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Design of Auxiliary Facilities to Reduce Potential Musculoskeletal Disorders in the Product Packaging Process

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ABSTRACT

The manufacturing sector continues to grow after the Covid-19 pandemic. One of the competitiveness that supports the development of this sector is a business engaged in the packaging process. Several research studies show that packaging has a major influence on product marketability. However, not all packaging processes are managed by the product manufacturers themselves, but are left to other organizational partners. PBX is one of the organizations engaged in product packaging management. When carrying out the production process, operators experience complaints of musculoskeletal disorders, which have an impact on decreased performance and the risk of injury to operators. This is certainly a bad impact for the PBX. The REBA method is used to carry out analysis and efforts to improve work methods. This method was chosen because this method can help analyze potential injuries based on the operator's body when carrying out a work operation. The results obtained in the initial conditions of the worker's way of working, the operator's way of working is currently in the high risk category. This is indicated by the REBA value of 9. Improvement efforts to reduce this risk are carried out by using tools that can be used by operators. The results of the design improvement of assistive facilities can reduce high risk to low risk.

1. Introduction

Developments in the Indonesian manufacturing sector are currently progressing after their performance was disrupted during the Covid-19 pandemic. The hope with this development is that people's purchasing power will increase and have an impact on increasing welfare for all Indonesian people. On the manufacturing side that produces products, one of the efforts to increase sales is to produce products that are necessary and attractive to be purchased by the public. There are many approaches that provide information on how a product can increase its selling power. One approach is to improve the performance of product packaging (Klimchuk & Krasovec, 2013). In addition to this, packaging also acts as a medium of information and promotion for potential consumers (Soni & Kaur, 2023). Consumer buying behavior today is also influenced by the quality and design of product packaging (Norton et al., 2023; Kumar& Gaikwad, 2023). Although the role of packaging is important in efforts to increase sales power to consumers, not all manufacturing companies manage their own product packaging processes.

The process of collaborating with other companies to help manage product packaging processes has been carried out by many companies in Indonesia today. Apart from being known as a city of culture, the city of Yogyakarta also has a well-developed manufacturing sector. PBX is an organization with a Small and Medium Industry (IKM) scale that is engaged in making packaging (boxes) according to consumer demand.

PBX products are divided into three categories, namely large, medium and small boxes. Every month the most sold boxes are boxes in the small category. PBX can produce boxes in the form of regular boxes or boxes with patterns, plain boxes or boxes with screen printing. Not only that, consumers can also order boxes using staples or glue that functions as an adhesive. Three types of raw materials that are often used are SWM (Single Wall Medium), SWK (Single Wall Kraft), and DWM (Double Wall Medium). However, if consumers want boxes to be produced with other raw materials, this can be adjusted between the two parties. The production process at PBX starts from moving raw materials, cutting, forming patterns, screen printing, assembling and packing.

2. Method

2.1 Musculoskeletal Disorders (MSDs)

Baskaran et al., (2023) said that Musculoskeletal Disorders (MSDs) are complaints on the part of the skeletal muscles that are felt by a person. Complaints that are felt can start from mild complaints to very severe complaints. If in this condition the muscles receive loads continuously and repeatedly for a long time, it will cause a dangerous risk. This will cause the risk of damage to muscles, nerves, cartilage, joints and intervertebral discs. Transport workers usually experience complaints such as back pain, pain in the shoulders, neck, arms, elbows and legs. The upper body such as the back and arms are the parts of the body that are most susceptible to Musculoskeletal Disorders (MSDs). This is because that part of the body has to bear a heavier burden than other parts of the body.

2.2 REBA method

Wahyudi et al., (2015) said REBA is a method developed in the ergonomics area to analyze body posture in workers. This method can be used to quickly assess the working position or posture of the worker's neck, back, arms, wrists and legs. The calculation results obtained from this method will be able to know the level of risk and what kind of corrective action must be taken. The REBA method is also a more effective method in the analysis of managing material in a moving body position and is carried out manually by the operator (Liao et al, 2023). Hignett and McAtamney (2000) say that the REBA method is influenced by several factors such as external loads supported by the body, coupling and worker activities. REBA calculations are performed on all body postures using worksheets. The REBA worksheet is divided into 2 parts, namely parts A and B. In part A, namely the neck, back (trunk) and legs (legs) while in part B, namely the upper arm, lower arm) and wrist (Al Madani & Dababneh, 2016; Joshi & Deshpande, 2020).

2.3 Data Collection Stage

This data collection stage is the process of finding data and information needed in the process of applying the methods and theories to be used. In this study the data needed is primary data. This data is obtained directly from the source without going through intermediaries. The Nordic Body Map worksheet is one of the research tools used to analyze workers' complaints. Data collection was carried out by observing and interviewing informants. The data needed in this method is in the form of body angles when workers carry out activities, photos when workers move raw materials. Not only that body size, size of raw materials, the amount of raw materials that must be moved are the data needed in conducting research.

2.4 Data Processing Stage

The data processing stage is a process of processing data using the selected method. After the data is obtained, the data will be processed using the REBA (Rapid Entire Body Assessment) method. The data is processed using the REBA (Rapid Entire Body Assessment) method to analyze what factors lead to the risk of injury to the operator. This method helps to evaluate the posture, strength, load that must be borne by workers. Evaluation is carried out to reduce the risk of back and other injuries to workers.

a. Perform a posture analysis

Body posture analysis is the process of analyzing body posture from the results of REBA calculations. If the results of the assessment using the REBA method get a high score, then suggestions for improvements are made.

b. Making Improvement Proposals

Proposal for improvement is the process of providing suggestions to achieve the objectives of this research. If the REBA score is high, suggestions for improving the operator's posture can be made. Proposed improvements can be made after the authors carry out an analysis on posture and the risk of MSDs in operators. This is done to reduce the risk of injury to the operator.

2.5 Improvement Evaluation Stage

The improvement evaluation stage is an identification process to measure or assess the results of the improvements that have been made. This stage determines whether the results of the proposal can solve existing problems or not. If the results of the proposals implemented can fix existing problems, then the research can be said to be successful. If the results of the proposal do not show improved results, then the proposed improvement is repeated.

2.6 Completion Stage

The completion stage is the final stage in the research which briefly explains the results of this research. At this stage it is divided into two, namely conclusions and suggestions. The conclusion is the final result obtained from the research conducted. The conclusion explains the results of the comparison before and after the implementation of the results of the research conducted. While suggestions are things that are done to provide suggestions for implementing the results of research with the aim of reducing the risk of injury to workers.

3. Results and Discussion

3.1 Efforts to reduce the value of REBA.

The results of the assessment of the current working methods of the three operators fall into the high risk category. The assessment is carried out by measuring the REBA value and obtaining a score of 9. Based on observations and analysis of current work methods, the following information is obtained:

a. The REBA value of 3 operators is 9, which means that the way of working is in the high risk category.
b. The dominant activity carried out by the operator is the activity of lifting material.
c. The weight of the material lifted is an average of 25 Kg.

The next analysis process is to make an assessment if the work method is carried out regardless of the weight of the material. This is done to see the impact of material weight on the potential for injury in the current way of working. The rest of the body position does not change. The results of calculating this REBA value can be seen in Table 1. Results of analysis 1.

Table 1. Results of analysis 1

Step	Value (Operator 1)	Value (Operator 2)	Value (Operator 3)
Step 1: Locate Neck Position	2	2	3
Step 2: Locate Trunk Position	2	2	2
Step 3: Locate Legs Position	3	1	2
Step 4: Look-p Posture Score in Table A	5	3	5
Step 5: Add Force/Load Score	0	0	0
Step 6: Score A	5	3	5
Step 7: Locate Upper Arm Position	1	4	2
Step 8: Locate Lower Arm Position	2	2	2
Step 9: Locate Wrist Position	2	2	2
Step 10: Look-up Posture	2	6	3
Step 11: Add Coupling Score	0	0	0
Step 12: Score B	2	6	3
Step 13: Activity Score	2	2	2
Final REBA Score	6	7	6

From the calculation results in table 1. it can be seen that the REBA value has decreased. The REBA value for the three operators fell from 9 which is classified as high risk to 6 for operators 1 and 3, and to 7 for operator 2 which is considered medium risk. So, in this study improvements will be made to lifting activities, namely by proposing a pushing device to reduce the risk of injury.

3.2 The proposed design of the assistive device facility lowers the REBA value.

Based on the results of the analysis in table 3.1, it is hypothesized that by designing a push-aid facility it can reduce the work potential of the current operator. The design process is carried out by observing the tools that are currently available on the market. This is done to reduce the required design time. From the observation results, it is obtained that the design of the tool already exists on

the web: www.costway. Based on the existing design, improvements to the design are carried out according to anthropometric data from operators working at the work station in question. The application used to improve this design uses Catia V5R20 software. The results of the new design will be analyzed with the help of the Mannequin application to calculate REBA values. Figure 1 shows the designs that are currently on the market.

Fig. 1. Product Design in the current Market.

(Source: https://www.costway.com/handling-heavy-duty-sheetrock-sheet-panel-service-cart.html##)

Improvement design was carried out in this study by adapting to operator anthropometric data in the company. Another consideration that needs to be considered is that the material being transferred is cardboard sheets which have non-rigid physical properties. The following things are considered in designing improvements to the assistive device facilities so that they can be used by operators in the company:

a. The material being moved is cardboard sheets which have non-rigid physical properties.
b. Cardboard sheets have stacking & support limits to prevent warping.
c. Auxiliary facilities can pass through the aisle of the raw material warehouse and the production floor.
d. The auxiliary equipment can be operated comfortably by the operator.

Based on these considerations, the improved design is obtained as shown in Figures 1, 2, 3, 4, 5 and Figure 6.

Fig. 2.. Tool Design

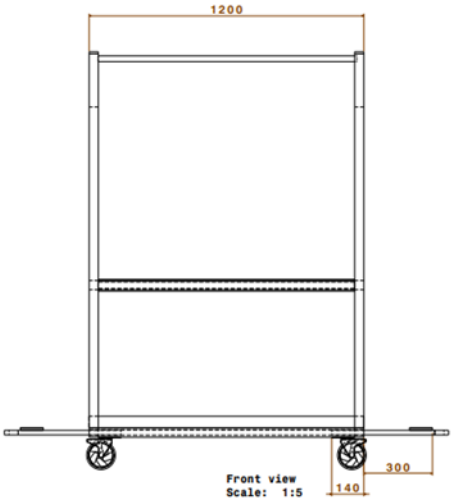

Fig. 3. Front View Tool Design

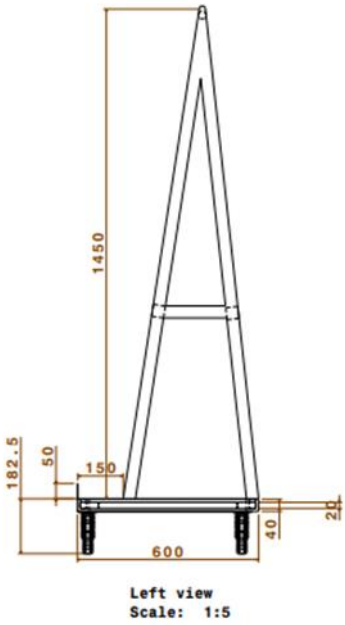

Fig. 4. Side View Tool Design

This design also has an additional function on the base which size can be adjusted according to needs. The base size can be extended to a maximum size of 30 cm on the right and left sides. The following illustration can be seen in Figure 5 and Figure 6

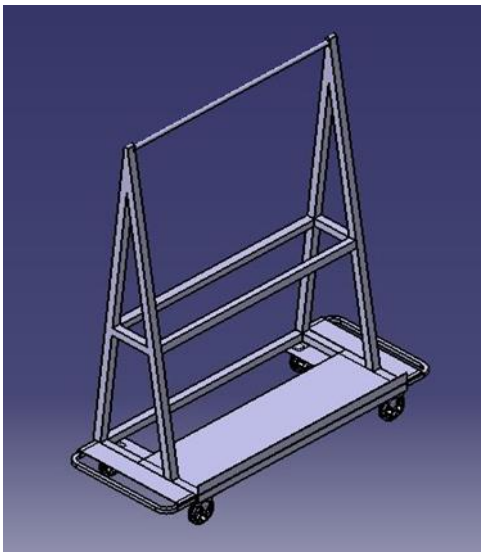

Fig. 5. Design of a Push Aid with Normal Base Size

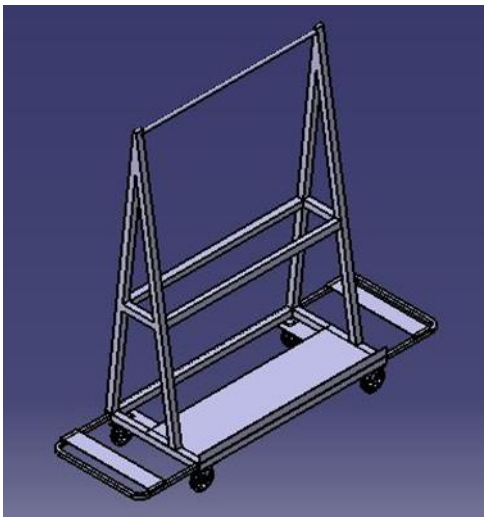

Fig. 6. Push Aid Design with Extended Base Size

The results of the improvement design of the tool facility are then analyzed when used by the operator. The results of the comparison of REBA values before and after using the tool can be seen in table 2

Table 2. Comparison of REBA Scores Before and After

Step	**Before Repair**			**Value (After Repair)**
	Value (Operator 1)	Value (Operator 2)	Valuei (Operator 3)	
Step 1: Locate Neck Position	2	2	3	1
Step 2: Locate Trunk Position	2	2	2	1
Step 3: Locate Legs Position	3	1	2	1
Step 4: Look-p Posture Score	5	3	5	1
Step 5: Add Force/Load Score	2	2	2	0
Step 6: Score A	7	5	7	1

Step 7: Locate Upper Arm Position	1	4	2	2
Step 8: Locate Lower Arm Position	2	2	2	1
Step 9: Locate Wrist Position	2	2	2	3
Step 10: Look-up Posture	2	6	3	3
Step 11: Add Coupling Score	0	0	0	0
Step 12: Score B	2	6	3	3
Step 13: Activity Score	2	2	2	1
Final REBA Score	9	9	9	2

In table 1. it can be seen that the value in REBA has decreased from 9 which is included in high risk to 2 which is included in low risk. The value of each part of the operator's body has decreased a lot, especially in the force/load, forearm, and activity scores. In force/load from 2 to 0 because after carrying out the repairs the operator no longer lifts manually, but instead pushes with tools. The forearm no longer gets a score of 2 because it is already at a good angle when moving raw materials. The activity score also decreased from 2 to 1, because during the process of moving raw materials the operator's posture became stable after repairs were made. The wrist posture did not decrease. This is due to the human tendency to do this in a position when pushing. After using this pusher it doesn't cause any new problems. However, in the activity of unloading and transferring raw materials from this pusher to the cutting table, it remains in the old position before the repair was carried out.

3.3 Proposed ways of working.

Based on the results of the assessment of the previous work method, the following is a proposed new way of working using the new assistive facility design. This new way of working also introduces a safer way of working with a smaller risk of injury. The details of how it works are as follows:

a. Material transfer is no longer done by lifting manually but by pushing with tools.
b. The position of the body does not twist or bend when moving the material, to avoid potential pain to the operator.
c. The weight supported by the operator's body does not exceed 10 Kg.
d. Avoid bending the operator's leg chart.

Figure 7 is a way of moving material with the proposed working method

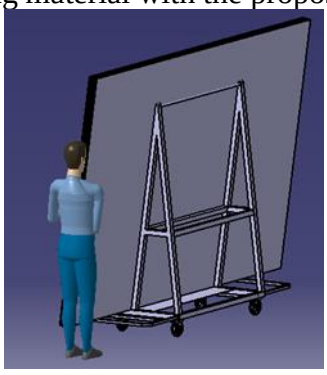

Fig. 7. Process of Transferring Raw Materials with Push Aid Devices

4. Conclusion

The conclusions obtained in this study are as follows: The position of the operator in carrying out the current work method is included in the high risk level category. This shows the need for efforts to improve work methods to reduce the potential for operator injury. Proposals for improving work methods to reduce the risk of injury are carried out using specially designed assistive devices, namely in the form of a pushing device. These tools can reduce the risk of injury in the material transfer process. This is evidenced by the decrease in the value of REBA between before and after using the tool. So based on the REBA value it can reduce the risk of injury from high to low.

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