Design analysis of vibrational input to torque energy system

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Abstract. The development of digital technology in the Industrial Age 4.0 focuses on the application of the Internet of Things (IoT), Virtual Reality (VR) and Augmented Reality (AR). IoT as one of the main topics for technological advancement, which is useful for improving information and communication that is developing in the fields of manufacturing, infrastructure, business, economy etc. The development in the field of material technology can make small materials where the energy requirement to generate a device only requires a millivolt range of power, so by using energy from the surrounding environment which is converted into electrical energy, a device design for energy harvesting is required. The purpose of this research is to design a device that is sourced from various vibrations and converted into electrical energy. The concept of designing a vibration conversion mechanism into electric energy is by combining and optimizing the design of several existing tools (technologies). This research was tested experimentally by utilizing braking force. Tests are carried out using a data logger for further processing. From the results of the braking test, it is able to produce a maximum voltage of 0.9 V with a braking force of 34.72 N.

1. Introduction
Industrial Era 4.0 digital technology focuses on the application of the Internet of Things (IoT), Virtual Reality (VR) and Augmented Reality (AR). IoT as one of the main topics for technological advancement, which is useful for improving information and communication that is developing in manufacturing, infrastructure, business, economy etc. [1-2]. In the field of technology, especially electronics, many use small materials, so the energy required is also small [3-5].

Energy is an important part that is used in everyday life. Energy in an effort to achieve survival, it needs to be used properly [6-7]. The energy that is often used today is electrical energy. Electrical energy is still very dependent on fossil fuels as the main energy. Fossil fuels will decrease over time, so it is necessary to reduce dependence and develop renewable energy. Energy Harvesting in the utilization of electrical energy is still a lot that can be utilized, therefore it is necessary to develop research on energy harvesting [6-8]. The basic principle of energy harvesting is converting energy from the surrounding environment which is converted into electrical energy.

A motion receiver transmission which is able to direct the translational motion back and forth into a unidirectional rotation is applied for energy harvesting in vehicle shock absorbers [9]. Rectification of the movement of the transmission before entering the generator is useful to avoid inertia losses and reduce fluctuations during electric discharge [10]. Utilization of the
ratcheting wheel which is commonly used in clock mechanisms as energy harvesting on the pendulum [11].

Research on mathematical modeling and experimental validation of the new energy WITT (Whatever Input to Torsion Transfer) design is able to maximize the energy obtained from the waves, because the force to rotate the generator is independent [12-14]. This mechanism consists of a pendulum connected to the gearbox and the movement of the pendulum is transferred to the output by rotating the direction of CW or CCW. WITT is currently used to convert ocean wave energy into electrical energy.

![Figure 1: Prototype of energy WITT design and Free body diagram of energy WITT](image)

The energy WITT design utilizes a pendulum as the main mover that can rotate 360°. The resulting rotation averaged 188 KW and had a power factor (Cos Phi average 0.59). Utilizing the WITT Energi mechanism is able to maximize the energy obtained from the waves, because the force to rotate the generator is independent. The results of this study, the maximum limit for getting the optimum power is in the range of 5-11 seconds [14].

Research on SEAREV technology where the pendulum is the main component for generating electricity. The pendulum design in this study is equipped with a piston capable of producing electrical energy [15]. SEAREV Wave Energy Converter (WEC) is a technology for generating electrical energy from waves of sea water. This technology was first introduced in 2002 with the aim of overcoming critical challenges in the energy conversion of sea waves. This technology consists of a closed cover and inside it consists of a pendulum which moves by oscillation. The relative motion of the pendulum is used to drive the generator so that it can generate electricity. SEAREV development, becoming an innovative technology that can compete in alternative markets in the context of sea wave energy [15-16]

![Figure 2: SEAREV working principle and (b) Free Body diagram SEAREV](image)

Research on SEAREV technology where pendulum is the main component for generating electricity. The results of this research can be seen that generation after generation is increasing,
just as from the 1st generation to the 3rd generation the production of this SEAREV technology can increase by 90%. The pendulum design in this study is equipped with a piston capable of producing electrical energy.

The concept of energy harvesting using a ball screw mechanism and two rectifier couplings which are used to replace the fluid damper in the vehicle suspension. Utilization of vibrations from the reciprocating suspension is converted to a mechanical motion rectifier which can convert the reciprocating motion into unidirectional motion. The shock absorber can achieve high efficiency, because the generator can rotate at a relatively stable speed. The shock absorber can be significantly reduced due to the use of a ball screw mechanism, which further improves durability and transmission efficiency [7].

2. Research Metodology
VITES technology is a tool for transferring braking forces into electrical energy. Generally the concept Vites pendulum motion system using the X, Y and Z movement on the pendulum will be rectified so that the lap enters the generator rotates only one either CW or CCW direction on the X axis.

This research was carried out by experimental method. Data logger is used to read input signal. Braking force of electric car were used to generate voltage at this research were 30.25 N, 32.45 N and 34.72 N. Each experiment repeated 3 times and.

3. Result and Discussion
The results of the VITES test on braking, which are used as energy harvesting, are performed by braking tests on electric cars.

Figure 5 shows that voltage generated is still quite low. Maximum voltage generated without flywheel is 0.7153 V with an average of 0.072141 V and maximum voltage generated using flywheel is 0.6839 V with an average of 0.07202 V. This small value is caused by the force that applied on the system is still not large, so the value obtained is too small .

Figure 5 shows that voltage generated is still quite low. Maximum voltage generated without flywheel is 0.7655 V with an average of 0.072572 V. and maximum voltage generated using
**Figure 4:** Concept of VITES

**Figure 5:** Voltage at force \( F = 30.25 \, \text{N} \) without flywheel and with flywheel

**Figure 6:** Voltage at force \( F = 32.45 \, \text{N} \) without flywheel and right side, with flywheel
flywheel is 0.8784 V with an average of 0.070763 V. This small value was caused by the force that applied on the system is still not large, so the value obtained is too small.

Figure 7: Voltage at force (F) = 34.72 N without flywheel and right side, with flywheel

Figure 10 shows that the voltage result is sufficient to meet the minimum value for increasing voltage, with a minimum limit of 0.9 V. Maximum voltage generated without flywheel is 0.9788 V with an average of 0.085419 V and maximum voltage generated using flywheel is 0.8973 V with an average of 0.1098779 V. Testing using the flywheel for the average is relatively higher than without using a flywheel, but in this variation the force is required to turn the generator is still not large enough, so the minimum voltage has not been reached.

4. Conclusion
Voltage generated could be increased by adding flywheel on VITES system. This VITES design is effective for the 34.72 N force which produces 0.8973 V with an average 0.1098779 V. Further development of this system could be carried out by applying a continuous force such as the ocean wave force.

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