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Speed-Based Coconut Fiber Spinning Machine to Increase MSME Productivity

Sefiyuchanna [1], Mukhamad Fauzi[2], Sri Jumini[3]
[1,2,3] Physics Education Study Program, Faculty of Tarbiyah and Teacher Training, Universitas Sains Al-Qur'an, Indonesia

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ABSTRACT

The accumulation of coconut fiber waste and limited spinning technology causes the rope production process to remain slow and have low economic value for small business owners. This study aims to design a coconut fiber spinning tool based on speed control and analyze the effect of electrical power on the rope length and rotations per minute (RPM) produced. The research method uses an experimental approach with stages of tool design, assembly, testing, and performance evaluation gradually following the waterfall flow. Tests were carried out with power variations of 30 W, 35 W, 40 W, and 45 W at a constant spinning time of 60 seconds, then the RPM value and the resulting rope length were measured. The results showed a directly proportional relationship between power, RPM, and rope length. At 30 W power, the RPM was obtained at 32 with a rope length of 1.72 meters, while at 45 W power, the RPM increased to 72 and the rope length reached 2.94 meters. Increasing power increases the dynamo rotation speed and the effectiveness of the winding process, so that production capacity increases at the same time. The impact of implementing this tool can be seen in the acceleration of the production process, reduction of manual workload, and increase in productivity and income potential for MSMEs or coconut fiber processing business owners through longer and more consistent rope results.

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Corresponding Author:
Sri Jumini
Physics Education Study Program, Faculty of Tarbiyah and Teacher Training, Universitas Sains Al-Qur'an, Indonesia
srijumini@unsiq.ac.id

INTRODUCTION

The coconut tree, known by its Latin name Cocos Nucifera L., thrives in coastal and mountainous areas (Nasution et al., 2024). All parts of this plant can be used for various purposes, so it is often referred to as the tree of life (Nasution et al., 2024). As the world's largest palm oil producer, the palm oil industry has directly and indirectly provided employment to 16 million people, making it a plantation commodity that plays a strategic role in Indonesia's economic development. Coconut is a plantation commodity that is very important for Indonesia's economic development and sustainability (Saragih et al., 2020; Purba & Sipayung, 2017). Coconut, as an annual plant, has proven to be a valuable multifunctional resource for the community. From the leaves and flesh of the fruit, the trunk, to the roots, every part of the coconut provides numerous benefits that can be used in various aspects of daily life (Fadel, 2023).

Coconuts have a covering called coir. Coconut fiber is broken down to produce cocofiber (coir fiber) and cococoir (coir powder) (Ayu et al., 2021). Coir fiber is the main product of coir, and cocofiber products will produce a variety of very useful products (Nurdin & Jufri, 2021). The outermost part of the coconut fruit that wraps the shell is called coir. Coconut fiber consists of two layers: the outermost layer (exocarp) and the inner layer (endocarp), each with a thickness of 5-6 cm. The endocarp contains fine fibers that can be used as a material for making rope, sacks, pulp, carpets, brushes, doormats, heat and sound insulators, filters, car and chair seat fillers, and hardboard. One coconut produces 0.4 kilograms of coir with a fiber content of 30%. Cellulose, lignin, pyroligneous acid, gas, charcoal, tar, tannin, and potassium are the chemical components of coconut fiber (Naibaho et al., 2022). A picture of coconut fiber can be seen in Figure 1 below.

Figure 1. Coconut Fiber
Source: Ministry of Agriculture

The outermost layer of the coconut, also known as the coconut husk, is the coconut fiber. When decomposed, coconut fiber is processed into a variety of ready-to-use and semi-finished products with high sales value (Sari & Solikatun, 2020). These products include: doormats, coir rope, coir fiber (cocofiber), coir powder (cocopeat), cocopeat brick, cocomesh, cocopot, cococloth, coco fiber board (CFB), and cocoir. Coconut fiber may have little use in its raw form, but when processed and shaped, it becomes highly valuable and functional in everyday life. Therefore, in the hands of creative people, its use is worthwhile. Until now, coconut fiber has only been used as fuel. In fact, coconut fiber can be used to make various crafts, such as doormats, rope, brooms, baskets, and more.

In addition to organic waste, unused coconut fiber waste will contribute to waste accumulation due to increased coconut production. Fiber is still financially useful if studied further. After being broken down, coconut fibers produce coco fiber and coco coir, both of which are types of solid and liquid organic fertilizer. There are many useful products that can be produced from cocofiber products. such as ropes, doormats, pots (called cocopots), brooms (called cocosheets), and sheets of coconut fiber (Indahyani, 2011). The picture of the coconut fiber rope is as in Figure 1.2.

Figure 2. Coconut Fiber Rope
Source: https://rumahsabut.com/manfaat-tali-sabut-kelapa/

Unprocessed coconut fiber has limited uses. When processed technologically, coconut fiber can produce fiber (coco fiber) and powder (coco coir), both of which have the potential to become valuable and economically profitable products (Azzaki et al., 2020). The coconut fiber processing technique, also known as the coconut fiber shredder, produces three types of materials as profitable processed products. The coconut fiber shredder produces three types of materials: coconut fiber powder, short coconut fiber, and long coconut fiber. Long coconut fiber is used for brooms, while short coconut fiber can be used for flower pots and many other products (Astuti et al., 2023).

However, coconut fiber utilization faces challenges in producing quality products and production volumes remain low (Nontji et al., 2022). This is because coconut fiber production is very limited due to the still-manual coconut fiber spinning machine. Spinning is still done manually. By beating the coconut fibers, the fibers are better broken down. This process takes a considerable amount of time, allowing the product to be processed in large quantities. However, the quality is often suboptimal, such as when spinning, the yarn is still rough, the fibers are quite short, and there is still a lot of powder stuck to the fibers.

The use of coconut fiber spinning tools plays a role in addressing the problem of coconut waste while increasing the added value of processed products (Adwimurti et al., 2022). This situation contributes to improving the welfare of communities in coconut-producing areas through more optimal utilization of local resources. The use of coconut fiber as a raw material for various industrial products has been widely practiced, but the application of appropriate technology at the spinning stage is still relatively limited. Research and development is focused on designing a speed-controlled coconut fiber spinning tool that simplifies the rope-making process and produces better quality rope. The presence of this spinning tool allows for a simpler and faster production process, resulting in increased business productivity. The aim of this research is to produce an effective and efficient coconut fiber spinning tool, with a real contribution in the form of increasing the productivity of MSMEs by accelerating the production process and improving the quality of processed products.

METHODS

The research was conducted using an experimental method. Experimental research is a research approach specifically designed to test the cause-and-effect relationship between two or more variables using an analytical quantitative approach (Agustianti et al., 2022). This approach involves the deliberate manipulation of independent variables subjected to specific treatments under controlled conditions (Kusumawati, 2024). The goal is to identify the influence of the manipulated variable on other variables, while minimizing or eliminating interference from other, irrelevant factors. By controlling variables that influence research outcomes, experiments enable researchers to more clearly reveal cause-and-effect relationships and provide strong empirical evidence of the impact of specific treatments on the phenomenon being studied. The research phase begins with introduction, implementation, design, and data collection (Payadnya & Jayantika, 2018).

The introduction begins with an understanding of the theory related to the tool to be created from various reference articles and journals. In the implementation phase, researchers innovate simultaneously with the design of the coconut fiber rope spinning tool. And in the final stage, namely data collection, which uses data analysis to find the Rotations Per Minute (RPM) and the length of the rope produced with the power used during the spinning process. Data is collected using the waterfall data analysis technique or gradually and repeatedly. The relationship between the influence of differences in power variations used during the spinning process on the Rotations Per Minute (RPM) and the length of the rope produced can be seen with simple linear regression, which is based on the functional or causal relationship of one independent variable with one dependent variable.

The variations in the research variables are as follows:

a. Independent variable
   The independent variable used in this study is the power used during the spinning process.
b. Dependent variable
   The dependent variables used in this study are Rotations Per Minute (RPM) and rope length.
c. Control variables
   The control variables used in this study are the type of coconut fiber and spinning time..

RESULTS AND DISCUSSION

A coconut fiber rope spinning machine is a tool used for the process of spinning coconut fiber rope. The coconut fiber spinning machine is used to twist the processed coconut fiber into rope. This coconut fiber spinning machine produces double rope. How the coconut fiber spinning machine works is designed where the coconut fiber is inserted into the spindle through the shaft hole. When the motor power is transmitted through the belt, the spindle rotates. The coconut fiber is fed into the spindle by hand. The spindle will rotate the coconut fiber. One twist (double rope) is made by combining two twists of coconut fiber. The working principle of the coconut fiber spinning machine is to rotate and twist the coconut fiber so that it becomes one twist.

The coconut fiber spinning machine, Figure 3, whose main drive uses electricity, works automatically without requiring fuel to move it. This machine only relies on electricity, so it cannot be used in places without electricity. Electric motors can be found in generators or dynamos. Generators can also be used to convert mechanical energy into electrical energy. Electric motors can be found in household appliances such as fans, washing machines, water pumps, and vacuum cleaners. Electric motors use electricity to produce mechanical energy. Electromagnets, magnets that convert electrical energy, carry out this change. Like poles of magnets will repel each other, and unlike poles of magnets will attract each other. Thus, movement can be achieved by placing one magnet on a rotating shaft and the other magnet in a fixed position. This coconut fiber spinning machine uses a sewing machine dynamo. The picture of the sewing machine dynamo is as in Figure 3.

Figure 3. Sewing machine dynamo
https://singerindonesia.com/products/detail/dinamo-singer-150w

Engine speed is the rotational speed of the crankshaft due to fuel combustion (Tarigan, 2024). Engine speed is measured in rotations per minute (RPM). The specific power generated is influenced by the engine's rotational speed. High engine speed can increase its rotational frequency, which means the piston makes more strokes. Engine RPM indicates engine power. Particle size and fineness are influenced by rotational speed. The engine rotates faster with a higher RPM or slower with a lower RPM. According to Ekoyanto Pudjiono and colleagues (2016), the working capacity of the spinning results is proportional to the motor's rotational speed. That is, more motor rotations mean more work capacity of the coconut fiber spinning machine. The yarn pulling process becomes faster with greater motor rotation and larger roller rotation.
The data from the experimental results are as follows:

Table 1. The effect of the power used on the resulting RPM

No	Power (W)	Time (s)	Mechanical Advantage	Coconut Fiber Mass (kg)	Rotations Per Minute (ω)
1.	30			0.0017	32
2.	35	60	2	0,0020	48
3.	40			0,0024	60
4.	45			0,0029	72

The data in Table 1 shows the effect of variations in electrical power on the rotations per minute (RPM) value produced by the coconut fiber spinner at a fixed spinning time of 60 seconds and a mechanical advantage of 2. An increase in power from 30 W to 45 W is followed by an increase in RPM from 32 to 72, which indicates that the input power plays a direct role in the rotational speed of the dynamo. The increase in power causes the electrical energy converted into mechanical energy to increase, so that the dynamo is able to rotate faster despite the increase in the mass of the spun coconut fiber. This relationship is in line with the working principle of an electric motor, where an increase in power is directly proportional to the motor's ability to produce a higher angular velocity (Yudha, 2020).

Table 2. The effect of the power used on the length of the rope produced

No	Power (W)	Time (s)	Mechanical Advantage	Coconut Fiber Mass (kg)	Centripetal Acceleration (m/s^2)	Length of String (m)
1.	30	60	2	0.0017	0,057	1,72
2.	35			0,0020	0,126	2,03
3.	40			0,0024	0,198	2,46
4.	45			0,0029	0,288	2,94

Table 2 shows the effect of electrical power on the resulting rope length under conditions of a spinning time of 60 seconds and a constant mechanical advantage. Measurement results indicate that increasing the power from 30 W to 45 W increased the rope length from 1.72 meters to 2.94 meters, accompanied by an increase in centripetal acceleration. A higher centripetal acceleration indicates an increased rotational speed of the spinning system, resulting in a more effective coconut fiber winding process and a longer rope. This phenomenon aligns with the concepts of circular motion and rotational dynamics, where higher angular velocity increases the force and effectiveness of the winding process in a rotating system (Widyantara, 2023).

In this study, data collection trials on the coconut fiber spinning machine were conducted using several variations of independent and dependent variables to examine the device's performance characteristics in more detail. The independent variable, electrical power, was varied at 20 watts, 35 watts, 40 watts, and 45 watts, while the spinning time was kept constant at 60 seconds to allow for more controlled observation of the power's effects. The testing approach with one fixed variable and one variable varying is a fundamental principle in analyzing the performance of mechanical and electrical systems. Test results show that variations in power result in differences in the resulting rope length and the rotations per minute (RPM) of the dynamo. Increases in power tend to be followed by increases in RPM, which in turn affects the spinning speed and the number of rope twists formed. These variations in rope length and RPM indicate that input power plays a significant role in determining the effectiveness and performance of the coconut fiber spinning machine (Pudjiono et al., 2016).

In the experiment to find the effect of the power used on the resulting Rotation Per Minute (RPM), data collection was carried out by wrapping coconut fiber on the tool and then looking for the RPM produced for 60 seconds with varying power, namely 30 watts, 35 watts, 40 watts, 45 watts. The Rotation Per Minute (RPM) obtained was 32 ω, 48 ω, 60 ω, 72 ω. From the research data, a graph of the relationship between the power used and the Rotation Per Minute (RPM) was produced, which is shown in Figure 4.

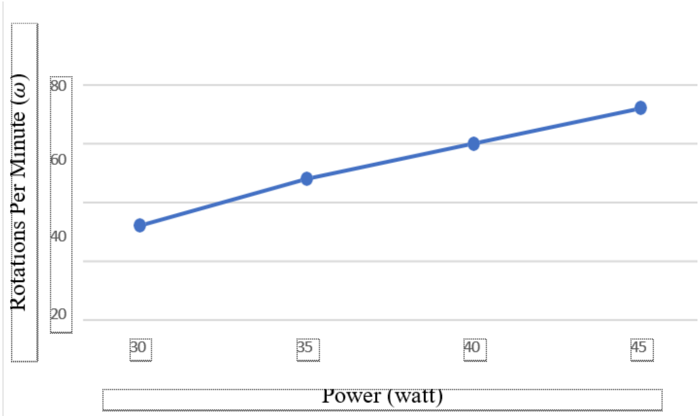

Figure 4. Graph of the relationship between the power used and the resulting RPM

Based on the graphical image of the relationship between the power used and the resulting RPM, it can be concluded that the greater the power used, the greater the resulting RPM. Therefore, the relationship between power and the resulting RPM is directly proportional. This is because the greater the power, the faster the dynamo rotates. The faster the dynamo rotates, the stronger the energy to move the lever, so the resulting RPM is also greater (Pudjiono et al., 2016). In the electric motor or dynamo used, the maximum RPM that can be produced is 6,000 RPM. However, in the application of this tool, the RPM has decreased. Because it has been divided by the lever load. However, the torque will be greater. In the experiment to find the effect of the power used on the length of the rope, data was collected by wrapping coconut fiber on the tool and then looking for the length of the rope produced for 60 seconds with varying power, namely 30 watts, 35 watts, 40 watts, 45 watts. The length of the rope produced was 1.72 m; 2.03 m; 2.46m; 2.94m. From the research data, a graph of the relationship between the power used and the length of the rope is produced, as shown in Figure 5 below.

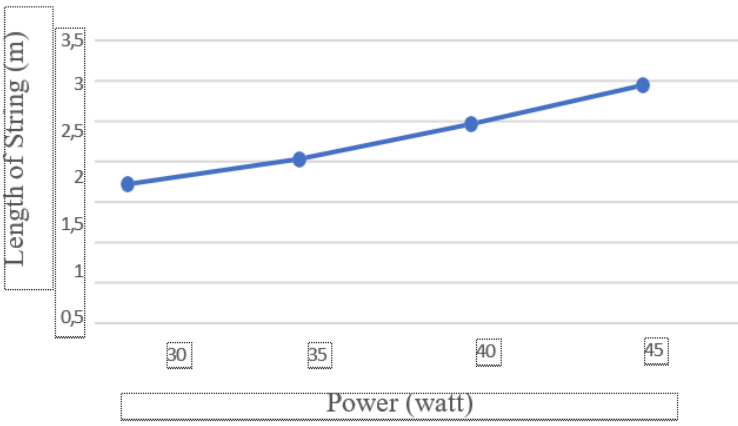

Figure 5. The relationship between the power used and the length of the rope

Based on the graph of the relationship between the power used and the resulting rope length, there is a tendency for the winding length to increase as the input power increases. Theoretically, increasing the power of an electric motor is related to increasing the rotational speed and mechanical performance of the system (Yudha, 2020), so the relationship between power and rope length is directly proportional. Greater power causes the dynamo to rotate at a higher speed, generating more mechanical energy to drive the spinning lever. The faster the dynamo rotates, the stronger and more stable the torsional force, making the winding process more effective. This condition results in an increase in the number of coils formed and causes the length of rope produced in a given unit of time to increase. The speed-based coconut fiber spinning tool has several advantages, including the use of a dynamo that makes the spinning process more efficient compared to the manual method .

The presence of a speed regulator allows the tool to operate more stably and consistently compared to the throttling system as a rotation controller. The process of making the tool that utilizes used materials also makes production costs more efficient so that it is more affordable for small businesses. On the other hand, this tool has several weaknesses, such as the level of precision that is still limited due to the use of used materials and the torque produced is relatively small so that under certain conditions the dynamo can stop. The results of this study provide practical benefits in the form of alternative appropriate technology that is easy to apply by MSMEs to increase the efficiency of the spinning process, reduce operational costs, and support the utilization of coconut fiber waste into products with economic value. Student innovation has a positive impact on building relationships with the business and industrial world (Jumini, 2023; Jumini, 2021; Jumini, 2025).

CONCLUSION

This coconut fiber spinning machine uses an automatic button to control the motor and is equipped with a speed regulator, so the spinning process can be more efficient and does not require a long time. Test results show that increasing power has a direct effect on the Rotations Per Minute (RPM) and the length of the rope produced. At 30 W power, the resulting RPM is 32 with a rope length of 1.72 meters, while at 45 W power, the RPM increases to 72 and the rope length reaches 2.94 meters. The data confirms that the relationship between power, RPM, and rope length is directly proportional. The faster rotating dynamo produces greater mechanical energy to drive the spinning lever, so the number of turns increases and the resulting rope becomes longer. The impact of this increased tool performance is seen in the acceleration of the production process and an increase in spinning capacity at the same time, which has the potential to increase the productivity and work efficiency of MSMEs processing coconut fiber. The implementation of this tool also helps reduce the manual workload so that the spinning process becomes more consistent. Increasing the consistency of production results provides an opportunity to develop the quality of coconut fiber rope products that are more uniform and have a higher sales value.

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