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Tool Design for Tea Cutting Machine to Reduce MSDs Using Ergonomic Function Deployment: A Research at PTPN 8 Ciater

Muhamad Adhi Guna Dwyantoro: Telkom University, Bandung, Indonesia
adhigunadwyantoro@gmail.com

Mira Rahayu: Telkom University, Bandung, Indonesia
Mira.rahayu82@gmail.com

Abstract— The process of picking the tea leaves is done in three different ways, the first one is using the farmet hands, the second is using a scissors, and the third is using a cutting machine. When the farmer uses the tea leaf cutting machine, the fatigue level is increasing compared with to the other tools such as scissors and hands. In the use of tea cutting machine, there are many operators complain about pain on their body parts. The pain felt by the operator might be the indication of Musculoskeletal Disorders. This risk is proven by existing condition who get value 7 (seven) in RULA score. Designing tools for tea-cutting machines is one of the ways to minimize the risk of Musculoskeletal Disorders (MSDs). In the development process of the tool, Ergonomic Function Deployment (EFD) approach should be so the concept of cutting tools has advantages on the side of ergonomics. Furthermore, the concept of cutting machine are analyzed by applying the principles of ENASE (Effective, Convenient, Safe, Healthy, and Efficient) which are parameters within the Ergonomic Function Deployment. The results showed that ergonomic tools can assist workers in performing tea-cutting activities, this is marked by a decrease in posture score. It can be concluded that the tool can be used as a solution to prevent musculoskeletal disorders (MSDs) in tea leaves cutting process.

Keywords— Design Tools, Tea Cutting Machine, Musculoskeletal Disorders, Ergonomic Function Deployment

I. INTRODUCTION

In the existing condition of the tea-cutting machine has a very large MSDs risk. From the problems that occur in the existing conditions, it requires tools that can reduce the risk of MSDs in workers. Developmental tools that have been made from previous researchers (Fauzi, 2017) is helpful, however it has not been concerned with the ergonomic aspects, this is based on a simulation analysis of work postures which generates a number > 4 for value of Rula. Simulation of work postures done by using a *software-based virtual environment.* The results of posture using the initial concept can be seen in Table I.1.

Table I. Values of Worker Posture on Use of Initial Concepts Tools

Activities	Scores of RULA	Level of Risk	Action
Use of Initial Tools Concepts	7	High	Immediate repair needed

Based on these issues ergonomic evaluation is needed to ensure that the application of tea cutting tools can facilitate workers from the previous tool and also can reduce the risk of MSDs to workers.

II. THEORETICAL BASIS

A. *Ergonomic Function Deplyoment*

Ergonomic Function Deployment (EFD) is the concept of Quality Function Deployment developed by adding a new relationship after a customer need or desire of to products that are ergonomic (Damayanti, 2000). The EFD approach is used to achieve the ENASE principles of Effective, Comfortable, Safe, Healthy and Efficient. By achieving the ENASE principle, ergonomic product improvements can be achieved and can reduce the risk of MSDs. (Adrianto, Desrianty, & Fifi Herni M, 2014).

B. *Musculoskeletal Disorders (MSDs)*

Musculoskeletal Disorders (MSDs) are conditions in which people experience fatigue in the skeletal muscle. The pain received by humans is due to the muscle state that gets repeated and static load and receives the load for a long time. MSDs cause damage to joints, ligaments, and tendons. Workers who perform recurrent activities in one cycle are particularly vulnerable to MSDs disorder (Tarwaka, 2004). Common sections suffered by patients with MSDs are in the arms, shoulders, and back. The main cause of MSDs is lifting with backs bent or twisting, pushing and pulling activities, static work positions with suddenly bent, holding with or without great strength.

III. RESEARCH METHODS

To produce *output* in accordance with the purpose of research, it is important to provide framework to describe the concept in solving problems. The frame of mind is illustrated in figure 2. Based on figure 2, it can be seen that the focus of development is on the concept of tea cutting tools that have been obtained from previous studies to get ergonomic tea cutter tools.

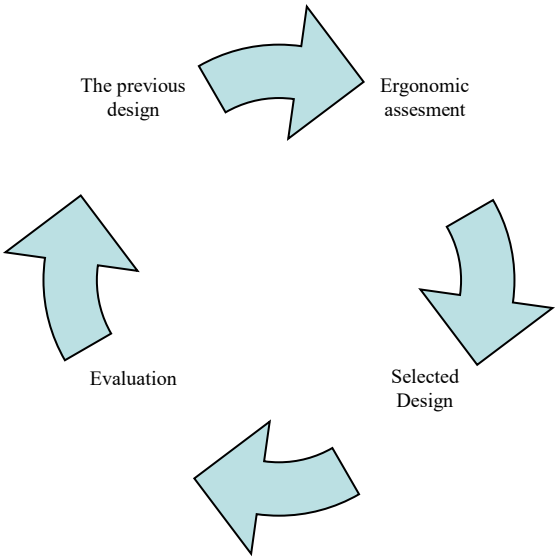


Figure 2 Conceptual Model

IV. RESULT AND DISCUSSION

IV.1 Ergonomic Evaluation on Initial Concepts Tools

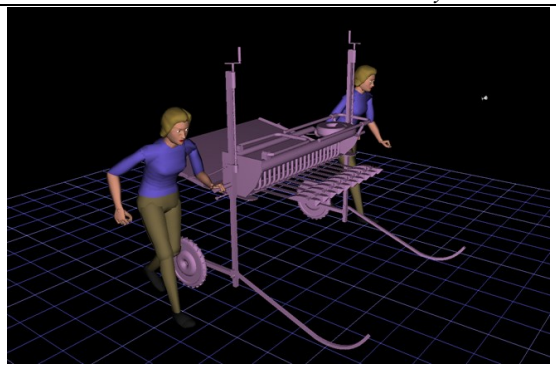
In the first stage of data processing, it performed the initial concept of data processing using multiple evaluation tools that Rula ergonomics and *Push / Pull Analysis.* Evaluation of RULA for the initial concept can be seen in Table II

Table II Score RULA Cutting Process Using Initial Conception Tools

Posture Body Push Activity Using Initial Concept											
Group A								Group B		Final Score	
Upper arm		Fore arm		Wrist		Wrist Round		Neck	Body		
Right	Left	Right	Left	Right	Left	Right	Left			Right	Left
4	4	2	2	2	2	1	1	2	3	7	7

From table IV.1 it was found that the worker's posture on the initial concept of the tool still has a score of 7 which means the tool can still lead to MSDs. Evaluation of the second ergonomics is a *Push / Pull Analysis* with the parameters are specified in Table III

Table III Parameter *Push-Pull Analysis*



Push and Pull Frequency	Every 30 minutes once a tea cutter is prepared on a tea tree to make the tea cutting process
Push and Pull Distance	The distance of tea garden is 15 m. Then *push and pull distance* parameter analysis approaching the Snook tables and Ciriello is 15.2 m
Tool Handle Height	In this analysis the height of the tool handle has a height of 73.9 cm so that the value in the Snook and Ciriello tables is 64.
Percent Capable	*Percent Capable* is the estimate of what percentage of workers can pull/push the tools to move. This contaminated tool can be boosted by 50% of the working population.

After determining parameter calculation using the Push and Pull Snook tables and Ciriello No of calculation obtained from push-pull analysis Limit Initial Force to push at a height of 95 cm by 4 N. While Sustained Force Limit to drive at 15kg.

IV.2 House of Ergonomic Formation

House of Ergonomic (HoE) is a method that supports the process of identifying the product into the draft specification that shows the structure to design and establish a cycle and is shaped like a house. After determining the HoE and then translated to get the final specification for the ergonomic tool. The final specification is used to determine the final concept of the tool product to be made and also the material to be used later. The final specification table can be seen in Table IV

Obtained from the above specifications for ergonomic tools, the material used for ergonomic tools using *Magnesium Alloy* material. This is due to the ergonomic tools require a strong and lightweight material.

The concept of ergonomic tool is made after obtaining the final specification of the HoE stage. The concept of ergonomic tools can be seen in Figure 3

Table IV. Technical Characteristic

Product Atribute	Techincal Characteristic	Unit
Tools adjust to dimensional cutting tea	*Clearance* small when installed	Milimeter
Tool safety when used	Material of tool have RoHs Standarization	List
Tool can hold tea machine	Material of tool have higher yield strength	Pa
Workers health when used tool	Score of *Rapid Upper Limb Assesment* (RULA)	Score
Tool easy to use	Material of tool have lower density	Kg/m^3
	Steps to use of tool	Step
altitude hilt persist in position	Locking system on handle	List
Tool adjustmen for worker	Tool adjustment for worker	Milimeter
Tool easy to save	Storage Mechanism	List
Tool have easy system of usage	Usage Mechanism	List

From the concept of ergonomic tools, it is gained posture analysis and the analysis of *the push / pull analysis* is brought to a comparison between the initial concept of the ergonomic concept: whether there is difference or not. Analysis of posture differences can be seen in Table V

Table V Comparison of RULA

	Initial Concept	**Ergonomic Concept**
Body posture		
Score	7	4
Analysis	Activities are at risk, so investigations and repairs are needed as soon as possible	Activity may be risky, so further investigation is required and improvements may be made

Based on Table V the differences are evidence in the value of RULA. Altitude difference handles on tools influencing RULA impairment that can affect the risk of *Musculoskeletal Disorders.* After analyzing posture, a research is also conducted a comparative analysis of *the push / pull analysis* which can be seen in Table VI

Table VI Comparison of *Push / Pull Analysis*

	Initial Concept		Ergonomic Concept	
Task Parameter	*Task Parameters: Push / Pull Frequency:* 30 min; *Push / Pull Distance* (m) : 15; *Handle Height* (cm): 64.		*Task Parameters: Push / Pull Frequency:* 30 min; *Push / Pull Distance* (m) : 15; *Handle Height* (cm): 95.	
	Initial	*Sustained*	*Initial*	*Sustained*
Push Force Limit	20	14	24	15

Based on the results of a comparative analysis of *the push / pull task*, there is a difference in the *initial* and *sustained high-force.* This is because the handle on the concept of early entry at 64 cm parameters and concepts of ergonomics entered in the category of 95 cm. So the initial force that needs to be released to drive the beginning of a tool is 20 kg (196 N) and the continuous force to drive a 14kg (137.2N) changes to 24kg (235.2N) to encourage the beginning of tools and sustainable styles to encourage A tool of 15 kg (147 N).

V. CONCLUSION

Based on the results of data processing and analysis some conclusions can obtained to solve the problems in this study. The purpose of the research is to produce an ergonomic product concept. Based on these objectives, the concept of ergonomic products are obtained.

The concept of ergonomic tools can reduce the risk of MSDs by achieving some test parameters on the ergonomic evaluations that have been done. Table V.1 is a recapitulation of the results of ergonomic evaluation that has been done by comparison of the initial concept.

Table VII Recapitulation of Ergonomic Evaluation Comparison

Evaluation	Initial Concept	Ergonomic Concept	Information
Body posture	Value 7	Value 4	The risk of MSDs decreases with the decrease in RULA values

Push / Pull Task	The initial power released to drive is 20 N	The initial power released to drive is 24 N	Posture that is not awkward can provide more power

Materials selected also supports how the concept can be practically produce ergonomic products, which for ergonomic tools require a strong and lightweight material so selected *Magnesium Alloy* is the chosen material.

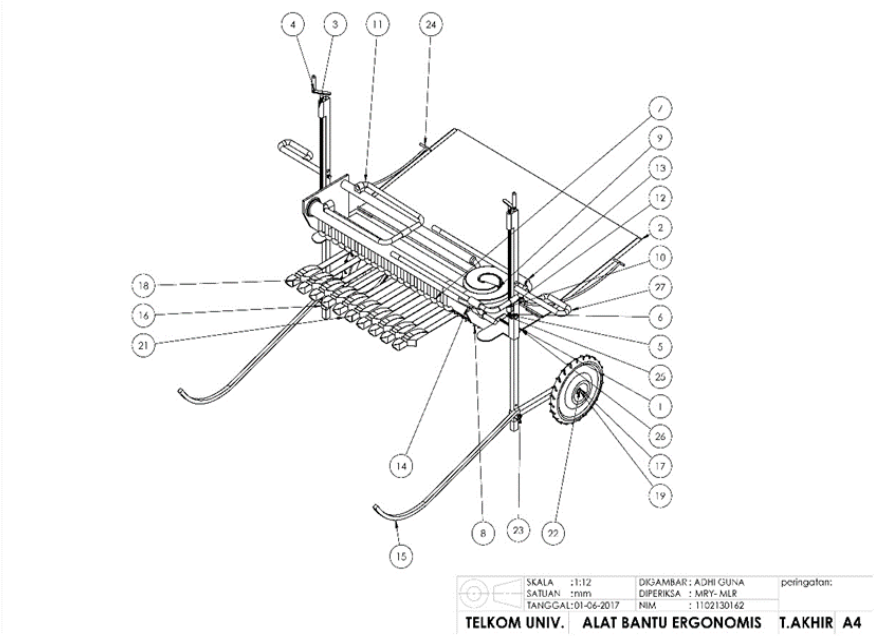


Figure 3. Concept of Ergonomic Aid

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