WORKING AIDS DESIGN BY USING 5-STEP METHOD BASED ON REBA AND RULA ANALYSIS TO REDUCE THE RISK OF LOW-BACK PAIN INJURY
A Case Study in Brickworks Center in Potorono, Banguntapan, Bantul

Wahyu Sidiq Saputra[1], Trio Yonathan Teja Kusuma[2]
[1]Student of Post Graduated Program of Industrial Engineering, Faculty of Industrial Engineering, Universitas Islam Indonesia Yogyakarta.
Jl. Kaliurang Km 14.5, Sleman, Yogyakarta, Telp 0274-898444
[2]Department of Industrial Engineering, Faculty of Science and Technology, UIN Sunan Kalijaga Yogyakarta
Jl. Marsda Adisucipto Yogyakarta, Telp 0274-512474
Email : wasidsap@gmail.com , trio.yonathan@gmail.com

Abstract

Brickworks Center in Potorono is the center of brickworks which is quite large in Bantul and produces high amount of both raw bricks, which has not been burned yet, and the mature bricks, or the burned one. Manual material handling work on the activity of brick production has high risk of causing spinal injury (low-back pain). This research aims to analyze the activity of material handling work by using Rapid Entire Body Assessment and Rapid Upper Limb Assessment approaches and also create design proposal by using 5-Step Method of Concept Designing to design working aids which can applied to improve working posture. From the data assessment and analysis, the result of Rapod Entire Body Assessment score on the first posture is 9, second posture is 4, third posture is 8, fourth posture is 5 and the score of Rapid Upper Limb Assessment is all 7, which in general, those scores are potential to have high risk of low-back pain so that it needs improvement of working postures. The improvement of working posture has carried out by creating Roller Conveyor Modification to reduce the risk of low-back pain injury. The final result after improvement has been carried out is the score of Rapid Entire Body Assessment is 1 and the score of Rapid Upper Limb Assessment is 3, which show decreasing score.

Keywords: REBA; RULA; 5-Step Method; Scoring Concept; Working Aids; Product Design

Preliminary
Background

A producer should not rule out the role of its human resources (HR), because product quality cannot be separated from it. However, in this era, most industries only emphasize quality, quantity, management and marketing, so they do not pay attention to the comfort and as well as safety and occupational health factors of workers. This has actually been regulated in article 86, Law No. 13 of 2013, In order to protect the safety of workers/laborers and to realize optimal productivity, an occupational health and safety scheme shall be administered.

The brickworks center in Potorono, Banguntapan, Bantul, is a micro-enterprise which can be said to have done the entire production process with human labor. Obviously, this makes it very likely that there are activities where the workers have wrong work posture so that they are at risk of low-back pain injury which can certainly harm the health and safety of the workers themselves. In this brickworks center, the production process always involves workers, meaning that in every part or type of work there must be an MMH (Manual Material Handling). One reason why there are still many who use Manual Material Handling is because it has advantages in the flexibility of movement that can be done for light loads. However, handling the production process without using tools or in the sense of MMH also has a pretty serious risk, these activities can cause low-back pain due to manual handling of work with an incorrect body position in doing work movements and material loads that are quite heavy.

Thus, it is necessary to anticipate this, business owners need to pay attention to the comfort of their workers so that their health and safety are guaranteed. This can be done by adjusting workers with work

methods, work processes and the work environment. This approach is known as the biomechanical approach which in this context is called REBA (Rapid Entire Body Assessment) and RULA (Rapid Upper Limb Assessment) analysis. This analysis serves to analyze bad work posture which has risk of low-back pain. After the analysis, of course, it must be able to provide a solution in the form of work posture proposals or tools to reduce those risks. Of course, by applying the analysis, it is expected to minimize the risk of low-back pain injuries and can produce maximum job satisfaction. Therefore, a research study should be carried out to analyze and evaluate work activities that focus on work postures so that workers can be avoided from muscle injuries in the spine.

Budiman (2006) conducted research by comparing biomechanical methods including OWAS, NIOSH, REBA, RULA, RWL and MPL based on manual analysis of material handling with these methods. All of these methods are examined for their strengths and weaknesses based on the sensitivity of the results of the analysis using these methods. The superior method in calculating data is NIOSH and in the data processing process is RULA, but each method cannot be separated from deficiencies therefore new methods such as REBA have been enhanced with the emergence of RULA method. At present, manual material handling analysis is more effective when using the RULA method. This method can display the posture on which part of the body is dangerous for the job.

Sukmana (2016) conducted a study for the design of a banana chopper, which was carried out by modifying a number of chopper tools which were then determined using a Involute Blade. In this study comparisons were calculated at 4 times the speed of the motor, at speeds of 1500rpm, 800rpm, 500rpm and 200rpm, with 3 thick comparisons of 3mm, 5mm, 10mm banana slices. Compared to manual slicing that takes an average of 1.5 seconds / slices, the chopper tool can work faster, 4.1 slices / second.

Objectives

The objectives of this research are:

1. Analyzing whether material handling work activities at the work station at the Potorono Brickworks Center is categorized as having low-back pain risk or not by using REBA and RULA approaches.
2. Creating a proposal of tool design which can be applied to improve work postures.

Benefits of Research

The benefits of this research are:

1. Knowing REBA and RULA scores for material handling work postures.
2. Providing suggestions for the workers regarding the improvement of work posture which is more efficient to health and reducing the risk of low-back pain
3. Researchers can apply ergonomics in analyzing work postures by using the Biomechanics approach and implementing it in the industrial field.
4. Obtaining a proposal of tool design for material handling work tools.

Literature Review

REBA & RULA

Rapid Entire Body Assessment is a method developed in the field of ergonomics and can be used quickly to assess the work position or posture of an operator's neck, back, arm wrists and feet. Besides, this method is also affected by factors such as coupling, external loads supported by the body and the activities of workers. Assessment using REBA does not require a long time to complete and to do a general scoring on the list of activities that indicate the need of risk reduction caused by the operator's work posture (McAtamney, 2000).

Rapid Upper Limb Assessment is a method developed in the field of ergonomics that investigates and evaluates work positions carried out by the upper body. This equipment does not require special tools to provide a measurement of the posture of the neck, back and upper body, in line with muscle function and external loads which is supported by the body. Assessment using RULA requires a little time to complete and to do a general scoring on the list of activities that indicate the need for risk reduction due to physical lifting carried out by the operator. RULA is intended to be used in the field of ergonomics with a broad scope area (McAtamney, 1993).

5-Step Method

Product concept is a description or an estimation of technology, working principles, and the shape of the product (Ulrich and Eppinger, 2001: 102). Product concept is a brief description on how the product satisfies customer needs. A concept is usually expressed by an outline of 3-dimensional sketches or models and is often accompanied by a description of the picture.

Generally, conceptualization method consists of 5 steps by solving a complex problem which becomes a simpler sub problem. The five steps of the concept formulation method are: 1. Clarifying the problem (Understanding the problem, Decomposition of the problem, Focusing on important subproblem), 2 External searches (Primary users, Experts, Patents, Literature, benchmarking)

3. Internal searches (Individually and in a group), 4. Digging systematically (Classification tree, Combination table) and 5. Reflecting on results (Compiling feedback).

Concept Selection

According to Ulrich and Eppinger (2003, p124), concept selection is the process of evaluating concept according to the needs of consumers and other criteria, comparing the strengths and weaknesses of each concept and choosing one concept that can proceed to the development stage. There are 2 stages of concept selection methods, the first stage is called concept screening and the second stage is called concept scoring. Both of these stages, follow the 6 step process of concept selection activities (Ulrich and Eppinger, 2003, p129), namely: a. Prepare the selection matrix, b. Rate the concept, c. Rank the concept, d. Combine and improve the concepts, e. Select one or more concept, f. Reflect on the result and the process.

Research Methodology

Research Object

The object of this research is a brickworks center located in Potorono, Banguntapan, Bantul, Special Region of Yogyakarta. This research will focus on workers in one of the producers in that area.

Data Analysis Method

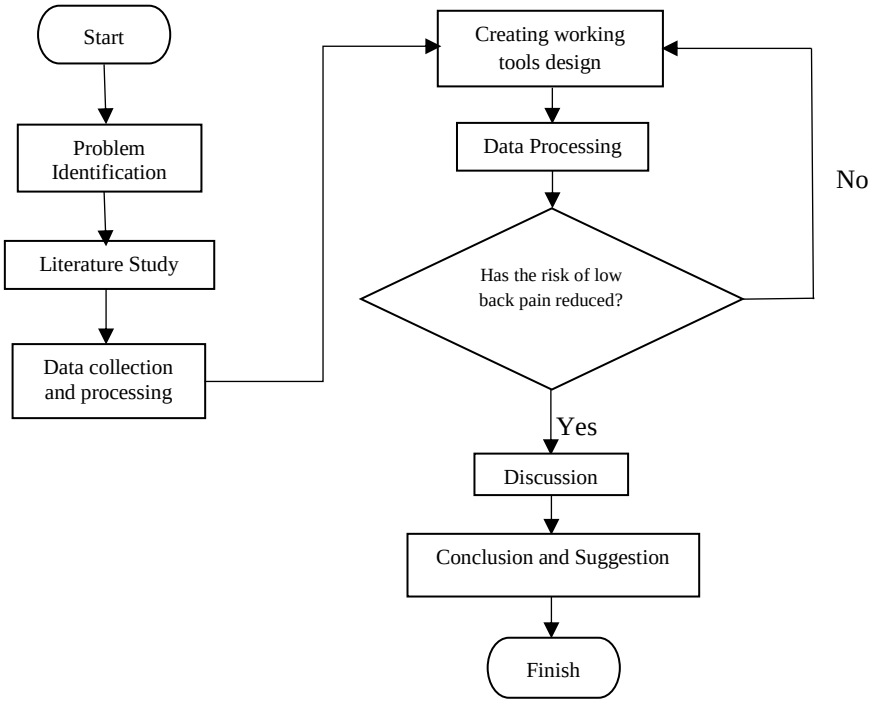


Figure 1. Flow Chart

Results and Discussion

Collection and Processing of Data

Posture observation in this study is used as a base before designing the concept of working tools that will be created. Researchers took image data from producers in the area of Potorono brickworks center for their analysis of Rapid Entire Body Assessment (REBA) & Rapid Upper Limb Assessment (RULA) analyzes.

Work Posture 1 Work Posture 2 Work Posture 3 Work Posture 4

Figure 2. Workers' Work Posture

Table 1. REBA & RULA scores

Posture	REBA score	RULA score
First	9	7
Second	4	7
Third	8	7
Fourth	5	7

Based on the analysis of REBA and RULA, it can be seen that almost all work postures analyzed are at risk of causing spinal injury which means that to date the process of making bricks manually in Potorono brickworks center can be said as not ergonomic yet and it is the time to improve the work posture to reduce the risk of spinal injury.

Design Preparation

Clarifies the Problem

No	Problem Identification	Information

1	There are work postures which are likely to cause spinal injury	Judging from the results of REBA and RULA analysis in the past, most of the results are the posture is potentially dangerous and it has to be corrected immediately
2	There are work processes which are less efficient.	Due to the absence of working aids, the working process becomes less efficient during material handling, because the workers have to walk back and forth while carrying materials and obviously perform posture that is at risk of low-back pain
3	There is no working aids for material handling	Judging from observations in the field that there are no special work tools for material handling

Table 2. Problem Identification

From the problem identification table above, the decomposition of the problem is "How to design work concepts with working aids which can reduce the risk of spinal injury and improve work processes more effectively and efficiently, especially for body healt

External Search

Table 3. Key Points (Main User Interview)

No	Producers' Will
1	The main user wants a kind of tool which can reduce fatigueness while working which means the tool is ergonomic so that it is comfortable to use during working.
2	The main user expects the tool that will be produced is low in production cost so that the producers do not hesitate in implementing it.
3	The main user wants the device to be easy to use and easy to anticipate when the weather does not support the production process.

From the various literature which has been studied, researchers determine several alternatives of material handling tools which have the potential to be developed to become working aids in the brickworks by considering their weaknesses and strengths. The following material handling tools can be seen in Table 4.

Table 4. Alternatives of External Search

Name	Tools Picture	Weakness	Strength
Trolley		-Cannot resolve the posture problem yet	-Minimalist form -Affordable -Potentially efficient
Conveyor		-Took space	-High potential in resolving posture problem -Automatically do the lifting
Wheelbarrow		-Cannot resolve the posture problem yet	-Easy to operate -Minimalist -Potentially Efficient

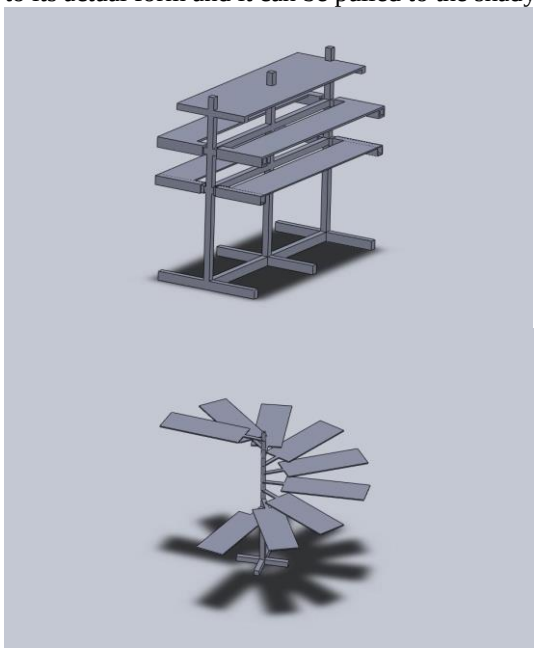
Table 5. Results of Consultation with Expert

No	Name	Occupation	Suggestion
1	Pribadi Prasetya	Creative tools Innovator	Suggest to create a modern brick-molding tools, making press molding tool and for the material handling he suggested to develop conveyor belt which can arrange bricks automatically.

The experts involved in this research are Mr. Pribadi Prasetya as a creative worker who has long been in the business of technical equipment. He with his home industry has created many products, both adaptation products from existing ones and innovation products.

Internal search

At this stage, 2 ideas were obtained, the first idea that the researchers found was to build a square-shaped rack which later could be used as a drying medium along with mold equipment nearby to make the brick printing position to be more comfortable because the worker sits in a chair and molds on the molding table. The next idea is a brick shelf drying tool with an axle in the middle and the drying table can be moved circularly, so later during the drying process the rack can be made to be circular so that the bricks are all exposed to the heat and when the weather is less supportive, the tools can be returned to its actual form and it can be pulled to the shady area or dried by using a dryer.

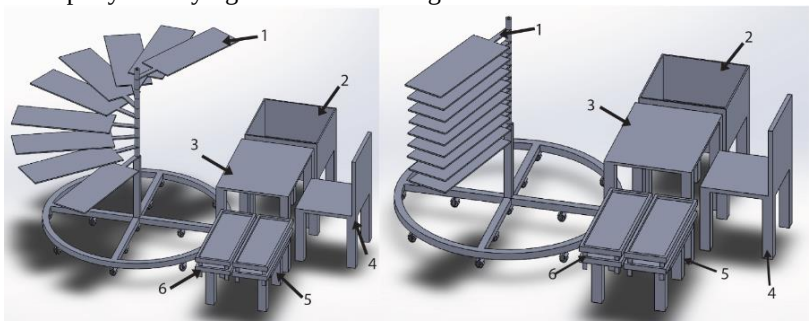


Square-shaped rack Circular rack

Figure 3. Internal Search Results

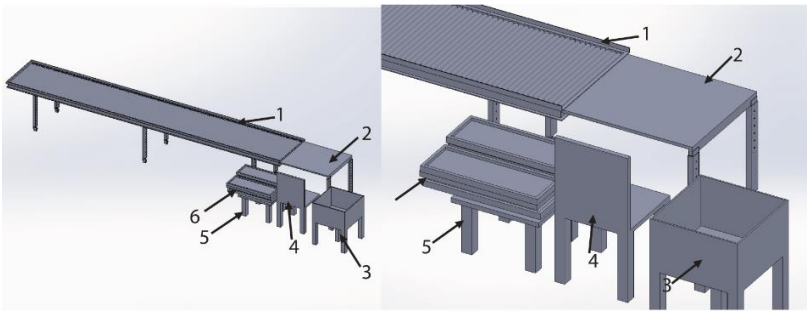
Digging Sistematically

From the internal and external search results, 3 alternatives are chosen to carry out the design concept by modifying and the final design results were obtained as follows:



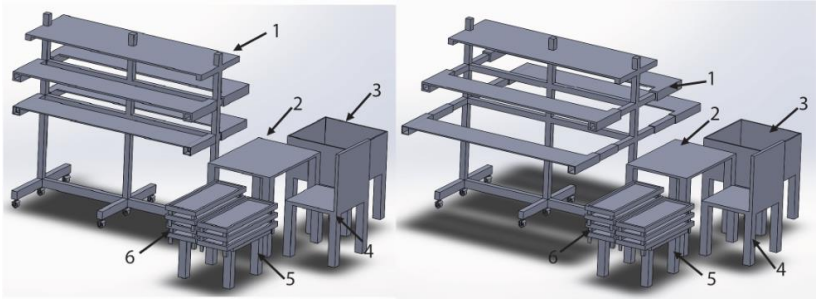
Information:
1. Drying Rack
2.Sand Box
3.Molding Table
4. Chair
5.Tray table
6. Mold Tray

Figure 4. Design Modification of Circular Rack



Information:
1. Roller conveyor
2.Molding Table
3.Sand Box
4. Chair
5.Tray table
6.Mold Tray

Figure 5. Design Modification of Roller Conveyor



Information:
1.Drying Rack
2.Molding Table
3.Sand Box
4. Chair
5.Tray Table
6.Mold Tray

Figure 6. Design Modification of Square Shaped Rack

Next step is holding concept selection to get the most suitable concept design. Concept selection uses the concept scoring method proposed by Ulrich and Eppinger as a comparison and assessment of the results of several concepts that have been made, which are then followed by the reciprocal ranking method. In the table below in the tool ergonomics column the criteria are produced after discussion with experts, these criteria are also assessed by experts for their priority scale according to needs with the step reciprocal ranking adopted from Sukmana research (2016). Starting from the criteria that best suits your needs based on the steps taken before getting rank 1 and the criteria that have the lowest suitability get rank 5. According to the rules of reciprocal rank column X in the contents of the number which if added to rank will produce number 6, then from the column is calculated by weighting, by dividing the X value in the criteria by the sum of the X values of all the criteria so that the weight is obtained.

Table 6. *Benchmarking* Design Concept to Design Needs

Determination of Weight On the Tool Ergonomics			
Tool Ergonomics Needs	**Ranking Determination**	**X**	**Weight**
Simple and Easy to Operate	4	2	0.13
Low Risk of Low-Back Pain Injury	1	5	0.33
Not Causing Tiredness	3	3	0.20
Good for Health	2	4	0.27
Affordable Production Cost	5	1	0.07
Total	15	15	1.00

Tabel 7. Reciprocal Ranking Concept

Criteria	**Weight**	**Reciprocal Ranking Concept**		
		Design 1	**Design 2**	**Design 3**
Simple and Easy to Operate	0.13	1	2	3
Low Risk of Low-Back Pain Injury	0.33	2	3	1
Not Causing Tiredness	0.20	1	3	2
Good for Health	0.27	1	3	2
Affordable Production Cost	0.07	3	1	2

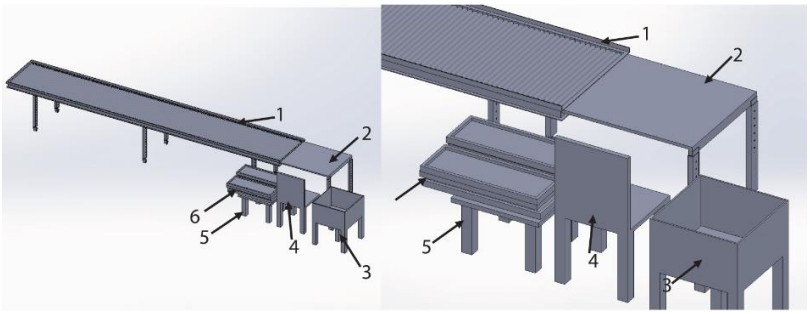
In table 7. The three selected designs are assessed by experts and researchers for each suitability to their needs, the most appropriate is given a value of 3 and the least appropriate is given a value of 1, then these values are multiplied by their weight so that a rating score is generated in table 8.

Table 8. Rating Score

Rating Score

Criteria	Design 1	Design 2	Design 3
Simple and Easy to Operate	0.13	0.26	0.39
Low Risk of Low-Back Pain Injury	0.66	0.99	0.33
Not Causing Tiredness	0.20	0.60	0.4
Good for Health	0.27	0.81	0.54
Affordable Production Cost	0.21	0.07	0.14
	1.47	2.73	1.8

From the results of the assessment above, then the highest assessment was taken, which is Design No. 2 with a rating score of 2.73 as the best final alternative that fits the criteria. After this is done the improvement of the work posture using the selected work aids namely the second design, in this case the main work aids which impact on the posture of the work chair. Based on previous research conducted by Agung Kristanto and Dianisa Adhi Saputra namely "Ergonomic Design of Tables and Chairs in Cutting Work Stations as Productivity Improvement Efforts" shows that according to research results one of which is based on percentiles shows that the size of an ergonomic work chair can be seen in Figure 8.



Information:
1. Roller conveyor
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3.Sand Box
4. Chair
5.Tray table
6.Mold Tray

Figure 7. Design Modification of Roller Conveyor

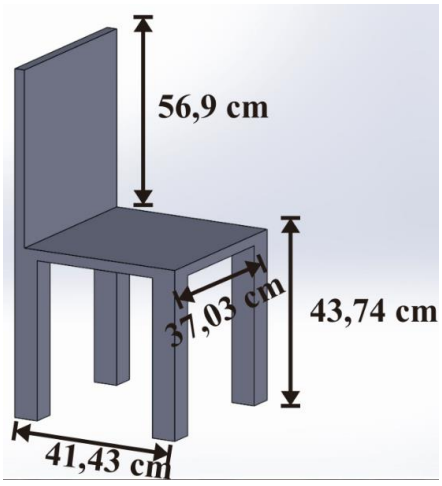

Figure 8. Size of an ergonomic chair

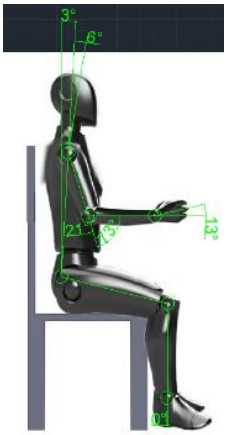

Figure 9. Posture Illustration after Improvement

Furthermore REBA and RULA calculations are performed after the improvement of the work posture using human illustrations from solidwork applications whose positions are seated on the chair designs made as shown in Figure 9.

Table 9. REBA Dimension Angles Posture Improvement

Group	Dimension	Angle(^{0})
A	Neck	6
	Back	3
	Knee	0
	Load	-

B	Upper arm	21
	Lower arm	73
	Wrist	13

Table 10. REBA Score Posture Improvement

Group	Dimension	Angle	Score	Table A	Score A	Score C	Score REBA
A	Neck	6º	1	2	2	1	1
	Back	3º	2				
	Knee	0º	1				
	Load			0			
Group	**Dimension**	**Angle**	**Score**	**Table B**	**Score B**		
B	Upper arm	21º	2	1	1		
	Lower arm	73º	1				
	Wrist	13º	1				
	Coupling			0			
	Activity Score					0	

Table 11. RULA Dimension Angles Posture Improvement

Group	Dimension	Angle (^{0})
A	Upper arm	21
	Lower arm	73
	Wrist	13
	Rotation	-
B	Neck	6
	Back	3
	Foot (prop)	-

Table 12. RULA Score Posture Improvement

Group	Dimension	Angle	Score	Table A	Score C	Score RULA
A	Upper arm	21	2	3	3	3
	Lower arm	73	1			
	Wrist	13	2			
	Rotation	-	0			
	Muscle			0		
	power			0		
Group	**Dimension**	**Angle**	**Score**	**Table B**	**Score D**	
B	Neck	6	1	1	1	
	Back	3	1			
	Foot (prop)	-	1			
	Muscle			0		
	Power			0		

Based on the calculation of REBA, it can be seen that the score on the repaired work posture is 1. Score 1 in the risk and actions level tables is included in level 0 action which mean the risks can be ignored and no need for corrective action. Then, in the calculation of RULA, it can be seen that the repaired work posture has a score of RULA 3. This means that the posture has a level 2 action which indicates that further investigation is needed and changes are also needed.

Reflecting on Result and Process

Overall, all the design processes of the working tool concept have been carried out to the fullest with the various stages that have been passed in order to obtain results that is matched with the initial criteria and also satisfying. During the research process, digging the solutions have been done to the maximum extent possible in order to obtain a satisfactory final design result.

The final design chosen, which is the roller conveyor modification design, is the closest to the criteria based on the scoring concept which has been done, the design pretty much reduces the previous

work posture that has the potential for injury based on the analysis of the work posture improvement which has been done.

It is expected that the tool design can be accepted by the producers and later it can be implemented and applied in a tangible manner so that the health of the brickworks workers can be maintained, especially from the risk of low-back pain.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Based on the data analysis result on the results of discussions that have been conducted by researchers to reduce the risk of low-back pain with the biomechanics approach, it can be concluded as follows:

1. After conducting REBA and RULA analysis, the first posture score is 9 which means the risk level is high and immediate corrective action is needed, then the second posture is 4 which means the risk level is moderate and there is a need for improvement, then the third posture is showing score 8 which means the risk level is high and it needs immediate remedial action, then the fourth posture shows a score of 5 which means that the risk level is moderate and it needs corrective action. For the RULA score of the four postures showing the same score of 7 which means entering the level 4 action which shows that this condition is dangerous, then checks and changes are needed immediately (right away).
2. From the results of REBA and RULA analysis, the design of work aids to improve working posture is then performed to reduce the risk of low-back pain injuries . The final design chosen was the Modification of the roller conveyor design combined with a printed table. The design can be seen in Figure 5.

Suggestions

Here are several suggestions for the research:

1. Future researches are expected to be more discussed to the level of cost production.
2. It is expected that the next research will be carried out until the product manufacturing stage so that it can be directly and visibly applied in the field.
3. The design of material handling work aids certainly cannot be said to be perfect. So, for further research, it is expected to improve the design to the perfection.

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