvest vibration energy

An electromagnetic gadget is used to collect vibration energy. This tool's mechanism involves the vibration energy harvesting device receiving vibrations from a dynamic rotor that uses an eccentric mass. The vibrations cause the tool's spring plate and magnet to move up and down. The copper coil at the bottom of the magnet is subjected to this up-and-down motion, which changes the magnetic flux within the coil and generates a current output.

The procedure for gathering data to quantify the vibrations generated by a dynamic rotor that makes use of eccentric mass fluctuations is shown in Figure 1 (a). A FFT Analyzer and an accelerometer sensor are used to gather the data. The purpose of gathering this data was to calculate the amplitude's magnitude resulting from fluctuations in the eccentric mass that was employed. Matlab R2020a software is then used to process the vibration data outputs. The procedure for gathering vibration energy harvesting data is shown in Figure 1 (b). The purpose of gathering this data is to ascertain the voltage current generated by the vibration energy harvester. The two sets of data were gathered at the same time.

A vibration energy harvesting device is depicted in Figure 2, and the components utilized in the vibration energy harvesting device in this research study are listed in Table *1*.

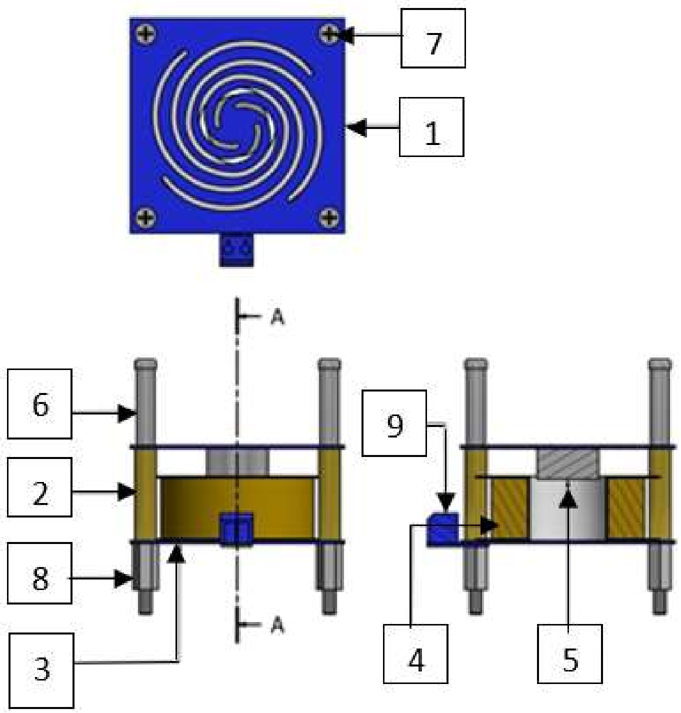

Figure 2. Vibration energy harvesting device

Table 1. Components of vibration energy harvesting equipment.

PART LIST		
ITEM	**QTY**	**PART NUMBER**
1	1	*Spring Plate*
2	4	*Spacer 1*
3	1	*Plate*
4	1	*Coil*
5	1	*Magnet N55*
6	4	*Spacer 2*
7	4	Bolt
8	4	Nut
9	1	*Circuit Board*

Figure 2 shows the spring plate component, also known as the spring, which is used to collect vibration energy from the dynamic rotor and deflect it later. The distance between plates can be widened with spacers. The N55 type magnet, which is composed of neodium, iron, and boron, is the one that is utilized. This magnet's strong magnetic field makes it a popular choice for energy production in generators. Then, as a result of vibrations that cause the spring plate to deflect, this magnet will travel up and down through the coil. An electric current is created by the coil's interaction with the magnetic field, and this current passes through the circuit board. This tool's various components are connected by bolts and nuts.

3. RESULTS AND DISCUSSION

In the study, a portable oscilloscope and an FFT analyzer were set up for testing. Flexible rotor The FFT Analyzer has 4096 data collection points with a frequency range of 1 to 10 kHz. Eccentric mass variations of 6.5 grams, 8.5 grams, and 10.5 grams are provided by the dynamic rotor rotation speed, which is given at 450 rpm. The FFT results of a dynamic rotor with a 6.5 gram eccentric mass are displayed in Figure 3. The fact that the average amplitude (RMS) is less than 1 mm/s^2 indicates how tiny the vibrations generated at the vibration source are.

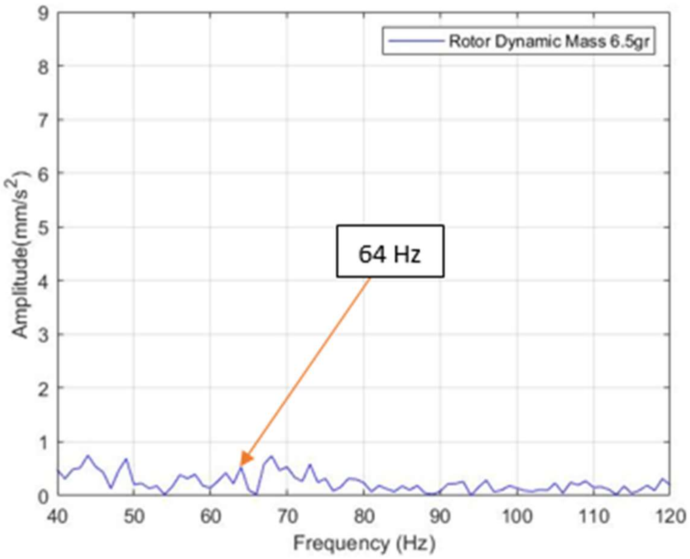

Figure 3. FFT results with an eccentric mass of 6.5 grams.

With an eccentric mass of 6.5 grams, we can determine the amplitude from dynamic rotor testing using Figure 3. The MATLAB software was then used to analyze the energy harvesting data results. The image above displays the energy harvested from the oscilloscope using an eccentric mass of 6.5 grams.

Figure 4 according to the above graph, the energy harvester's voltage results in a voltage of 21.16 mV at a frequency of 64 Hz.

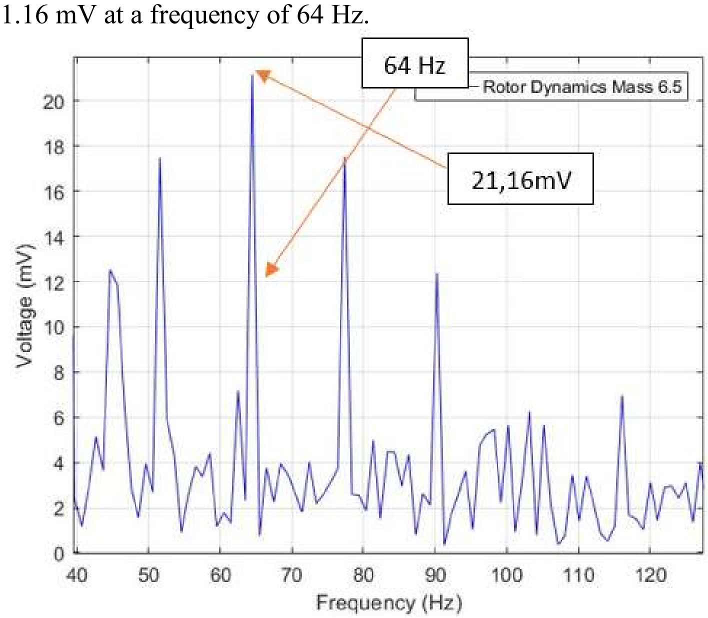

Figure 4. Energy harvesting results with an eccentric mass of 6.5 grams

Using the same technique and rotational speed, eccentric masses weighing 8.5 grams and 10.5 grams were also tested. The purpose of including the eccentric mass's weight is to ascertain how the eccentric mass affects the vibration energy harvested. The test results with an eccentric mass of 8.5 grams are shown in Figure 5 and Figure 6. Additionally, the outcomes of tests with an eccentric mass of 10.5 grams are shown in Figure 7 and Figure 8.

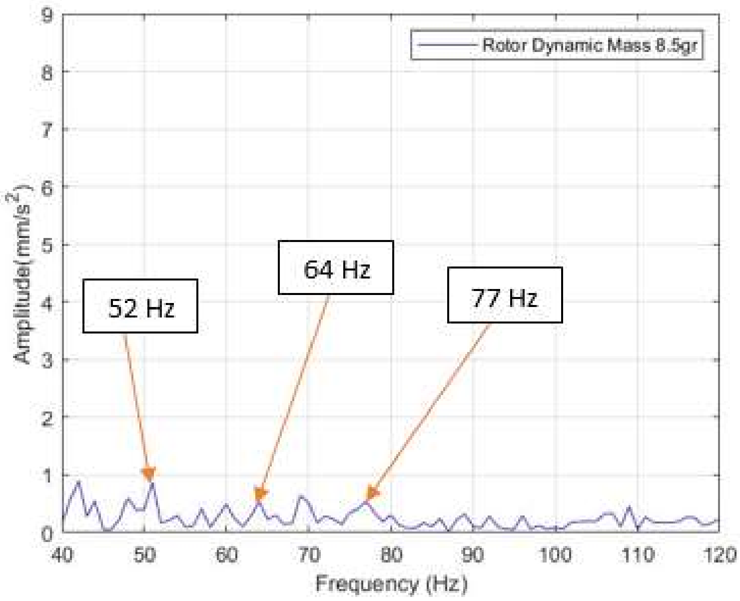

Figure 5. FFT results with an eccentric mass of 8.5 grams

The amplitude obtained with an eccentric mass of 8.5 grams is shown in Figure 5. Three points in Figure 6 represent the highest voltage current obtained at frequencies of 52 Hz, 64 Hz, and 77 Hz. At a frequency of 64 Hz, the highest voltage current obtained is 24.15 mV.

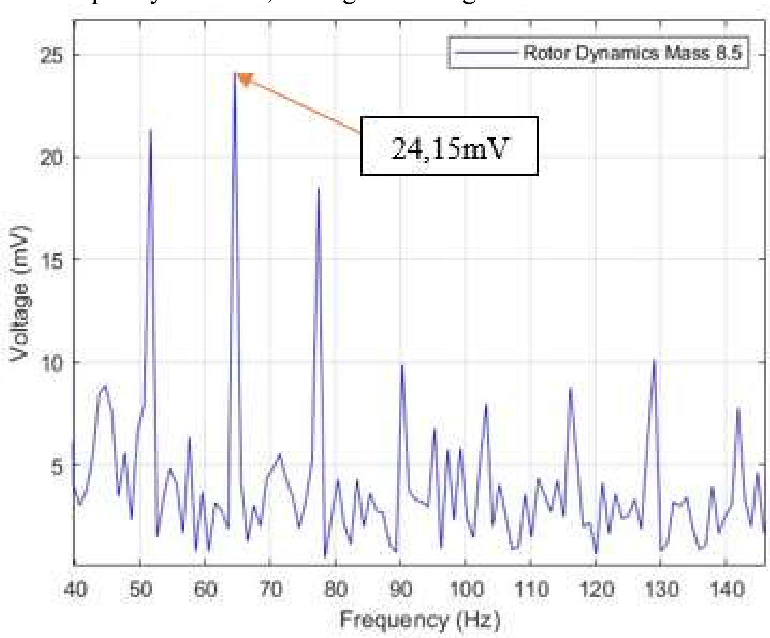

Figure 6. Energy harvesting results with an eccentric mass of 8.5 grams

Figure 7 indicates the existence of a shape mode. The vibration pattern that takes place is connected to the shape mode. There are two different shape modes in Figure 7. This shape mode can be seen at 42 Hz and 68 Hz frequencies. The first shape mode's amplitude value increases with increasing eccentric mass.

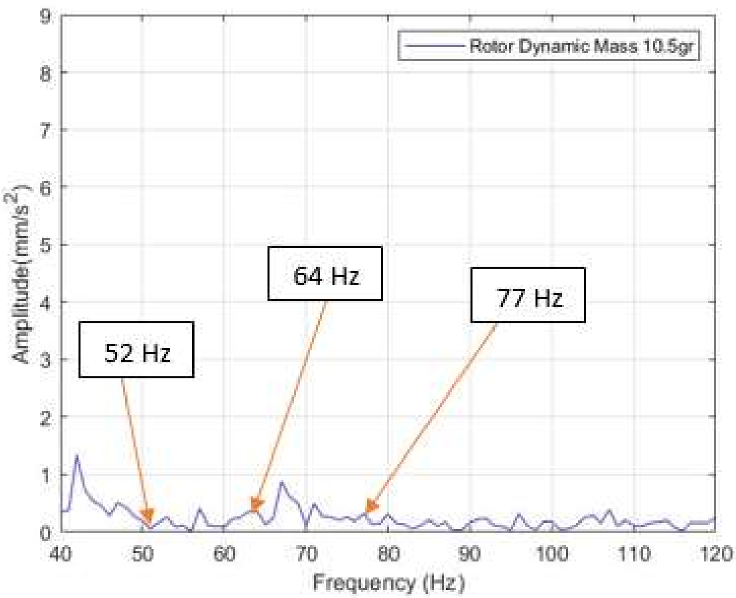

Figure 7. FFT results with an eccentric mass of 10.5 grams

The oscilloscope's data processing results are displayed in Figure 8, where three of the highest voltage current points are obtained, with frequencies of 52 Hz, 64 Hz, and 77 Hz. where a voltage of 19.07 mV is generated at a frequency of 64 Hz.

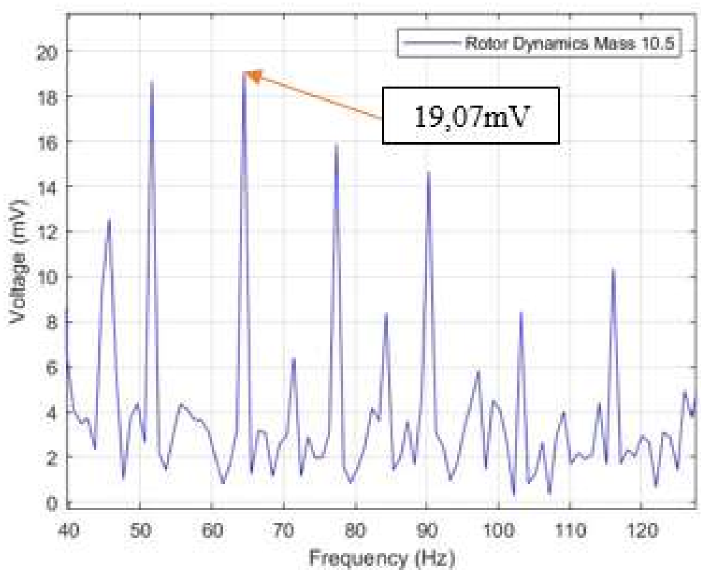

Figure 8. Energy harvesting results with an eccentric mass of 10.5 grams

This research indicates that the use of eccentric mass is the primary cause of vibration in this dynamic rotor. It goes without saying that using a heavier eccentric mass causes the dynamic rotor to vibrate more. The graph of the FFT Analyzer test results from different variations of the eccentric mass used illustrates the magnitude of the resulting amplitude and, in turn, the magnitude of this vibration. An eccentric mass rotor may experience imbalance or unbalancing in a dynamic rotor system, leading to vibration.

It is evident from the study findings of the three eccentric masses employed in this experiment that some frequencies generate significant amounts of electrical energy. For example, the frequencies

52Hz, 65Hz, and 77Hz, when combined with an eccentric mass of 8.5 grams, yield the maximum energy at 24.15mV. The use of a heavier eccentric mass affects the magnitude of the resulting amplitude but not the amount of energy produced, since the average high energy produced is at a frequency where the amplitude (RMS) is below 1 mm/s^2.

3 CONCLUSION

Based on this research, vibration energy sources and electrical energy harvesting devices can be used to use vibration energy as a source of electrical energy. The results of the research indicate that although dynamic rotors using eccentric masses can generate electrical energy, doing so would not be a practical way to use the energy. The dynamic rotor's eccentric mass also doesn't affect the amount of energy generated, but it does seem to have a significant impact on the size of the amplitude that results. With an eccentric mass of 8.5 gr, the maximum energy that can be generated is 24.15 mV. In order to maximize and maximize the amount of energy produced, vibration energy harvesting needs to be redeveloped.

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