Ergonomic Design of Weaving Yarn Spinning Machine from Doyo Leaf Fiber

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Abstract: The manufacture of woven yarn has been tested through a prototype by designing a yarn spinning machine whose principle is almost the same as other natural fiber spinning machines. The design of the existing doyo fiber spinning machine still has shortcomings in the shape and size of the machine that is not ergonomic so that it can affect the safety, comfort and even productivity of workers. This study aims to overcome these problems where the machine to be developed will be more ergonomic by using worker anthropometric data. The results of the study using ergonomic analysis from the application of anthropometric data for adult women, 50th percentile, Indonesian ethnic groups aged 18-45 years, obtained ergonomic sizes and shapes than before. Changes in the dimensions of the machine have a length of 125 cm, a width of 45 cm, a height of 95 cm, a fiber entry hole height of 75 cm. This machine has a footrest with a height of 25 cm with a tilt angle of 45 degrees

1 INTRODUCTION

Doyo plants are plants that are often found in the province of East Kalimantan, Indonesia. Since ancient times, the doyo plant has been used by the Dayak tribe in the West Kutai area, East Kalimantan Province, where the fiber from the doyo leaves is used as a woven material to make clothes for traditional events. The material in the form of woven yarn is obtained from doyo leaf fibers which have been specially treated before becoming yarn and are handicrafts with cultural and historical value.

The process of making doyo leaf fiber into woven yarn is a production process that is usually done by women and takes a long time because it is done manually. With current technological advances, the manual production process of making woven yarn is carried out by designing a yarn spinning machine whose principle is almost the same as other natural fiber spinning machines.

The design of the Doyo woven fiber spinning machine has been made in a prototype, but it still has several shortcomings, one of which is the shape of the machine that is not ergonomic and can cause accidents for workers from the production process. The shape and size of the doyo leaf fiber spinning machine into woven yarn that is not ergonomic and does not match the user's anthropometric body size can affect the safety, comfort and even productivity of workers. This study aims to overcome these problems where the machine that will be developed later becomes more ergonomic, namely prioritizing the principles of safety, and comfort and according to the body size or anthropometry of workers. The contribution of this research will provide input to the machine manufacturing industry so that the design of the machine, especially the spinning machine which is designed to have more ergonomic elements and without leaving its main function.

2 LITERATURE REVIEW

2.1 Doyo Weaving

Doyo weaving is derived from the leaf fiber of the doyo plant which has the Latin name (*Curliglia Latifolia*) which is a type of pandan with strong fiber

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and grows wild in the interior of Kalimantan as the main ingredient for doyo weaving (Purbasari and Rahardja, 2018, Meilita et al., 2020, Indriastuti, 2021).

Along with the development of fashion and handicraft products today, doyo weaving is widely used not only as clothing used in traditional events, but has developed into fashion products and other handicraft materials such as wall hangings, tablecloths and others because has the uniqueness of its own natural ingredients as shown in Figure 1 (Cahyadi et al., 2019b)

Figure 1: Utilization of doyo weaving for formal clothes and wall decoration.

2.2 Ergonomics and Anthropometry

Ergonomics can be regarded as a field of science that is oriented towards the interaction between humans and their environment, covering the cognitive, physical, and organizational fields. Ergonomics also studies humans in relation to the work they do to make them safer, more comfortable and productive (Wignjosoebroto, 1995, WHO, 1972, Nurmianto, 1998).

Ergonomics will emphasize the importance of safety, comfort and human well-being and overall system performance. One of the fields in physical ergonomics is anthropometry. Anthropometry is used as a standard for determining dimensions in product manufacturing and development (Lehto and Landry, 2013).

Anthropometry is the measurement of the human body that can be used as a basis for determining the size of the minimum or maximum limits of products, equipment or ergonomic machines based on ethnicity, gender, disability, body position and posture during activities, as well as the type of work performed. designing a product such as equipment, machinery and furniture adapted to the user's anthropometry can provide maximum benefits (Lee et al., 2018a, Lee et al., 2018b, Adnan and Dawal, 2019, Wang and Cai, 2020)

The use of the latest anthropometric data will produce products, equipment or workstations that are more in line with the size of the human body as its current user (Castellucci et al., 2016, Cahyadi et al., 2019a). Some software applications use anthropometric data to determine the size of products and ergonomic equipment, one of which is Mannaquin Pro (Cahyadi, 2014).

2.3 Yarn Spinning Machine

The combined flow spinning and forming technique is widely used because of the high flexibility it provides for producing complex machine tool parts especially in the automotive industry (Das et al., 2010). For machines the manufacture of yarn from plants such as flax, mesta, and sisal can be done through the help of mechanical processing and the intervention of a number of machines. Therefore, it becomes important to explore all spinning technologies for low-cost yarn production. In the process of making single yarns it can be assisted by coating several materials to improve some yarn and fabric properties such as hairiness, strength, elongation, evenness and abrasion resistance (Yurtaslan and Yilmaz, 2016, Wongkasema and Aksornpimb, 2015, Seisarina, 2021)

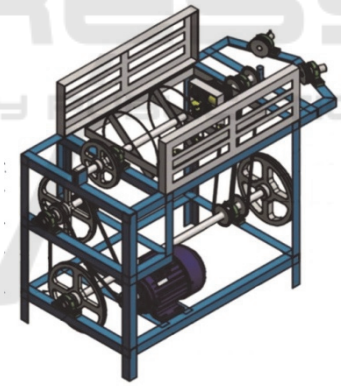

Figure 2: Prototype of doyo leaf fiber spinning machine (Seisarina, 2021).

Figure 2 is a prototype machine for spinning Doyo leaf fiber into a woven thread. Doyo leaf fiber spun machine has specifications of length 130 cm, width 46 cm, height 115 cm with a single phase electric motor, 220 V, 250 watts, 1400 rpm. This doyo leaf fiber spinning machine has a maximum capacity of 4900 cm/hour, an increase of 59.67% compared to manual spinning.

This spinning machine is able to shorten the stages of the process of making doyo leaf fiber rope, namely by eliminating the pre-processing process. This is because the doyo leaf fiber can be directly fed

to the twisting and spinning process. This spinning machine produces the best doyo leaf fiber rope with a maximum capacity at a ratio of 18:5:1 rotational speed of the twisting shaft, spinning shaft and pulling roller, 750 rpm main shaft rotation and 100 cm length of agel (Seisarina, 2021). In using this machine, in addition to using personal protective equipment, workers are still at risk in using the machine. The open form of the machine, the machine design that does not match the user's anthropometry and the shape that has sharp angles can pose a safety risk and work accidents.

3 METHOD

The research on the design of this doyo leaf fiber spinning machine uses ergonomic analysis using anthropometric data that is adjusted for workers. This doyo leaf fiber spinning machine is specially designed for standing position work. So that ergonomic analysis in determining the safety and comfort of workers will pay attention to the type of work standing.

Anthropometric data used as the basis for determining the size of the machine uses the sex of an adult female, aged 18-45 years with an average adult female size of 50 percentile, from the Indonesian ethnic group. Data obtained from Indonesian anthropometric data (Indonesia, 2022). The data that will be used are shoulder height, forward hand reach, side arm span, and elbow height as seen in figure 2.

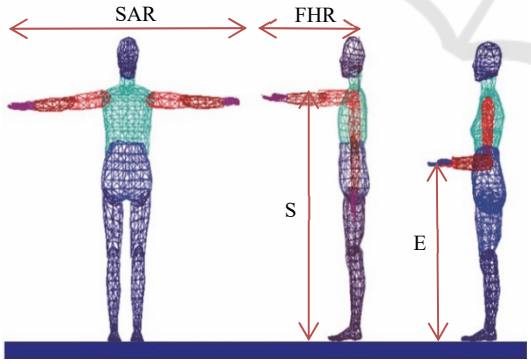

Figure 3: Anthropometric measurements.

4 RESULT AND DISCUSSION

To design an ergonomic doyo leaf fiber spinning machine design, anthropometric data is used as a measure that suits the user. The size of the machine height is taken from the anthropometric data of shoulder height (SH). From Indonesian anthropometric data, the average shoulder height of adult women is 129.2 cm. This value is the maximum value for the height of the machine, so in the design of this machine the height used is 95 cm from the floor.

For the size of the width of the machine, the anthropometric data used is the size of the forward hand reach (FHR). This value is the maximum value for the width of the machine, so in designing this machine the width used is 45 cm.

The length of the machine uses side arm reach (SAR) anthropometric data. From Indonesian anthropometric data, it was found that the average side arm reach for adult women is 155.7 cm. This value is the maximum value for the width of the machine, so in designing this machine the length used is 125 cm.

In the design of this machine, the fiber to be spun enters through the machine through two parallel holes before being spun by the machine. The hole for inserting this fiber has a diameter of 3 cm according to the shape of the fiber. Hole height for more ergonomics should be measured at elbow height to optimize work and avoid fatigue too quickly. In this design, the height of the hole for fiber entry uses anthropometric data from elbow height (EH).

From Indonesian anthropometric data, the average elbow height of adult women is 97.6 cm. This value is the maximum value for the height of the fiber entry hole into the machine, so in the design of this machine the height of the hole and from the floor is 75 cm.

In the design of this machine, a foot rest will also be added which serves to rest the feet so that they are not too tired when working in a standing position. The foot rest is designed to form a triangle with a footrest that has a tiered shape to rest one foot while working. Footrest height is 25 cm with 45 degree angle.

Figure 4: Perspective view of the machine.

With a more ergonomic size in accordance with this worker's anthropometry, the design of the machine designed will experience changes in terms of size and shape that are more ergonomic and aesthetic. The machine design is shown in the figure 4 and figure 5.

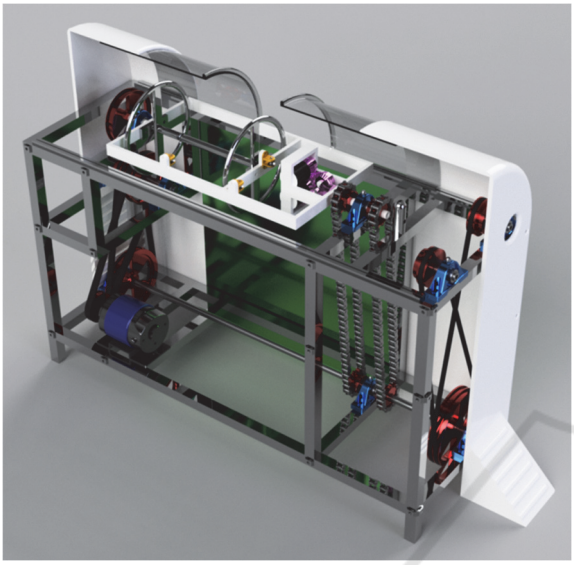

Figure 5: Half cover view of the machine.

Some improvements from the design of this machine design as a technical research contribution are:

1. Aesthetic machine design by making curves and avoiding sharp shapes than before.
2. The machine designed has measurements such as height, length and width of the machine that are more ergonomic than the previous machine according to the size of the Indonesian human body as the worker.
3. The hole where the fiber enters has two holes 75 cm high parallel to the position of the hand when standing. These holes are made to create a more directional pull during the fiber spinning process.
4. The design of the machine that has a transparent cover will make it easier for workers to see the process when the machine is working. The transparent cover can be opened or closed again to make it easier for workers to pick up the spun yarn and clean the machine.
5. The design of the machine has a footrest to reduce worker fatigue on the feet when working standing position.

Thus the design of the yarn spinning machine from Doyo leaf fiber has an ergonomic shape that makes workers safer, more comfortable and easier to do their work so that in the end it will lead to an increase in work productivity.

5 CONCLUSIONS

In this research, the design of the yarn spinning machine from Doyo leaf fiber was developed to make the machine more ergonomic so that it has a level of safety and comfort in its use. By using anthropometric data of adult women, 50th percentile, ethnic groups of Indonesia aged 18-45 years. Changes in the dimensions of the machine have a length of 125 cm, a width of 45 cm, a height of 95 cm, the height of the hole for the entry of fiber is 75 cm.

In addition, this machine has a foot rest with a height of 25 cm with 45 degree angle. This size is adjusted to the worker's anthropometry which is supported by an ergonomic shape by avoiding sharp corners to make it safer, more comfortable and in the end will also increase work productivity.

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