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The Design of Material Transporter for Paper Sack in Packaging to Decrease The Risk of Musculoskeletal Disorders using Ergonomic Function Deployment (EFD) Approach: A Research at PT. Perkebunan Nusantara VIII Ciater, West Java

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Abstract. The Tea packaging paper sack process at PT. Perkebunan Nusantara VIII is done manually using human labor to lift paper sack weighing 40-60 kg. This condition makes it harder for the labor and increases the risk of Musculoskeletal Disorders (MSDs). In the existing condition, the RULA score is seven which have high risk of work accidents. To minimize the risk of MSDs, a proposed work tool is designed using the Ergonomic Function Deployment approach to produce ergonomic tools. The proposed work tool was developed with the ESHCE principle (Effective, Safe, Healthy, Comfortable, and Efficient) which became a variable in meeting the Ergonomic Function Deployment (EFD) approach. The research results showed that the proposed work tools could help workers in carrying out packaging activities with the decrease in the RULA value on the labor's posture and could reduce processing time because it united all activities in the packaging area. So it can be concluded that the proposed work tools can reduce the risk of MSDs and can help workers to process the packaging of tea with minimum time.

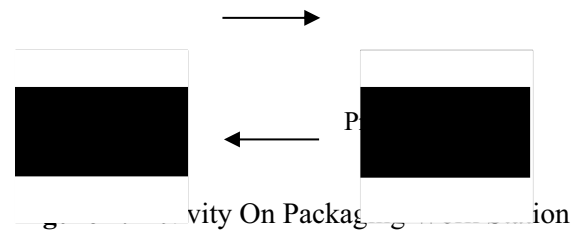
Keywords: Material Transporters, Musculoskeletal Disorders, Work Accident, Product Design, Ergonomic Function Deployment.

1. Introduction

PT. Perkebunan Nusantara VIII located in Ciater, West Java is a company that produces orthodox black tea. There are several steps that must be passed to produce orthodox black tea, from the process of transporting and receiving raw materials, the process of foraging, grinding, enzymatic oxidation process, drying, sorting process, packing, and storage process to the warehouse. The stages of producing orthodox black tea have a goal to produce the best tea products, but to distinguish between competitor tea products and orthodox tea products owned by PT. Perkebunan Nusantara VIII can be seen from the packaging.

In general, the packaging process is done using the machine so that the processing time is shorter and can minimize errors commonly done by humans. However, some activities at PT. Perkebunan Nusantara VIII at the packaging work station still uses human power, this can increase the risk of work accident. The following is the flow on the packaging work station, which is illustrated in Figure 1 below.





In the packaging process carried out some paper sack transport activity by lifting a paper sack weighing 40-60 kg using human power, the activity gives a very high impact MSDs, so it takes work tools that reduce the risk of MSDs in workers. The previous work tool produced a RULA score of seven that was simulated on the CATIA software as shown in Figure 2.

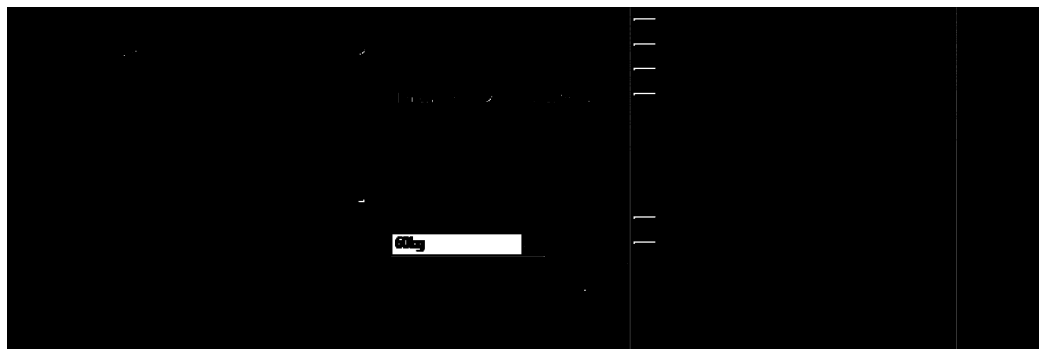


Figure 2. Simulation of Paper Sack Lifting Condition at Packaging Workstation

Based on the results that have been obtained will be conducted ergonomic evaluation of the existing work tools in the company so that when the use of tools of the proposal work can facilitate the operator in completing the work and can reduce the risk of MSDs.

2. Methods

2.1 Ergonomics

According to [1] states that ergonomics is a systematic branch of science to utilize information about the nature, abilities and limitations of humans in designing a work system so that people can live and work on the system well, that is to achieve the desired goal through the work, effectively, safely, healthy and comfortable.

2.2 Anthropometry

According to [2] Anthropometry comes from the word *Anthropos*, which means man, and *metricos*, which means measurement. In short, anthropometry is a science that deals with aspects of human physical size.

2.3 Formatting author affiliations

Ergonomic Functional Deployment (EFD) is the development of Quality Function Deployment (QFD) by adding new relationship between consumer desire and ergonomic aspects of the product [3][4]. This

relationship will complement the shape of the house of quality matrix which also translates into desirable aspects of ergonomics.

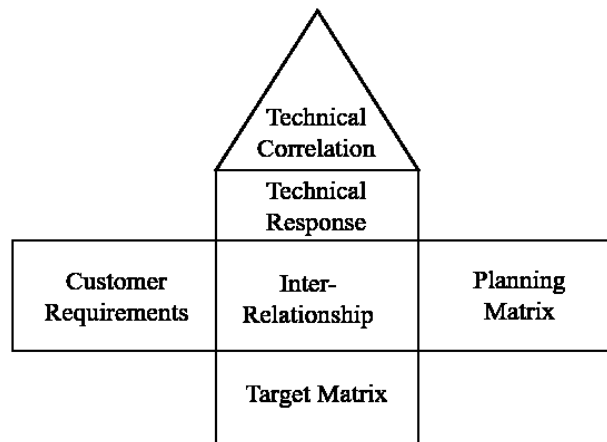


Figure 3. House of Ergonomics

The EFD approach is used to achieve EASNE principles of Effective, Safe, Healthy, Convenient and Efficient. With the achievement of the principle of EASNE, ergonomic product improvements can be achieved and can reduce the accident that occurs in the operator doing packaging activities.

2.4 Conceptual Model

In solving the problem, a framework is needed to solve the problem in the study which is poured into the following conceptual model:

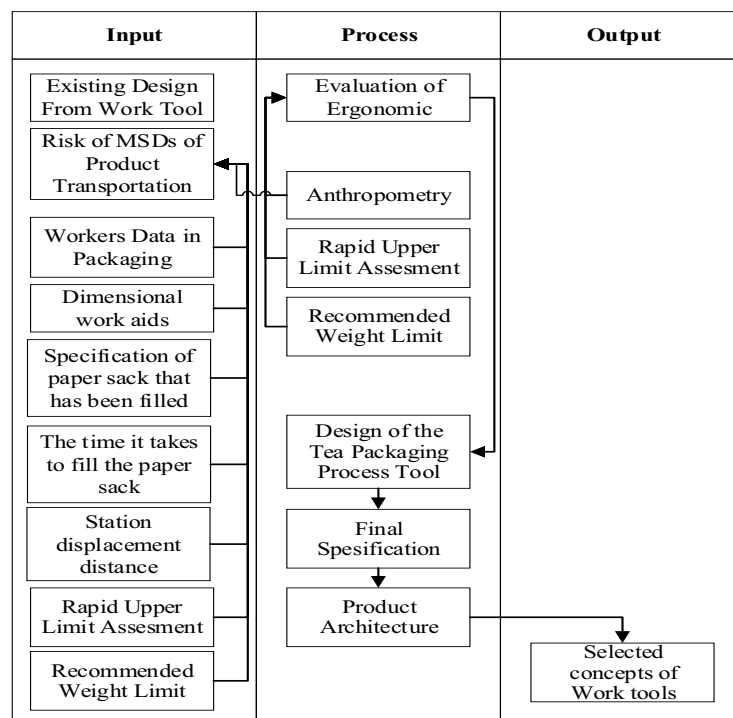


Figure 4. Conceptual Model

3. Result And Discussion

3.1 Ergonomic Evaluation of Existing Work Tool

The ergonomic evaluation is performed by determining the RULA score when the operator does the job of moving the paper sack for the next activity in Table 1 and knowing the recommended loads that the operator can carry out in doing the work that can be seen in Table 2.

Table 1 The Result Of RULA Workers For Existing Condition

Body Posture of Distribution Activity Paper Sack Without Work Tool										
Posture A						Posture B			Final Score	
Upper Arm		Forearm		Wrist and Arm		Neck	Trunk	Leg		
R	L	R	L	R	L				R	L
2	2	1	1	7	7	7	7	7	7	7

Based on Table 1, the results of RULA from the condition of the worker's exciting with the value 7 which means that the working conditions using the tool can cause high MSDs and must be made directly changes to the work performed by the operator.

Table 2. Recommended Weight Limit for Existing Condition

Object Weight		Hand Location (cm)				Vertical Distance (cm)	Asymetrix Angle		Frequency Rate	Duration	Object Coupling
		Origin		Destination			Origin	Destination			
L (avg)	L (Max)	H	V	H	V	D	A	A	F		C
60	60	37.5	89	-	-	175	0	-	0,2	<1	Fair

Here is the recommended weight limit calculation (RWL) for lifting objects in the existing working tool condition used:

$$\begin{aligned}
 \text{a. RWL} &= LC \times HM \times VM \times DM \times AM \times FM \times CM \\
 &= 23 \times \frac{25}{37.5} \times ((1 - 0,0032(89 - 75)) \times (0,82 + \frac{4.5}{175})) \times (1 - (0.0032 \times 0)) \times 1 \times 1 \\
 &= 23 \times 0.67 \times 0.95 \times 0.84 \times 1 \times 1 \times 1 \\
 &= 12.31
 \end{aligned}
 \tag{1}$$

$$\begin{aligned}
 \text{b. Lifting Index} &= \frac{\text{Object Weight}}{\text{RWL}} \\
 &= \frac{60}{12.31} = 4.84
 \end{aligned}
 \tag{2}$$

Based on the result of Recommended Weight Limit obtained value of 12.31 which means that the recommendation of the load that can be done by the operator with the existing condition should be 12.31 kg, because the burden of the existing condition of the value generated from the Lifting Index of 4.84 which means that the work is risky to do.

3.2 House Of Ergonomic

In making House of Ergonomic is one way to determination of ergonomic design by knowing the related relation between design specification and consumer requirement to work tool which will be proposed by researcher. HoE can be seen in Figure 5 [5].

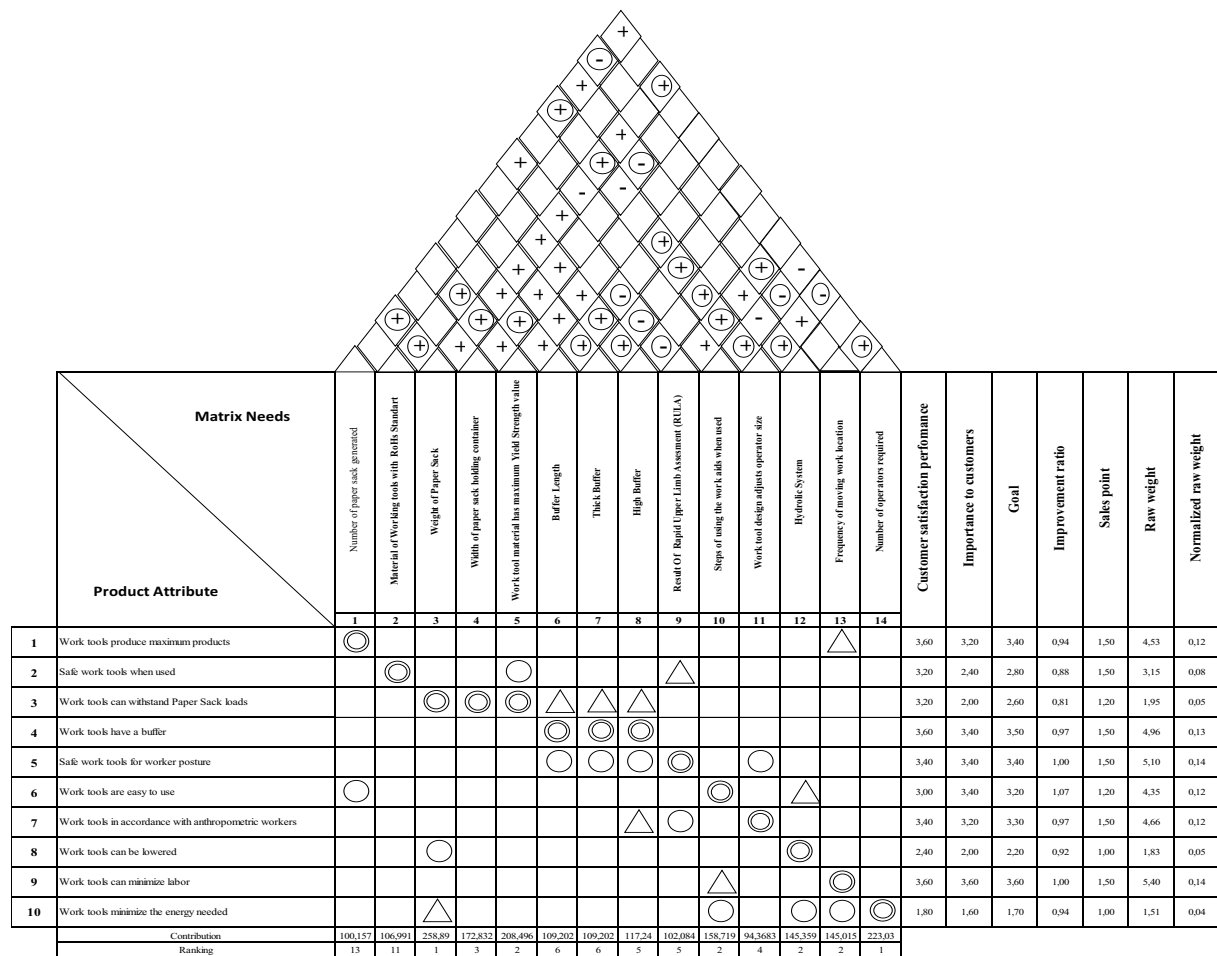


Figure 5. House of Ergonomic

Based on House of Ergonomic Figure can be specified final specifications for ergonomic devices. The final specifications are used to determine the size dimensions of the proposed packaging work aids, and the determination of the material to be used in the proposed work tool. The final specification table can be seen in Table 3.

Table 3. Final Specification of Proposed Work Tool

No	Matrix Needs	Part Spesification	Target Value	Unit
1.	Number of paper sack generated	Number of paper sack generated	>10	Sack/hr
2.	Material of Working tools with RoHs Standart	Material of Working tools with RoHs Standart	-	List
3.	Weight of Paper Sack	OP	40	kg
		BOP	50	kg
		DUST	60	kg
4.	Width of paper sack holding container	Length Of Container	60	cm
		Width Of Container	20.5	cm
5.	Work tool material has maximum Yield Strength value	Work tool material has maximum Yield Strength value	-	List
6.	Buffer Length	Buffer Length	60	cm
7.	Thick Buffer	Thick Buffer	15	cm
8.	High Buffer	High Buffer	115	cm

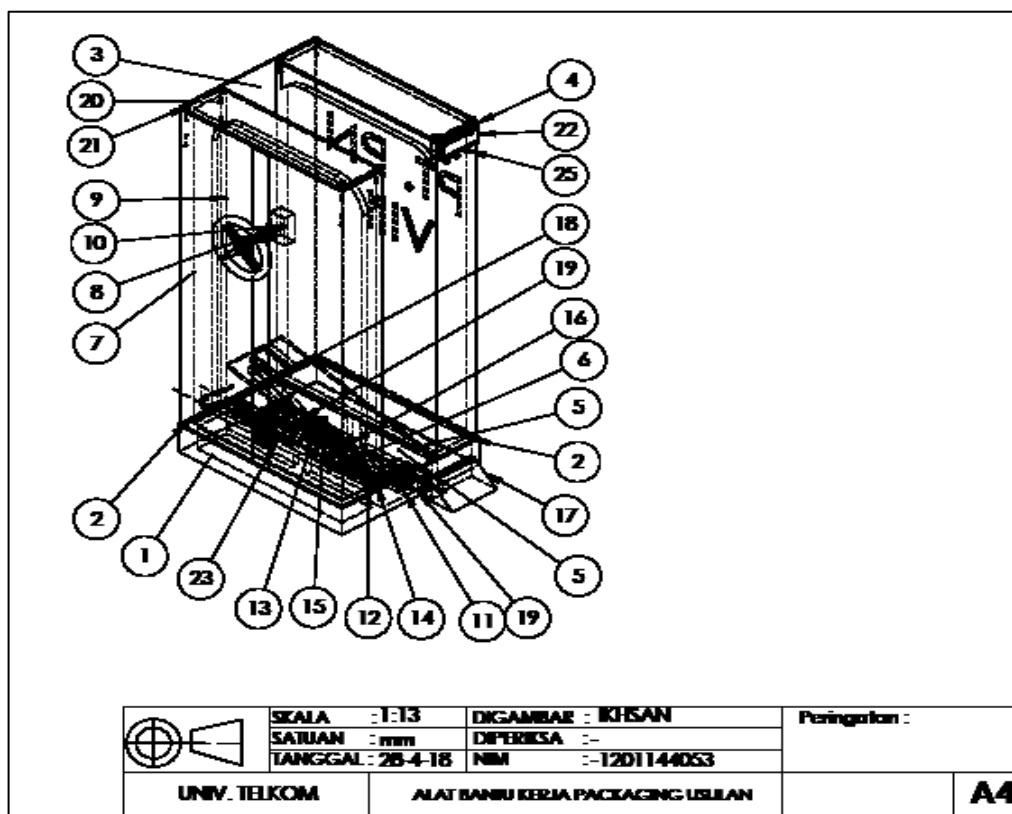
Table 3. Final Specification of Proposed Work Tool (cont.)

No	Matrix Needs	Part Spesification	Target Value	Unit
9.	Result of Rapid Upper Limb Assesment (RULA)	Result of Rapid Upper Limb Assesment (RULA)	4	Score
10.	Steps of using the work aids when used	Steps of using the work aids when used	4	Step
11.	Work tool design adjusts operator size	Work tool design adjusts operator size	-	List
12.	Hydrolic System	Hydrolic System	Yes	Binary
13.	Frequency of moving work location	Frequency of moving work location	1	Times
14.	Number of operators required	Number of operators required	1	People

Based on the final specification table we get the dimensions to design the ergonomic tools, and the material used is Nickel Alloy this is because the ergonomic tool requires a strong and durable material.

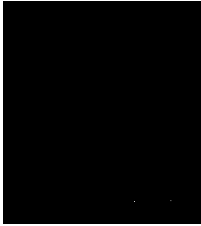
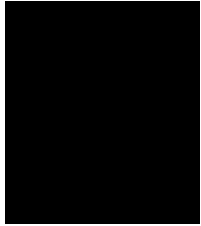
3.3 Analysis

In the analysis of the proposed tool aids were conducted to determine the condition of the operator doing his job using the better proposal work tool and did not give the effect of risk of Musculoskeletal Disorders (MSDs). The concept of the Ergonomic Proposed Working Tool can be seen in Figure 6.

**Figure 6.** Concept of Proposed Work Tools

From the concept that has been designed to do work posture analysis using RULA analysis to know the condition of Working Tools Proposed when used by the operator so that it can know the relationship with the existing condition. Analysis of differences in posture collapse can be seen in Table 4.

Table 4. Comparative Analysis of RULA Existing Work Tools and Proposed Work Tools

	Existing Work Tool	Ergonomic Work Tool
Body Posture of Worker		
Score	7	4
Analysis	Risk activity to do, so it takes investigation and make changes directly	Activity may be risky to do, so further investigation is needed and changes may be possible

Based on Table 4 the comparison between the existing work tools and the proposed work tools that have been designed to have significant differences can be seen clearly when the existing condition to move the paper sack is done by lifting, while the working aid is not charged for lifting but just stepping on the pedal to lower the paper sack without lifting, so it can affect the decline in the value of RULA which can prevent the occurrence of Musculoskeletal Disorders. As for the paper sack transport activities are reduced, this is because the tools of the proposed work can complete all activities at one work location and not fully use human labor to operate or move paper sack to the next work site, because the worker only stepped on the pedal that was useful to lower the paper sack from the next work tool the worker just pulled the paper sack with a small load.

4. Conclusion

Based on the results of data processing and analysis obtained some conclusions to solve problems at the work station packaging to reduce the risk of Musculoskeletal Disorders, among others:

1. Analysis of the RULA score is seven which means that the value can cause high work fatigue so that it must be made changes directly on the work posture. With the existence of work tools packaging proposal that has been designed to make the work posture on the operator to be ergonomic, it can be marked by the decline in the value of RULA score into four so as to reduce the risk of MSDs
2. Work tools proposed for tea packaging can reduce processing time from packaging work because all activities will be carried out in one location without the transfer of work activities that can increase work time and cause MSDs risk when operators lift loads that should not be done repeatedly.
3. In the selection of materials for the design of the working tools of the packaging of tea selected Nickel Alloy material because the material can be said ergonomically when the usage time long enough so that can be defined that the material required is a strong material and durable.

5. References

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