ORIGINAL ARTICLE

ERGONOMIC DESIGN OF THE CUTTING MACHINE FOR CHOPPING CYPERACEAE PLANT

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ABSTRACT

The manual cutting is still applied in the Small and Medium Industries (SMI) especially in cutting the Cyperaceae plant. One of the varieties is "Fimbristylis Globulosa (Mendong)". This plant is used as a raw material to manufacture the handicraft. The process is commenced with chopping the plant by using a manual tool. However, the existing tool still causes some complains where 90% of users experienced discomfort and unsafe in the use. The tool is also not effective and efficient for cutting. Thus, it is significant to improve the better cutting tools. This objective of this study is to design the innovative and ergonomic cutting tools for satisfying user requirements. The survey was done to identify some discomfort. The participatory ergonomic method is applied to determine the specification of design on basis anthropometry data of users. Non-parametric statistical analysis is conducted to test the hypothesis. The results of this study show that the developed design is a valid to reduce the risk of work-related musculoskeletal disorders and more comfort and safer at 5% of the significant levels where the proposed design specification used electric motor system and pneumatic system.

Keywords: *Cyperaceae, musculoskeletal disorders, participatory ergonomic, fimbristylis globulosa*

INTRODUCTION

Currently, there are countless Small and Medium Enterprises (SME's) with a rapid growth in food, the and handicrafts sectors. The soaring demand for raw materials is especially contributed by the handicraft industry manufacturing mainly producing mats, wallets, bags, tissue boxes, slippers, and other various handicraft products. These products use basic ingredients derived from *Fimbristylis Globulosa (Mendong)*. The process of handcraft manufacturing is preceded by plan harvesting, drying, and cutting.

In the fact, many SMEs still rely on manual cutting tools for the cutting process, which takes time and energy and can cause several work-related diseases such as Musculoskeletal Disorders (MSDs) because the methods used are not comfortable and is unsafe for workers. Based on preliminary study, it was identified that the manual cutting process has made 60% of worker suffer from extreme pain in the buttocks (upper), right wrist, and left hand. As many as 50% of worker feel severe pain in the right hand. 30% of worker experience terrible pain in the knee, calf, arm, neck, shoulder, wrist, ankle, and foot. On the average, these workers involved in the survey, have worked for more than 15 years. Most of them suffer from injury complaints not only in one part of the body, but also in many parts of the body, because of the repeated work they have done for a long time.

METHODOLOGY

Paper based survey was conducted to identify some complaints or disorders on the body part of workers when cutting *Fimbristylis Globulosa (Mendong)* plant manually. Interview was done to explore the data required in detail. Furthermore, the survey was also conducted to identify worker's criteria of the design developed. This survey took 30 days to complete with the whole activities of survey taking about 30 days.

This study used the Nordic body questionnaire, which consisted of 27 body part from neck to foot. This questionnaire uses the Likert scale, which encompasses 4-order levels, namely: there is no pain, there is a little pain, there is a pain, and there is an extreme pain. Meanwhile, the second questionnaire also uses the Likert scale type in a statement sentence, which comprises 7-order levels, namely: very disagree, disagree, somewhat disagree, neutral, somewhat agree, agree, and very agree.

SPSS software is used to process the data that consist of anthropometric data, complaint data, and user criteria design data. This study uses the IBM SPSS Statistics 22.

Solid work is a software application for drawing a conceptual design of the cutting tool. This study used the Solid work x64 Edition SP05 that is commonly used tool in the design.

Anthropometry is a measurement of the body dimension of living subjects. This measurement plays a significant role in determining the design dimension[8]. According to [6], anthropometric data are used to identify the physical dimensions of equipment, furniture, clothing and workstations. However, when the design fails to fulfil the users' anthropometric dimensions, it can have a negative impact on human health. Meanwhile, the use of the anthropometric data is described in the following steps[4]: (1) Determining the potential population to use the design, (2) Determining the number of users to accommodate the design, (3) Determining the body part dimension, and (4) Determining the percentile of body dimension used.

According to [1], participatory ergonomic (PE) is a strategy to implement ergonomic measurement and it has been recommended by the National Institute of Occupational Safety and Health (NIOSH) and the European Agency for Safety and Health at Work (EASHW) as a method to control the work of musculoskeletal disorders (WMSDs) in the work system. This notion is supported by [5] explaining that the participatory methods can be used in designing things such as workplace improvement, building, etc.

One of the methods to apply the PE in design is the Focus Group Discussions (FGD). Focus group discussion is a research methodology in which a small group of participants gather to discuss a specified topic or an issue to generate data[7]. It is a technique which uses a scripted brainstorming to solicit questions and answers from a group of people[11]. In this study, the FGD involves four stakeholders, two ergonomic experts, a mechanical engineer and a worker. The FGD was conducted in the following steps: (1) Choosing stakeholders, (2) Developing background problems, (3) Compiling group discussion, (4) Analysing the problems and solution and (5) Making decision based on the discussion.

The virtual concept design of the cutting tool is developed by using the solid work software based on the result of FGD. This design also refers to some attributes that the workers requires. Anthropometric data of workers is applied in the design to prevent the discomfort in completing the task.
Non-parametric statistical method was used to test the hypothesis, which shows no difference between the proposed design specification and the stakeholder's criteria. The homogeneity test using Kruskal-Wallis was applied in this study to validate the design developed.

RESULTS

Table 1 presents the survey result of customer's preferable criteria on the design of the cutting tools. They are safety, comfort, effectiveness and efficiency, and ease of use.

***Table 1**: Customer Survey*

Attribute
Safety
Comfortable
Effective and Efficient
Easy to use

Safety attribute required by users of the cutting tools is a knife with a shield to avoid accidents at work. In terms of comfort, the users require that the tools shall be operated by a control panel that satisfies user's anthropometric. Meanwhile, effectiveness and efficiency attributes of the cutting tools refer to the big capacity and the faster operation of the tool. Another user's need of the cutting tools is ease of use to ease user in the operation and maintenance.

Specification Design of the Cutting Tool. Safety: The design uses the control button for operation, located far from the cutting tool to avoid an accident. The tool is also covered to protect user from the material cut. The size of the cutting tool is 90 cm in length (including the cover), 5 cm in width, 0.3 cm in thick and 1.06 kg in weight with a chainsaw system designed to control the rotation. While the container of material is made with flexibility to move forward and backward to ease users to manage the cutting tool at a distance. To operate the tool, user should wear glove to protect his hand (as depicted in Figure 1).

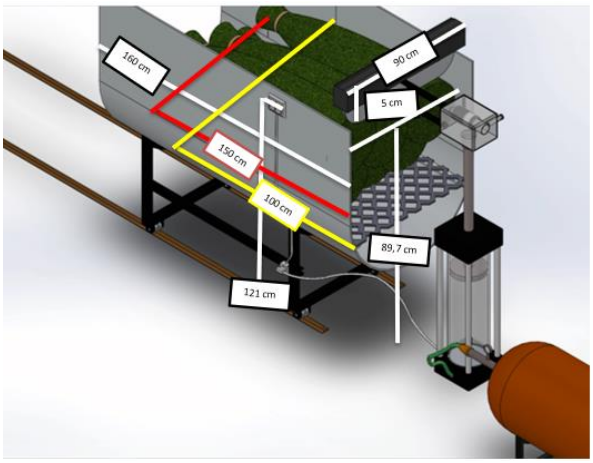

Figure 1: The Size of Cutting Tool

Comfortable: Therefore, the height of the control button should be determined on the basis of the anthropometric data of workers which is as high as 121 cm to preventing unnatural posture of arms. Moreover, the capacity of the

tube shall be made adequate for loading the materials to avoid the users from the requirement to re-measure it repeatedly.

Effective and Efficient: Figure 2 represent that the cutting tool developed is in the form of the static slabs with chainsaw system with a rotating edge chain and is operated using the electric motor power.

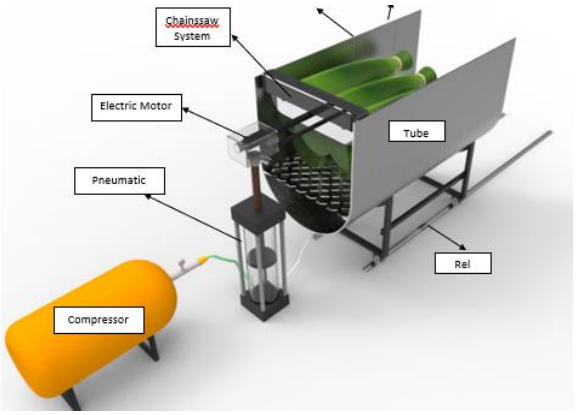

Figure 2: The Chainsaw System are moved by Electric Motor Power

Easy to use: A yellow and a red line inside of the tube ease the users to load the material. Meanwhile, the waste product resulted from the cutting process goes into the bin to ease the waste management. The tool is also controlled by the button to ease the operation for the users. As depicted in Figure 3 a yellow line represents a length of 100 cm and a red line represents a length of 150 cm.

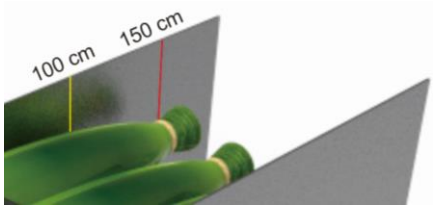

Figure 3: A yellow and A red Line on the Tube

Develop of Virtual Design. Figure 4 shows the result of the designed cutting tool based on the resutls of the Focus Group Discussion using Participatory Ergonomics Method.

Validation of the Proposed Design. Table 2 presents the result of the Kruskal-Wallis test. It is revealed that the calculated value is 5.425,which was smaller than the table value of 9.49. Thus, null hypothesis (H_0) is accepted. It is meant that the proposed design is not significantly different from the stakeholder's criteria

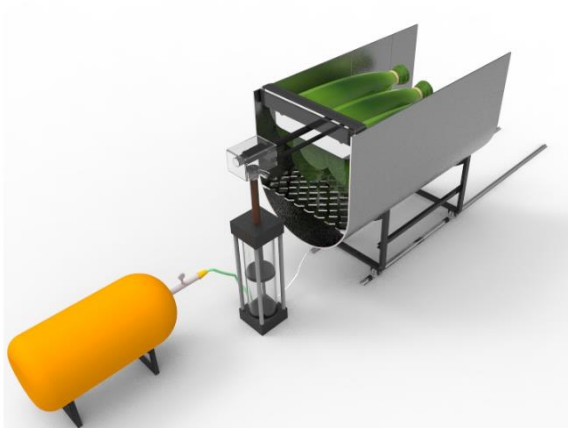

Figure 4: Virtual Design of Cutting Machine

Table 2: *The Result of the Kruskal-Wallis Test*

Test Statistics[a,b]

	Stakeholders. Validation
Chi-Square	5.425
df	4
Asymp. Sig.	.246

a. Kruskal Wallis Test

b. Grouping Variable: Subyek

DISCUSSION

Customer surveys found four attributes that it was required in design. Safety is a critical attribute which it may ensure users doing a task continuously without being worried. By installing a control button for operating the machine in reached location, this will be spared from an accident as well as supporting a comfortable working for long period of time. Design accommodating users whether a button or other part such as cutting tool should be applied, the anthropometric data in order to satify the comfortable criteria has being implemented for it in this study. This condition will increase efectiveness and efficiency in completing the job as well. It is also supported by installing an exertion of the electric motor with the double of air pressure pneumatic power from a compressor for increasing the capacity of cutting. And this design can likewise be able to ensure the users for easeness in exerting the machine as they need to prevent overexertion in cutting for long time that will consume a lot of energy. Moreover, use of a red and a yellow line through the length of the plants to be cut makes easer for users to set the plant in a desired size.

Finally, the statistical test presents a value is smaller than the table value. It is proven that the developed design is valid to satisfy the customer's requirement at 5% of significant level

that is safer, more comfortable, easier to use and more effective and efficient.

CONCLUSION

Based on the study, it is possible to draw the following conclusions:

1. The user criteria of developed cutting tool design are safe, comfortable, easy to use, effective and efficient.
2. The design of the cutting tools uses the control button to operate. The height the control button should be determined on the basis of the anthropometric data of workers, which is as high as 121 cm. The cutting tool developed is in the form of the static slabs with chainsaw system with a rotating edge chain and is operated using the electric motor power and is made of a yellow and a red line inside the tube.
3. The proposed design is valid to satisfy the customers' requirement at 5% of significance level.

LITERATURE REFERENCES

The fact states that on average many SMEs can achieve higher levels of productivity in making their products which consequently increases the demand for raw materials[2]. The raw material mentioned is a kind of grass plant which is found in tropical countries which is included in monocotyledonous plants and entered into one of the most 102 genera member of *Cyperaceae* which is a type of shrub or Liana which is also efficacious for plants called *Fimbristylis Globulosa (Mendong)*[3]. The process of fulfilling these raw materials leads to MSD. MSDs are the most commonly reported diseases in 1995. The general household survey conducted revealed that 159 of 1000 adult women and 143 of 1000 adult men experienced Musculoskeletal Disorders. In addition, it is estimated that 15% of general practitioner consultations are for musculoskeletal problems[9]. MSD arises because many workers still use manual cutting tools in the cutting process[10].

ACKNOWLEDGEMENTS

The authors wish to thank the Directorate of Student Development, Islamic University of Indonesia Yogyakarta for supporting this study.

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February 11, 2019

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