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Improving Packer Machine Operators' Working Methods Considering REBA, RWL, and CTDs Analysis

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ABSTRACT

To support the production activities to maintain a good production activity, the company should concern on the operators' health and productivity by providing proper working condition and tools considering the ergonomics aspects. This observation was conducted for operators in handling Bobbin Film Pack materials manually in cigarette company. The problem solving is analyzed by assessment of REBA, RWL, and CTDs. After analyzing the current working posture and lifting method from all of the chosen operators, the root causes were found. The result shows the bad working conditions which are the incorrect working methods and tools. The proposed improvements are used to provide better working condition, which are the new design of materials pallet that suiTable with the ergonomics aspects.

Keywords: ergonomics, working posture, REBA, RWL, CTDs, design of materials pallet

ABSTRAK

Untuk mendukung kegiatan produksi dalam rangka menjaga aktivitas produksi yang baik, perusahaan harus memperhatikan produktivitas dan kesehatan operator dengan menyediakan kondisi kerja dan peralatan yang sudah mempertimbangkan aspek ergonomi. Pengamatan ini dilakukan terhadap operator dalam penanganan material dari *Bobbin Film Pack* secara manual di perusahaan rokok. Pemecahan masalah dianalisis melalui penilaian REBA, RWL, dan CTDs. Setelah menganalisis keadaan sekarang dari postur kerja dan metode pengangkatan dari semua operator yang dipilih, maka akar penyebabnya ditemukan. Hasilnya menunjukkan kondisi kerja yang buruk merupakan penyebab metode dan alat kerja yang tidak benar. Proses perbaikan diusulkan untuk memberikan kondisi kerja yang lebih baik, yaitu dengan merancang baru palet material yang sesuai dengan aspek ergonomi.

Keywords : ergonomi, postur kerja, REBA, RWL, CTDs, palet

1. Introduction

Health and safety are the important combination to support every activities done by the workers in the company, especially for the operators in manufacturing industry. Everyone knows that one of the company's aim is to gain profit as much as it could and this opportunity is supported by the condition of the operators. For the big manufacturing company, the alternative to increase the profit is by using machines that help the operators finishing their jobs and making the production activities faster, smoother, and giving better finished goods. Since the machines can not work by itself and can not insert the materials automatically, machines need the operators' roles to do those activities, and it becomes the main jobs that should be done by the operators in repetition every day. Those activities are called manual material handling.

PT. PMI is a leading company that works in manufacturing field which produce cigarettes in huge amounts. This company uses big size and complex machines for producing the cigarettes to have more finished goods with better result in shorter time. There are also some operators that directly in charged to run the machines. All operators should put the materials into the machines to make it works every day in repetitive actions, especially for packaging activities, because there are so many materials involved and should be inputted manually by operators. Doing those activities force the operators to do some heavy, rapid, and repetitive activities with the shocking distance movements that maybe exceed their body limitation, sometimes the operators do the activities with the random posture and lifting strategies to make their jobs seemed easier, even if they do the jobs in the improper ways. A study related to working performance for repetitive works also

have been conducted (Shikdar *et al*. [1]). Those repetitive activities may cause some common body illness to be happened that may attack their body health and immune system and may ruin the production activities.

The common body illness that usually happens in this kind of repetitive situation is Cumulative Trauma Disorders (CTDs). The rate of complaints from the operators for having back pain, painful, soreness, and cramps during working hours are quite high from the operators based on the preliminary observation by informal interview, and it will give bad effects on production activities. Because, as the operators get the body illness from the incorrect working posture, absolutely, the health condition of the operator will be decreasing, the efficiency of the production will be decreasing, and the safety of the operators and production activities can be in danger. Thus, company should take some actions to prevent the failures and accidents to be happened. In this kind of case, the company should do some improvements in management and production point of views to prevent the worst conditions.

Based on the problem background, the objective statements of this research are:

1. To analyze the current ooperators' working condition for manual material handling.
2. To analyze the effect of current working condition to the risk of CTDs.
3. To provide a suitable working condition for operators.

2. Methods

In analyzing the operator's working posture of his job, is assessed through the ergonomics concept. Ergonomics is the study of people at work (Lehto & Buck, 2008). Ergonomics is the the science of work : of the people who do it and the ways it is done, the tools and equipment they use, the places they work in, and the psychosocial aspects of the working situation (Phesant, 2003). Therefore, the human activity is carried out, both in factories, offices, social life, and other activities should be organized and managed in such a way, so that it can put people as being humane and natural. People can show their optimal performance by considering the capabilities and limitations (Pulat, 1992). However, for simplicity, ergonomics makes things comfortable and efficient (Adams, 2009). In outline of assessment methods to assess the operator's working posture is presented in a flow diagram and shown in Figure 1.

2.1 Assessment Methods

There are some methods that can be used to provide a good working condition and tools by analyzing the current condition using qualitative and quantitative data analyses. For qualitative data analysis, the method that can be used is Rapid Entire Body Assessment (REBA**)** that is more focus on the working posture and for quantitative data analysis, the method that can be used is Recommended Weight Limit (RWL) that is more focus on lifting method. For analysis on complaint or pain which is perceived by operator as a result of doing a job, the method that can be used is Cumulative Trauma Disorders (CTDs).

2.2. Rapid Entire Body Assessment (REBA)

REBA (Rapid Entire Body Assessment) is a method of scoring and evaluating the targeted body posture of human while doing critical activity with heavy and rapid condition. REBA is developed by Sue Hignett and Lynn McAtamney (Hignett McAtamney, 2000) REBA is used as the qualitative approach in ergonomic to analyze the working posture of human while doing the specific activity. REBA can be done in a short time duration by watching assessed people doing the job while the examiner assesses using the REBA form.

The human body is divided into two groups for the Rapid Entire Body Assessment, which are Group A that consists of trunk, neck, and legs, for the Group B that consists of upper arms, lower arms, and wrists. The scores later will be calculated by adding the other considerations such as weight of the object, the condition of working, etc. For manual calculation, the score for each point in part A and B should be calculated. Nevertheless, there are so many software that can be used to help in observing the REBA result.

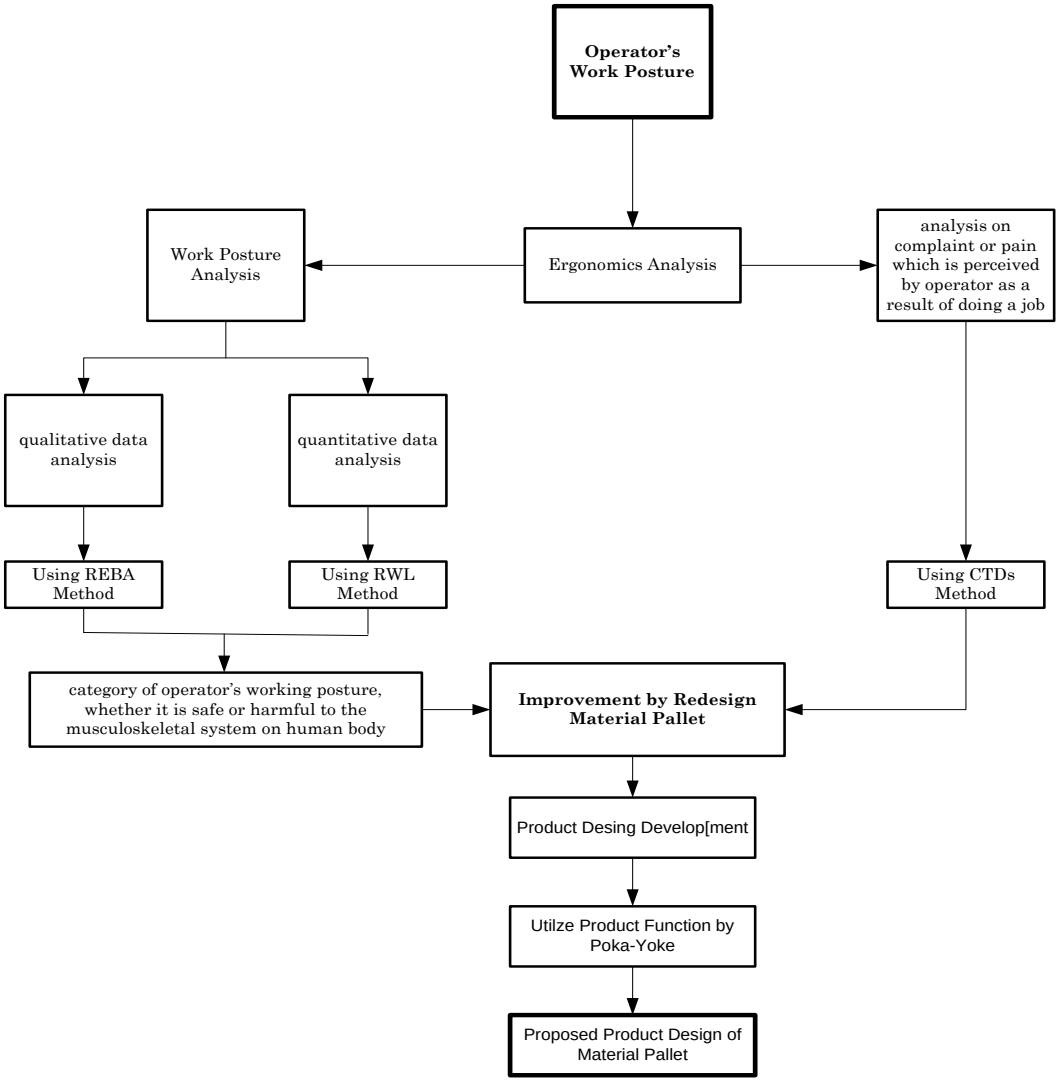


Figure 1. Assessment methods

2.3 Recommended Weight Limit (RWL)

RWL is the maximum weight of materials that can be handled manually by relative estimation of level of physical stress and CTDs risks, which is Lifting Index (LI). RWL has been developed by NIOSH in 1991. RWL is used to analyze the proper limits and weight in handling materials, also to analyze the limit of human body in handling a material with specific weight and method (Lehto and Buck, 2008). A good lifting index value should be less than 1.0. Below is the formula to calculate the RWL value and the Lifting Index.

$$RWL = LC\ x\ HM\ x\ VM\ x\ DM\ x\ AM\ x\ FM\ x\ CM \quad (1)$$

Where,
LC = Loading weight (23kg)
HM = Horizontal multiplier of the object relatives to the body (25/H)
VM = Vertical multiplier of the object relatives to the body (1-(0.003[V-75]))
DM = Distance multiplier of the object that moves vertically (0.82+4.5/D)
AM = Asymmetry multiplier of twisting movement (1-(0.0032 A)
FM = Frequency multiplier of lifting activity (in Table)
CM = Coupling multiplier or the quality of handling material (in Table)

$$LI = \frac{Weight}{RWL} \quad (2)$$

2.4 Cumulative Trauma Disorders (CTDs)

Manual material handling by definition refers to a workers using their hands to bodily lift and handle materials (Reese, 2000). It is a transportation activity done by the workers that consists of handling, lifting, pulling, pushing, grabbing, and moving materials from one place to another. Those movements will cause higher risk of repetitive stress because most people usually do manual handling activities without any handling standards or methods. Incorrect manual material handling will cause injuries or disorders or failures for worse.

Cumulative Trauma Disorders is a group of physical disturbance musculoskeletal system on human body (Ranney *et al*, 1995 in Salvendy, 2012). It against the neuron system, muscle, bones, and the extreme points on human body. It mostly happens in human's body parts that are overused for some activities in repetition without good working guidelines, such as neck, shoulders, arms, hips, waist, wrists and fingers, calf, knee, and feet. A heavy repeated activity may cause fatigues in some body parts on human body that may create a bad musculoskeletal system and affect other on going activities. There are two kinds of factors that may cause the risks of CTDs, the details are written below.

- Human
  - Age
  - Gender
  - Physical Condition
  - Anthropometry
- Working Activities
  - Repeated Activities
  - Overused Body Capability
  - Manual Handling
  - Improper Working Tools

Product Design Development

Product design development is a set of activities start with analyzing the market opportunity until the production process, sales, and delivery process. There also several consideration in designing a product. The characteristic of successful product development are (Ulrich and Eppinger, 2013):

- Product quality should satisfy the customer needs
- Product cost, to determine the profit for the company
- Development time should be in short time
- Development capability to ensure that the product is effective.

Poka-Yoke

Poka-Yoke is one of product design and development with more concerns on avoiding mistakes of the product usage Poka-Yoke itself comes from Japanese word which means mistake proofing (Tooley, 2010). The objectives of using Poka-Yoke as supporting method for product design and development are:

- To reduce the inspections activity
- To avoid any mistakes.
- To provide zero defects.

3. Result and Discussion

The research was conducted in secondary multibrands area of PT. PMI, especially for packer machines. The details of information for secondary multibrands area, operators, and the observed material which is Bobbin Film Pack, are shown respectively in Table 1 until Table 3.

Table 1. Detail information of secondary multibrands area

Points	Details
No. of Production Zone in Secondary Multibrands Area	3 Production Zone
No. of Production Line in Secondary Multibrands Area	12 Production Lines
No. of Production Line in Production Zone	4 Production Lines
No. of Packer Machine in Production Line	1 Packer Machine

This research discussed about manual materials handling activities that should be done by packer machine operators in handling bobbin film pack material as heavy as 7.14 kg from current materials pallet to packer machine. Figure 2 below shows the current condition of materials pallet and working methods that have been done by the operators which contain risks of CTDs.

Table 2. Detail information of operators

Points	Details
No. of Shift in Secondary Multibrands Area	4 Group Shift
No. of Operator in Production Line	1 Operator
No. of Operator in Secondary Multibrands Area/ Shift	12 Operators/ Shift
No. of Operator in Secondary Multibrands Area	48 Operators

Table 3. Detail information of material

Points	Details
Name of Material	Bobbin Film Pack
Weight of Material	7.14 kg
Frequency of Used/ Shift	230 Bobbin Film Pack/ Shift
Function of Material	Wrap the Packaging of Cigarettes
Diameter of Material	32 cm
Width of Material	12 cm

According to the data collected during the observation, which are the REBA and RWL assessments, also the CTDs questionnaires result to strengthen the complaint from operators related to working illness experiences, it is shown that from three production zones that have been observed, operators in production zone 1 got the worst assessment results. Below is the manual calculation for REBA and RWL results followed by software calculations, then followed by CTDs result.

(a) (b) (c) (d)

Figure 2. (a) front view of current materials pallet; (b) side view of current materials pallet; (c) working methods from middle side of materials pallet; (d) working methods from bottom side of materials pallet

REBA Calculation

For REBA, the assessment is done by filling the score box for each body part based on each steps, then the result in some boxes will be combined to find the score for each part. For example, as shown in Figure 3, after being assessed, Achmad Buhori, the Operator who handles the materials from the middle part with straight body, good handling and coupling for materials as heavy as 7.14 kg got REBA score as 3, which is in low REBA risk level.

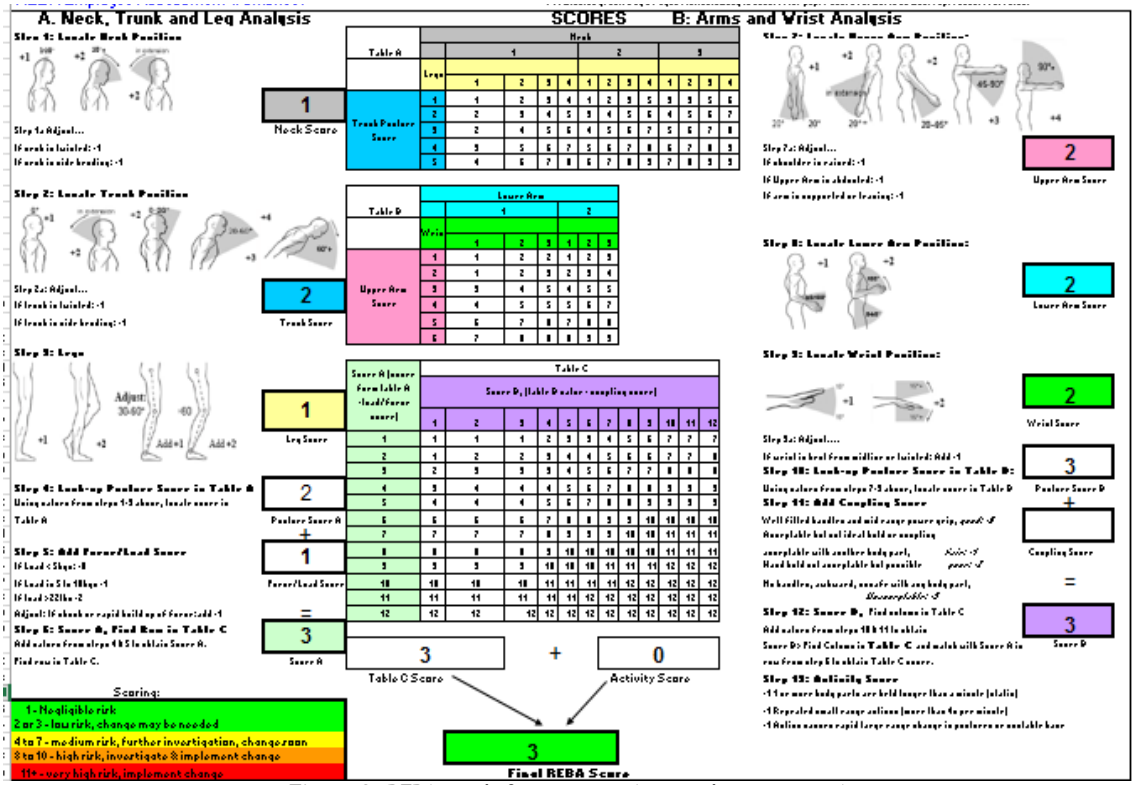


Figure 3. REBA result for operator 1 in production zone 1

RWL Calculation

For RWL, the assessment is done by evaluating both origin and destination of handling activity, which is handling bobbin film pack materials from current materials pallet and to the packer machine. The manual calculation is written below. Known that Achmad Buhoari handles bobbin film pack with variable of RWL are :

H_o	: 34 cm	A_d	: 90°
H_d	: 50 cm	Frequency	: 2 lifts/ min = 0.65
V_o	: 65 cm	Coupling	: Good = 1
V_d	: 170 cm	Weight	: 7.14 kg
A_o	: 0°		

- Origin Calculation (Materials Pallet)
  $HM_o = 25/H_o = 25/34 = 0.735$
  $VM_o = 1 - (0.003|V-75|)$
  $= 1-(0.003|65-75|) = 0.97$
  $DM_o = 0.82+4.5/D = 0.82+4.5/105$
  $= 0.862$
  $AM_o = 1-(0.0032A) = 1-(0.0032 \times 0) = 1$
  FM = 0.65
  CM = 1
  RWL = LC x HM x VM x DM x AM x FM x CM
  = 23 x 0.735 x 0.97 x 0.862 x 1 x 0.65 x 1
  = 9.187
  LI = weight/ RWL = 7.14/9.187
  LI = 0.777
  The Lifting Index for origin is below 1, which means safe for the musculoskeletal system on human body.
- Destination Calculation (Packer Machine)
  $HM_o = 25/H_o = 25/50 = 0.5$
  $VM_o = 1 - (0.003|V-75|)$
  $= 1-(0.003|170-75|) = 0.715$

DM_o = 0.82+4.5/D = 0.82+4.5/105
= 0.862
AM_o = 1-(0.0032A) = 1-(0.0032 x 90) = 0.712
FM = 0.65
CM = 1
RWL = LC x HM x VM x DM x AM x FM x CM
= 23 x 0.5 x 0.715 x 0.862 x 0.712 x 0.65 x 1
= 3.28
LI = weight/ RWL = 7.14/3.28 = 2.17

The Lifting Index for destination is above 1, which means harmful for the musculoskeletal system on human body and needs improvements.

CTDs Result

CTDs Questionnaire has been distributed to prove the complaints from operators related to working illness experiences. The CTDs questionnaire is divided into 2 parts, the first part discusses about the details information about the operators and the daily habits, the second part discusses about the CTDs that they feel during working hours in specific frequency level. The observed body parts are divided into 3 groups to make the observation and analysis become simpler and easier, which are neck, shoulder, wrist and fingers, lower arm, and upper arm as body part A, upper hips, middle hips, lower hips, upper waist, and lower waist as body part B, and knee, calf, and feet as body part C.

Improvements of Material Pallet

After conducting the REBA and RWL assessments, also CTDs questionnaires, the improvements should be proposed to provide suiTable working condition and reducing the risks of Cumulative Trauma Disorders for operators in packer machine. The proposed improvements are designing a product to support the working activities, especially for manual materials handling. For designing a supporting product for the improvements, should pass some steps and considerations, which is by product design development process.

Product Design Development

For Product Design Development, there are some steps should be done according to Ulrich and Eppinger (2013). This step lead to find out the most suitable product to be developed based on some considerations compared with some options.

1. Development Process
   This step mostly known as brainstorming activity which consists of collecting any ideas related to improvements for supporting the condition that should be improved. For this research, the ideas collected are adjusTable mobile stairs and materials pallet.
2. Product Planning
   Based on beginning considerations, such as the capability and ability of the company to implement the improvements, the chosen product is materials pallet. There are two proposed designs for materials pallet, which are materials pallet with FIFO features which called Alpha and materials pallet with Poka-Yoke features which called Beta.
3. Identifying the Customer Needs
   In this steps, the general customer needs are mentioned to be compared with the features offered by each materials pallet design. The specific customer needs will be compared in next step. Figure 4 below shows the general and specific customer needs to be compared by the features offered by each materials pallet.
4. Product Specification
   This step explains about the product specifications for each materials pallet, such as the maximum load capacity, the features offered, and the designs of materials pallet. For Alpha Materials Pallet, the AutoCAD design is attached in Appendix 1 and for Beta Materials Pallet, the AutoCAD design is attached in Appendix 2.
5. Concept Generation
   This step consists of comparisons of specific customer needs to metrics for each materials pallet in form of a Table to provide the clearer information. Also, the benchmarking activity for comparing Alpha and Beta Materials Pallet based on some considerations and needs importance. Table 3 below shows the details of benchmarking activity for Alpha and Beta designs.

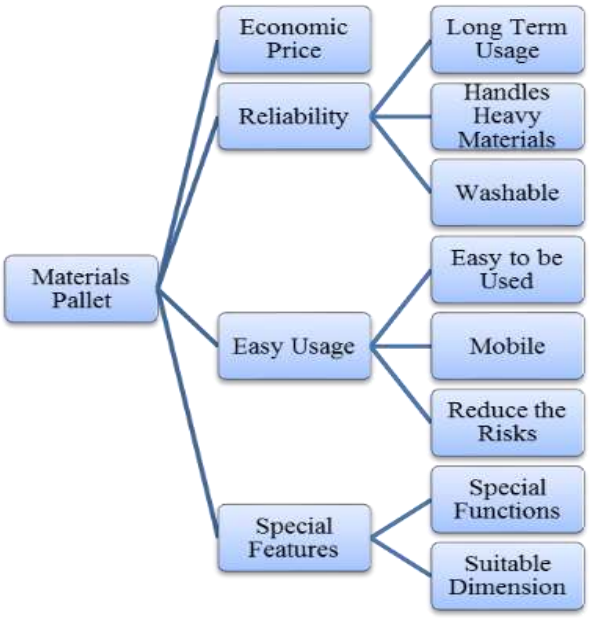


Figure 4. The customer needs

6. Concept Generation
   This step consists of comparisons of specific customer needs to metrics for each materials pallet in form of a Table to provide the clearer information. Also, the benchmarking activity for comparing Alpha and Beta Materials Pallet based on some considerations and needs importance. Table 4 below shows the details of benchmarking activity for Alpha and Beta designs.

Table 4. Benchmarking activity

Needs	Imp.	Alpha	Beta
1. Easy to be used	3	**	***
2. Reduce the risks	4	**	***
3. Economist	3	**	***
4. Long term usage	4	**	***
5. Mobile	3	***	***
6. Washable product	3	***	***
7. Provide special functions	4	****	***
8. Suitable and proper dimension	4	***	***
9. Handles heavy materials	4	***	****

7. Concept Selection
   This is the last step of product design development, after passing some steps before, which mostly about discussing the product specifications and features offered compared with the customer needs, here is the discussion of product cost and product selection activity. Table 5, Table 6, Table 7, and Table 8 show the Table for product cost for each materials pallet that consist of labor and materials cost.

Table 5. Labor cost for alpha

No.	Details	Amount	Total
1	Labor Cost	1 Month (22 Days)	3.500.000
2	Duration for Creating a Product	3 days	477.272
3	No. of Workers	2	954.545

Table 6. Material cost for alpha

No.	Items	Amount	Price	Total Price
1	Anchor Bolt (16 mm)	2	12.000/ item	24.000
2	Hollow Iron (ø3cm x 90 cm)	47	89.000/m	3.764.700
3	Hollow Iron (ø3cm x 194 cm)	6	89.000/m	1.035.960
4	Hollow Iron (ø3cm x 18 cm)	4	89.000/m	64.080
5	Hollow Iron (ø3cm x 70 cm)	4	89.000/m	249.200
6	Connector	90	4.000/pcs	360.000
7	Plastic Board (160 cm x 90 cm)	3	689.000/sheet (2m x 1m)	2.067.000
8	Plastic Separators 10 x (160 cm x 5cm)	1	689.000/sheet (2m x 1m)	689.000
9	Wheels (ø4 inches)	4	167.500	670.000
10	Bolts and Nuts (Pack)	170	1.150/pcs	195.500
Total				9.119.440

Total Cost for Alpha = Labor Cost + Materials Cost
= 954.545 + 9.119.440
= IDR 10.073.985

Table 7. Labor cost for beta

No.	Details	Amount	Total
1	Labor Cost	1 Month (22 Days)	3.500.000
2	Duration for Creating a Product	2 days	318.181
3	No. of Workers	2	636.636

Table 8. Material cost for beta

No.	Items	Amount	Price	Total Price
1	Hollow Iron (ø3cm x 160 cm)	4	89.000/m	569.600
2	Hollow Iron (ø3cm x 98 cm)	48	89.000/m	4.186.560
3	Hollow Iron (ø3cm x 170 cm)	4	89.000/m	605.200
4	Hollow Iron (ø3cm x 18 cm)	2	89.000/m	32.040
5	Hollow Iron (ø3cm x 25 cm)	4	89.000/m	89.000
6	Connector	100	4.000/pcs	400.000
7	Plastic Board (160 cm x 98 cm)	3	689.000/sheet (2m x 1m)	2.067.000
8	Plastic Separators 13 x (160 cm x 5cm)	1	689.000/sheet (2m x 1m)	689.000
9	Wheels (ø4 inches)	4	167.500	670.000
10	Bolts and Nuts (Pack)	240	1.150/pcs	276.000
Total				9.584.400

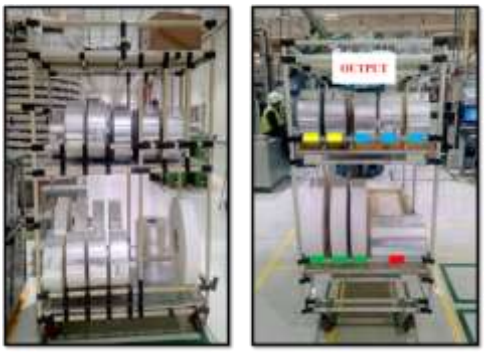
Total Cost for Beta = Labor Cost + Materials Cost
= 636.636 + 9.584.400 = IDR 10.221.036

Based on product cost, the Beta Materials Pallet has more expensive price for developing a product with a slight difference with Alpha Materials pallet. Table 9 below shows the concept selection that consists of some considerations according to the needs and weight, then the scoring activity is done by giving scores for each materials pallet according to the customer needs and features offered.

Table 9. Concept selection

		Concept Scoring of the Materials Pallet			
		Alpha		Beta	
Selection Criteria	Weight	Rating	Score	Rating	Score
Easy to use	10%	3	0.3	4	0.4
Safe	10%	4	0.4	4	0.4
Economist	10%	4	0.4	4	0.4
Long-term usage	20%	3	0.6	4	0.8
Mobile	10%	5	0.5	5	0.5
Cleanliness	5%	4	0.2	4	0.2
SuiTable dimension	20%	4	0.8	4	0.8
Input and Output System	15%	4	0.6	3	0.45
Total	100%		3.8		3.95

Based on the concept selection activity, the result shows that Beta Materials Pallet with Poka-Yoke features is chosen because it has greater score than Alpha Materials Pallet. Figure 6 and Figure 7 show the real picture of comparison between current materials pallet with Beta Materials Pallet with Poka-Yoke feature to avoid the mistakes for inputting and outputting materials.



(a) (b)

Figure 6. Front view comparison of (a) current materials pallet and (b) beta materials pallet

(a) (b)

Figure 7. Side view comparison of (a) current materials pallet and (b) beta materials pallet

REBA and RWL Re-Assessments

After being implemented, the assessments for REBA and RWL were conducted again to check whether the improvements are significantly effecting or not. The assessments concern in the same manual material handling activity with the same materials, the differences are the materials pallet that is used which is Beta Materials Pallet with Poka-Yoke features.

For Rapid Entire Body Assessment, after conducting the re-assessment using improvements, the result shows that there is a significant effect from the improvements to the working condition. All operators in production zone 1 got low risk level, it is different with before improvements condition which operators in production zone 1 got low until very high risks level. It is because the working posture and methods have been improved by Beta materials pallet as the supporting tools.

For Recommended Weight Limit, after conducting the re-assessment using improvements, the result shows that there is a significant effect from the improvements to the working condition. All operators in production zone 1 have Lifting Index below 1 for origin, since the improvements can only be done for origin, it is different with before improvements condition which operators in production zone 1 got various Lifting Index, including Lifting Index upper 1 for origin. It occurred, because the working posture and methods have been improved by Beta materials pallet as the supporting tools.

4. Conclusion

The current working condition in PT. PMI has not been suiTable enough to support the working activities for operators in manual materials handling activities in repetitive actions, moreover, it is supported by the rate of complaints from operators related to working illness experiences, which is known as CTDs.

The assessments to evaluate the current working condition were applied using REBA and RWL. After the assessments have been distributed, the results show that production zone 1 got the worst REBA and RWL results with until 9 operators who got bad result in REBA and RWL assessments. To ensure and prove the complaints from operators related to working illness experiences, the CTDs questionnaires are distributed, the result shows that many operators got working illness experiences in some areas of for wrist and fingers, hips, waist, and feet for high frequencies.

The proposed improvements are re-designing materials pallet. After passing the product design development process to find the most suiTable materials pallet for supporting the working activities, comparing the proposed designs with FIFO and Poka-Yoke supporting methods, based on some considerations, the materials pallet with Poka-Yoke features is chosen.

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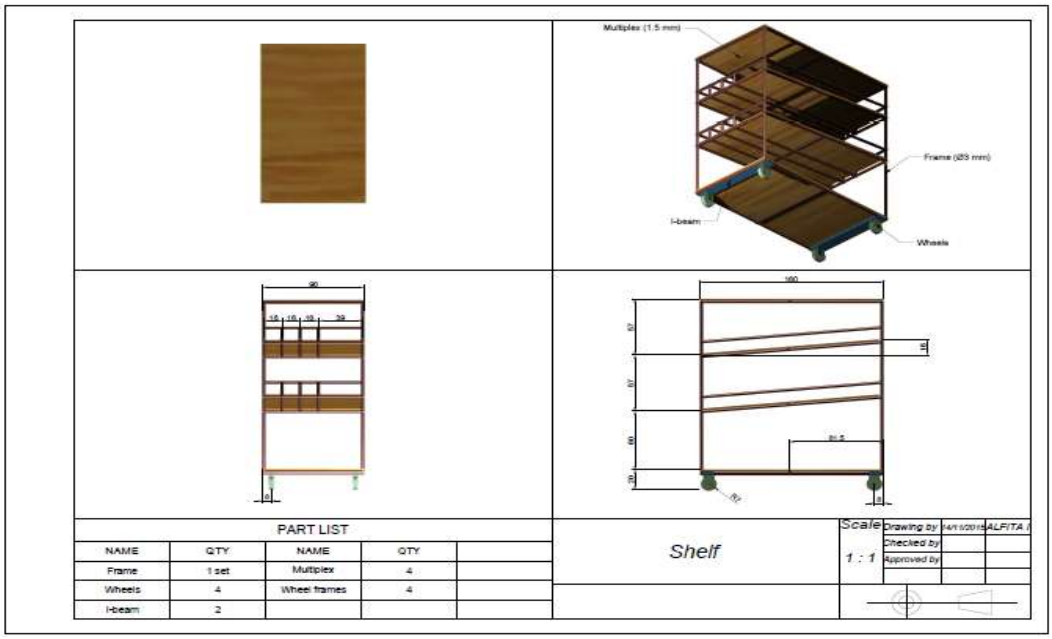
Appendix

Appendix 1. Alpha Materials Pallet



Appendix 2. Beta Materials Pallet