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Design a Concept of Electrical Energy Regeneration from Conventional Lathe Based on Workload Analysis

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Abstract

To reduce excessive power consumption, this study developed a conceptual design for power generation based on the movement of the machine motor during machining processes. The objective of this study is to develop the concept design of energy recovery from conventional lathes while determining the effects of conventional lathe load through five basic machining activities. The researcher conducted the study methodically by creating the conceptual design by the phases defined in the research methodology, which refers to the Analysis Process Model to achieve the objective of this study. According to the study conducted, electricity can be generated with the right calculation technique and equipment, including generators, solar inverters, and batteries. In conclusion, the objectives have been achieved in creating the design concept for power generation from conventional lathes under the influence of machining load.

1. Introduction

According to Jeffrey et al., (2004), machining is a material removal process that usually involves cutting metal with various cutting tools. It is a very useful process due to its high dimensional accuracy, process flexibility, and cost-effectiveness in producing small quantities of parts. Machining is unique in the variety of manufacturing processes because it can be used to create a product that has excellent finishes. However, because a machine is a process that removes material, it can be wasteful in terms of material and electrical energy consumption.

Based on a report from REN21 (Renewable Energy Policy Network for the 21st Century), renewable energy can contribute as much as 24.5% in electricity generation in 2015 and 2016. Based on the above data, the concept of energy regeneration can help users in terms of saving electricity costs from the occurrence of excessive wastage of electricity which can hurt the environment. The content of this study is to explain the combination of the analysis of the operating load of conventional lathe machining and the development of a concept of electricity regeneration using appropriate methods to optimize the use of electricity in a machining workshop at an educational institution.

1.1 Problem Statement

The use of conventional lathes has been widely used in the manufacturing field regardless of whether it is a large-scale or small-scale industry. To operate this lathe requires a machining workload for each machining operation. Machining operating loads are often associated with high-value electrical energy consumption. The use of electricity is necessary to move equipment or machines so that they can operate well and help users carry out manufacturing work using conventional lathes. Mechanical education institutions also need a lot of electricity to launch the teaching and learning process continuously. However, the excessive use of electricity has a bad effect on the ecosystem and can cause a lot of waste in terms of the cost of paying for electricity and its maintenance. In addition, the electricity used by conventional lathes is only used directly and cannot be reused, further contributing to excess waste to educational institutions. The implications of this problem can cause the educational institutions involved to suffer a lot of losses and not have excess allocations to improve the infrastructure of the machining workshop.

1.2 Objective

There are two objectives in the study. The objective of this study is to cover aspects such as:

1. Identifying the influence of the machining load of a conventional lathe through five basics machine operations, namely face turning, side turning, grooving, knurling, and threading.

2. Designing a concept of electrical energy regeneration from a conventional lathe based on workload analysis.

2. Methodology

The research methodology aims to discuss the development of the product concept that will be carried out and is a part that focuses on the development of a good and orderly concept. In addition, the methodology can also be used as planning in the development of concept design according to the design chosen by the researcher so that the objectives and goals of this product concept development can be systematically achieved.

2.1 Research Design

Research design is a method that will be used as a plan to carry out concept development. It includes methods and procedures for collecting and analyzing data and the development of conceptual designs. Thus, the researcher has chosen an analysis process model for the development of the concept of electricity regeneration products against the analysis of the machining load of conventional lathes. This model consists of five main phases namely:

i. Problem identification and determination.
ii. Experimental procedure design.
iii. Experiment and data collection.
iv. Analysis of experimental data.
v. Problem solution proposal.

Therefore, the researcher needs to follow each of these phases so that the development of the concept can be completed and achieve the objectives and goals of the study.

2.2 Research Procedure

2.2.1 Identifying and Defining the Problem Phase

The instrument used during this phase is the researcher using field notes, where the researcher has evaluated the use of electricity from conventional lathes that are used frequently but cannot be recycled or regenerated which can have a bad impact on educational institutions and the environment such as payment of excessive electricity costs and greenhouse gas emissions. According to studies, as much as 68% of energy generation Today's electricity depends on fuel combustion type generation which produces smoke and results in negative effects in the long-term length to the country's ecosystem (Mohd Nor Naim, 2017).

2.2.2 Designing Experimental Procedures Phase

This experimental design was developed to obtain an analysis of the influence of the machining load imposed on a conventional lathe during the material cutting operation carried out through the rotation of the lathe motor. The following is the experimental procedure that has been developed by the researcher, which is to choose the location, determine the type of machine, determine the testing parameters, prepare the experimental sheet, test and analyze the data, and finally propose the concept design.

2.2.3 Conducting Experiments and Collecting Data Phase

This experimental process will be performed six times on the same parameters and operations to obtain accurate data. The experiment that will be done is on the speed of the motor during the machining process using the RPM sensor or digital tachometer.

2.2.4 Experimental Data Analysis Phase

From the data collected during the phase of conducting the experiment and collecting data, the researcher will analyze the test data using the average calculation from the motor rotation of the machining operation obtained. All the analysis made is important to be used as a reference source for selecting the type and size of alternator and battery to develop a concept of electricity regeneration in the final phase.

2.2.5 Proposed Solution Phase

The researcher developed a product concept for the regeneration of electricity using the understanding obtained from reading sources and concepts found in the system of electricity generation in cars and solar where this system uses an alternator device and a solar controller inverter as the main source of electricity charge generation.

2.3 Research Instrument

In this study, the research instruments chosen by the researcher are divided into three methods, namely instruments through experiment. This testing needs to be studied in the machining workshop to take machine load data from the selected type of lathe. There are several main parameters set by the researcher to test the research hypothesis and ensure that the readings taken are accurate. To perform this analysis or testing, the researcher needs to use appropriate and calibrated equipment. This test will be run six times for each machining operation to obtain an average score for the selected machining operation load. In this instrument, the researcher uses a digital tachometer to read the reading of the motor movement during the test. in addition, the researcher also used a lathe conventional machine to carry out the selected machining operation, which is idle, facing, turning, knurling, and threading.

3. Results and Discussion

Data analysis is the phase of analyzing the rate of rotation of the motor affected by the machining load and analysis of the appropriate design to develop the concept of electricity generation suitable for the use of hand tools in the machining workshop from the rotation of the conventional lathe motor. The analysis phase is made through the data collected during the experimental process carried out to achieve the objectives of the study.

3.1 Motor Rotation Rate Analysis

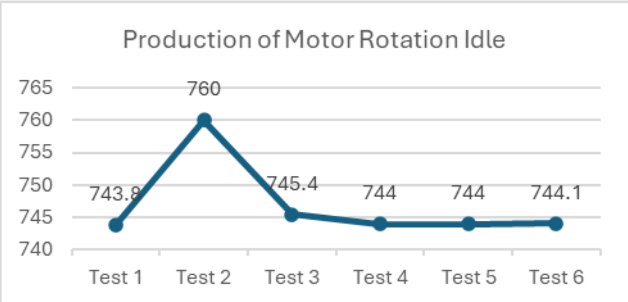

Fig.1 *Production of motor rotation (Idle)*

From Fig. 1, several load-influencing factors cause differences in the motor rotation value resulting from idle operation. The average reading for this operation is 746.88 RPM. (1)

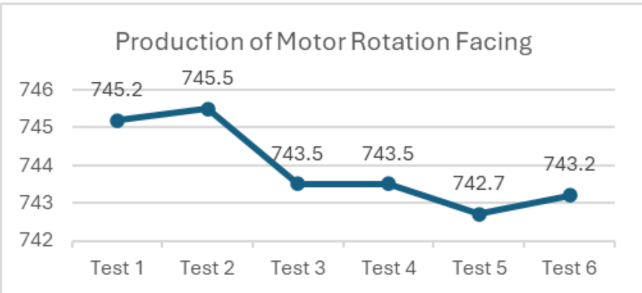

Fig. 2 *Production of motor rotation (Facing)*

According to Fig. 2, rotation readings are not static. There is a reading difference between all the tests which is in the range of 742.7 - 745.5 RPM. The average reading for this operation is 743.93 RPM.

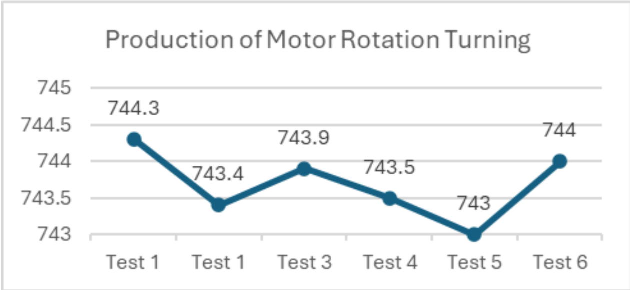

Fig. 3 *Production of motor rotation (Turning)*

From Fig. 3, The sixth test of rotation rate is increased due to the factor of the finishing process during operation where the influence of load or feed rate is getting lower. The average reading for this operation is 743.68 RPM.

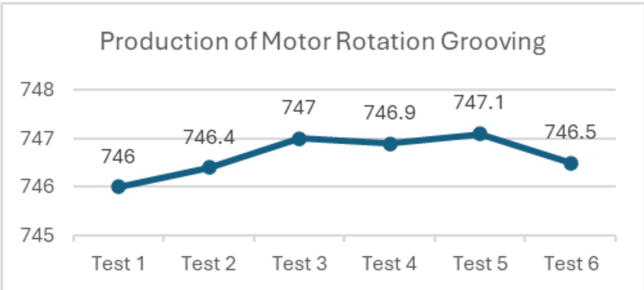

Fig. 4 *Production of motor rotation (Grooving)*

According to Fig. 4, In the last test, the rotation rate experienced a slight decrease. This is because there is an increase in temperature that affects the machine load after the lathe has been used for five hours. The average reading for this operation is 746.65 RPM.

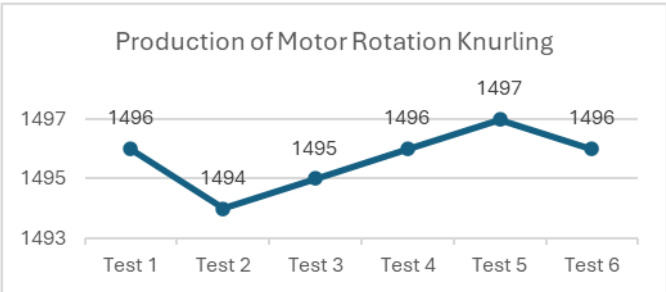

Fig. 5 *Production of motor rotation (Knurling)*

From Fig. 5, the second test of the motor rotation data experienced a slight decrease due to the factor of the workpiece having a hard surface and forcing the lathe motor to work with more force. The average reading for this operation is 1495.67 RPM.

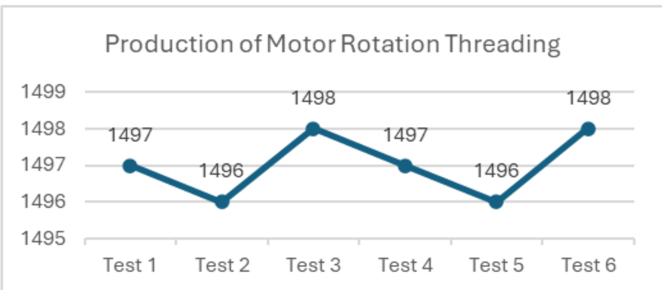

Fig. 6 *Production of motor rotation (Threading)*

According to Fig. 6, motor rotation reading value data is unstable and consistent. This is because there is an influence of machining load such as increased temperature, wear and tear of tool points, wear and tear, and hardness of the work material. The average reading for this operation is 1497 RPM.

3.2 Concept Design of Power Generation from Motor Rotation

The design of the energy generation concept includes the calculation of the rate of current released from the rotation of the motor after connecting the alternator device as well as the development of the circuit design.

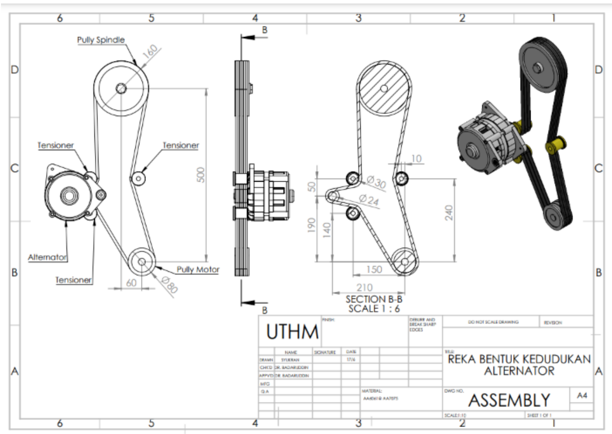

Fig. 7 *Alternator position design drawing*

According to Fig. 7, the size of the alternator pulley was chosen to be 40 mm in diameter to make the alternator rotation rate reach a ratio of 1:2. In addition, the researcher has added three tensioning devices with a diameter of 30 mm to ensure that the installed belt has a safe tension and can work properly. The researcher also emphasized the friction rate between the pulley and the belt. This is because, when the area of friction is wide, then the force applied to each pulley will increase.

Table 1 *Current reading produced from 12v 100amp alternator*

Motor speed		500rpm	750rpm	1000rpm	1250rpm	1500rpm
Pulley ratio		1:2	1:2	1:2	1:2	1:2
Alternator speed		1000rpm	1500rpm	2000rpm	2500rpm	3000rpm
The current produced	Hot	0	50amp	70amp	80amp	93amp
	Cold	0	51amp	83amp	100amp	106amp

From Table 1, the researcher can calculate the amount of output produced from the rotation of the motor that has been analyzed through the average calculation of each machining operation. From the average rotation motor at first to fourth sample operation (Idle, facing, turning, and grooving) which is 745RPM, the energy current that can be generated by the alternator is around 51amp when cold and 50amp when hot. Whereas, for the operation at the fifth and sixth samples (Knurling and threading) which is 1497RPM, the energy current that can be produced is around 106amp when cold and 93amp when hot.

Table 2 *Power value and charging duration of the selected battery.*
Source: Mohd Nor Naim, (2017)

Battery Capacity (mAh) x Battery Voltage Value (V) = Battery Power Value (Watt) **100000mAh x 12V = 1200Watt** Battery Power Value for Four Batteries = 1200Watt x 4 batteries **= 4800 Watt**
Capacity of Four Batteries (mAh) / (Value of Charger Current Value (Amp) = Duration of Charging Time (Hours) **400000mAh / 50Amp = 8hours**

According to Table 2, the battery power value for four batteries is 4800Watt per hour. This total value is suitable for use in hand tools such as hand drills, hand grinders and vacuums that have an energy load of around 1100Watt to 1500Watt. The duration of the clock to charge the battery size 100000mAh x 4 is 8 hours. This period is compatible with the daily use of the machining workshop which is 8 hours from 9 am to 5 pm.

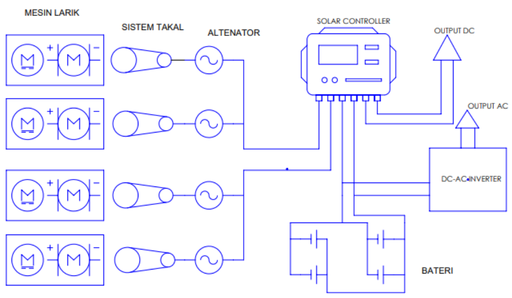

Fig. 8 *Design a power generation circuit from a conventional lathe*

Guided by Fig. 8, a power generation circuit design is shown which will be used for this concept. Through this design, the researcher developed a test analysis found through Microsoft Excel software. The researcher can estimate the amount of energy generated and the functionality of the circuit design for the development of the concept through the development of the table of analysis findings.

Table 3 *The results of the analysis of the energy produced*

Num. Machine	Operation	Total motor speed	Total alternator speed	current produced	Power produced	Charging current from solar controller	Output voltage	total battery power	Charging period
Machine 1	idle facing turning grooving	750	1500	Hot: 50Amp Cold: 51Amp	Hot: 869Watt	50Amp	AC 220V	4800Watt	8 Hours
	knurling threading	1500	3000	Hot: 93Amp Cold: 106Amp	Cold: 936Watt				
Machine 2	idle facing turning grooving	750	1500	Hot: 50Amp Cold: 51Amp	Hot: 869Watt				
	knurling threading	1500	3000	Hot: 93Amp Cold: 106Amp	Cold: 936Watt				
Machine 3	idle facing turning grooving	750	1500	Hot: 50Amp Cold: 51Amp	Hot: 869Watt				
	knurling threading	1500	3000	Hot: 93Amp Cold: 106Amp	Cold: 936Watt				
Machine 4	idle facing turning grooving	750	1500	Hot: 50Amp Cold: 51Amp	Hot: 869Watt				
	knurling threading	1500	3000	Hot: 93Amp Cold: 106Amp	Cold: 936Watt				

3.3. Discussion

This topic discusses the results of the entire study that has been analyzed. Among those discussed is related to the machining load analysis for the development of the power generation concept design from conventional lathes.

3.3.1 Influence of Conventional Lathe Machining Load

To analyze the data to achieve this objective, the researcher carried out an experimental phase on the rotation of the lathe motor pulley using a device that is a tachometer. As for the speed of the spindle set according to the operation carried out, the researcher has set the spindle speed for idle operation, face turning, and side turning is around 1000RPM. Whereas, for the operation of grooving, knurling, and threading, different spindle speeds of 430RPM, 220RPM, and 30RPM are used. This is because, according to Arthur et al., (2020), this cutting speed has been set by the manufacturer of cutting tool points and metal as the best for the production and lifespan of cutting tools. In addition, the feed rate for each operation has also been set based on the information the researcher has obtained. According to Arthur et al., (2020) for rough-type cutting the user is recommended to set a feed rate of 0.25mm to 0.4mm while for neat-type cutting it is recommended to set a feed rate of around 0.07mm to 0.25mm. It is suitable for the work material and tool point of mild steel and high-speed steel cylinders used in the experiment.

Some errors occur where the researcher found that the selected lathe has a wear and tear effect where when the motor of the lathe is hot, it will produce a slight vibration on the motor which will affect the rotation rate of the motor. In addition, the researcher found that a feed rate that cannot be set accurately can also cause the rotation reading to experience slight differences for each test. Next, the difference in the data taken is also due to the wear of the tool tip which can result in the friction force between the tool tip and the workpiece increase which can cause the motor rotation to decrease.

3.3.2 The Concept of Electrical Energy Regeneration from Conventional Lathes

In this study, the selection of concept design is highly critical because it can ensure the attainment of the desired information, which is the generation of electrical energy from the lathe machine to be stored in a containment and battery. The use of the alternator device is very suitable because the production of current from the alternator is through the pulley rotation method where the rotation of the lathe motor can be transferred to the rotation of the alternator through a pulley system and conveyor belt with a ratio of 1:2. Through literacy studies, alternators can generate AC voltage currents. However, it needs to be converted to DC before entering the battery system using the alternator rectifier that is already present in the selected alternator component. According to A. Prabhakan et al., (2021), AC Current needs to be converted to DC to charge the battery.

Because the current produced by the alternator is not stable or consistent, the researcher chooses a suitable device which is a solar controller inverter to transfer the energy produced to a storage place. According to H. Kristiawan et al., (2019), ROff grid connection is a stand-alone system, while On Grid connection is electricity generation through solar connected to the utility grid. With that, the researcher has chosen the Off Grid connection system in the developed circuit design because the developed circuit design is not connected to the utility of the grid.

The researcher has chosen to use a wet cell battery (gel) with a capacity of 100Ah with an output value of 12V where this battery is a secondary type of battery. This battery was chosen because the size and value of the output produced are suitable for hand tools in the machining workshop of an institution. According to Zhorif et al., (2019), a secondary battery is a battery that can be recharged because of its reversible chemical reaction.

4. Conclusion

In conclusion, the development of this concept design can prove that the result of the machining load and rotation of the lathe motor used can generate energy for the use of hand tools in the machining workshop of educational institutions. Analyzing the rotation of the motor on a conventional lathe against the influence of the load according to the machining operation that is set, can help the researcher ensure that the concept design that is to be developed can be carried out. The selection of devices such as alternators, solar controller inverters, and batteries used in the design of the electricity generation concept needs to be done in detail to ensure the feasibility of the concept in the future.

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