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Research paper

Tools design of bread production process to minimize musculoskeletal disorders based on OCRA method

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Abstract

Less supportive working methods may lead operators inconvenience while working. This discomfort can be caused by a non-ergonomic work environment. Bread baking process is done manually using human energy. This work is done repeatedly for a long time, thereby posing a risk of musculoskeletal disorders. This is at risk of causing pain in some parts of the worker's body. Ergonomic work facilities and equipment are essential to minimize risk at work. The result of NBM (Nordic Body Map) questionnaire indicate that the biggest complaint is on the right back of the worker's arm and shoulders. In baking process, the operator must bend almost 90 degrees. This posture can cause health problems, especially musculoskeletal. Based on observations using the OCRA (Occuptional Repetitive Action) method, the OCRA index value for the right hand is 8.56 and for the left hand is 7.84, with the red area and the average category of risk. Therefore, a trolley is designed in this study as a tool to minimize musculoskeletal complaints, using workers anthropometric data.

Keywords*: Musculoskeletal Disorders; NBM (Nordic Body Map); OCRA; Anthropometric*

1. Introduction

Humans have an important role in the industry. Operator plays an important role in production process activities, specially in manual and conventional companies. Therefore, companies are required to pay more attention to the operators convenience in the work place, because manual work will be at higher risk to accidents, health and safety. The higher the work activity, the greater the risk of occupational health problems (1).

Baking process has several process activities, starting with dough mixing process, milling process, molding process, combustion process, and packing process. These processes were done by some operators who work from 7:00 to 17:00 pm with an hour of break time. Most operators work in a standing position, with repetitive movements during the production process. In addition, the hot temperature in the factory environment causes the operator more easily tired, due to the greater energy released thus causing muscles complaints. Physical work can cause muscle tension due to repetitive work movements. The musculoskeletal disorders risk will increase with the increasing of repetitive motion at work (2).

Over time, repetitive motion disorders (RMD) can cause temporary, even permanent damage of the soft tissues in the body, including muscles, nerves, tendons, and ligaments. Repetitive motion injuries can result in substantial losses in the cost of maintenance for labor. In addition, the company will also lose its optimal productivity (3).

Repetitif working and a non-ergonomic working attitude, causing pain in the back, shoulders, arms, and other body parts of the operator. This is due to inadequate work facilities and improper work posture, resulting in musculoskeletal disorders so that operators feel tired quickly. The more work activity done by the workers, the greater the chances of suffering occupational health disorders (1).

One type of ergonomic problems often encountered in the workplace, especially relating to human strength and endurance in doing their jobs or biomechanics, is musculoskeletal or flexes (1). Using the observational method, real-time works in ergonomics (4-6) have shown that ergonomic feedback by looking directly at workers' posture in work can affect workers motion and minimizes hazardous risk score values.

In the combustion process, the operator picks up a baking pan on the floor repeatedly. The combustion process takes duration ± 30 minutes, while the oven can contain 48 pieces of baking pan. In combustion process the operator requires to bent and forms an angle up to 90°. This posture can cause health problems, namely musculoskeletal disorders. To reduce the problems in bread production activities, work risk identification is done using the OCRA method.

Therefore, this study was conducted to identify the operator working posture/ position and provide solution to improve the operator's posture, thereby reducing the muscoluskeletal risks experienced by the operator at work, using the OCRA method. This Occuptional Repetitive Action (OCRA) method is used to identify risk at work, specially for repetitive work. The purpose of this study was to identify work stations at risk of operator work posture in bakery factories and to design operator aids at work stations at risk for muscoluskeletal.

2. Literature Review

2.1. Muscoloskeletal Disorder

Musculoskeletal disorders are a complaint of skeletal muscle, ranging from mild complaints to painful complaints. If the static muscle receives static load repeatedly and for a long time, it can cause complaints of joints, ligaments, and tendons. This could causes pain, called musculoskeletal disorders (MSDs) or injuries to the musculoskeletal system (7). The posture and movement of a worker is important information to determine the risk of musculoskeletal injuries in the workplace in Ergonomic (6, 8).

Nordic Body Map (NBM) is use to obtain MSDs symptoms, with levels of complaints ranging from discomfort (a little pain), pain, to very pain. By analyzing NBM, it can be estimated the level and type of skeletal muscle complaints felt by the workers (9). The Nordic Body Map questionnaire is one form of the ergonomic checklist questionnaire. Another form of ergonomic checklist is the International Labor Organization (ILO) Checklist. The questionnaire uses a human body image that has been divided into 9 main parts: neck, shoulders, upper back, elbow, lower back, wrist/ hand, waist, knee and heel/ leg (10).

2.2. OCRA Method (Occuptional Repetitive Action)

The OCRA method invented by Occhipinti and Colombini is a quantitative method for identifying work methods on repetitive work, especially for upper gestures. This method classifies risks at three levels: not risky, rather risky, and risky, to evaluate risk factors that affect musculoskeletal complaints such as large force, abnormal posture, repetitive and break period (11).

According to Occhipinti, the OCRA method specializes its testing on the upper body. Occhipinti has conducted research that proves manufacturing involves more of the upper body and the incidence of musculoskeletal complaints. The complaints in this section are more often than the lower body. The steps performed by OCRA method is fill the OCRA checklist and calculate OCRA index. To evaluate the upper limb musculoskeletal load caused by repetitive tasks and the risk of developing MSDS may use the OCRA method (12). OCRA is intended for arm movements under the shoulders and focuses more on the forearm movement without distinguishing exposure caused by arm posture (13).

3. Methodology

The steps performed using the OCRA method are as follows:

- Fill in technical movement data and duration, arm posture, recovery period and additional factors.
- Calculates the OCRA index
- Determine workplace risk zones based on the OCRA index

The research was conducted through 2 stages:

Phase 1: Rating Operator Posture

Conduct assessment of the operator's working posture by distribute questionnaires to see workers complaints. The questionnaire used refers from the Nordic Body Map (NBM) method. Then the operator working posture were identified using the OCRA method.

Phase 2: Designing Tools

The assessment results indicate the work risk level of each operator. To minimize operational risk, this research design a tool with several stages; designation and classification of design objectives, design function structure, determine the design requirements using the anthropometry data, determine design characteristics, develope design alternatives, drawing design, design evaluation.

4. Results and findings

NBM (Nordic Body Map) questionnaires were distributed to determine the level of complaints of the operator. 30 questionnaires were distributed to bakery operators in several factories. The recapitulation results can be seen in Figure 1 below:

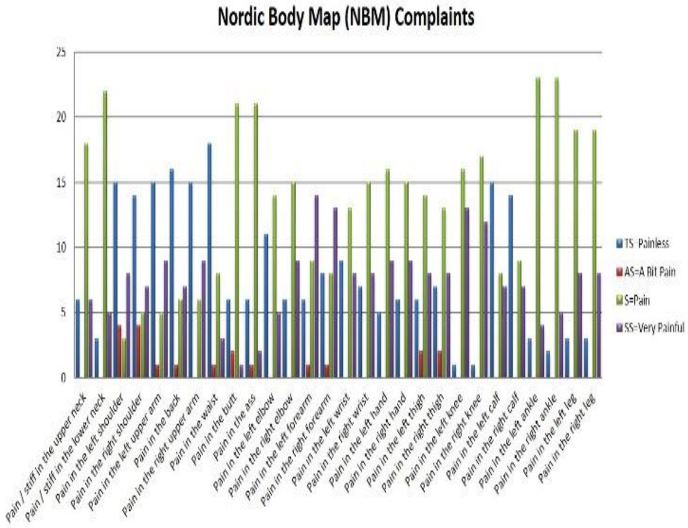

Fig. 1: Recapitulation of NBM Complaint

4.1. Technical Measures

Bread production process through several processes; milling, forming, and baking. There is one operator on duty at each work station. The results of the observations are as follows:

Table 1: Number of Technical Measures on The Millling Work Station

No	Technical Measures	Number		Duration (Seconds)
		Right	Left	
1	Turn on the milling machine	1	-	0.92
2	Take the dough	1	1	2.51
3	Bring the dough to the milling machine	-	0	1.46
4	Put the dough on the pallet	1	1	0.28
5	Place the dough to be milled	1	1	0.99
6	Take the dough that has been ground	1	1	0.71
7	Bring the dough to the table	0	0	1.48
8	Put the dough on the table	1	1	0.28
9	Cut out the dough with a knife	1	-	1.05
	Amount	**7**	**5**	**9.711**
	Total	**210**	**150**	**291.3**
	Frequency	**43**	**30**	

Table 2: Number of Technical Action in Forming Work Station

No	Technical Measures	Number		Duration (Seconds)
		Right	Left	
1	Take the dough off the table	2	2	0.90
2	Pull the dough to lengthen	2	2	1.48
3	Bring to a forming machine	1	1	2.51
4	Placing the dough on a forming machine	2	2	8.24
5	Presses the dough that has been formed	-	1	0.57
6	Lay the dough onto a baking sheet	1	-	0.70
	Amount	**8**	**8**	**14.43**
	Total	**8**	**8**	**14.43**
	Frequency	**33**	**33**	

Table 3: Number of Technical Measures of the Baking Station

No	Technical Measures	Number		Duration (Seconds)
		Right	Left	
1	Unlock the oven	-	1	0.28
2	Open the oven	1	1	0.29
3	Take a baking pan from the floor	1	1	1.19
4	Bring the baking pan to the oven	1	1	1.48
5	Place the baking pan in the oven	1	-	1.46

6	Unlock the oven	1	-	0.57
7	Open the oven	-	1	0.28
8	Take a baking pan from the oven	1	-	1.48
9	Bring the baking pan out of the oven	1	1	1.48
10	Put the baking pan on the floor	1	1	0.90
11	Move the pan to the packing station	2	2	2.79
	Amount	**9**	**9**	**12.26**
	Total	**9**	**9**	**12.26**
	Frequency	**44**	**44**	

The unnatural repetitive working posture on the three workstations is bending and turning. Percentages for working postures are summarized in Table 4, and power levels are shown in Table 5. OCRA Index calculations as well as OCRA checklists are obtained manually using Index calculation formulas. Table 6 is the calculation result of the checklist and the OCRA Index.

Table 4: Not Ergonomic Body Posture

Awk-ward Postur	**% Milling**		**% Printing**		**% Burning**	
Flexion	R	L	R	L	R	L
Extension/abduction	8.49	8.49	0	0	0	0
Elbow Flexion	30	30	8.24	8.24	5.03	2.09
Shoulder Flexion	38.4	38.4	8.94	8.94	5.03	2.09
Kind of hand grip						
Hook	0	0	0	0	0	0
Pinch	0	0	1.48	1.48	0	0
Power	75.5	75.5	0.90	0.90	0	0
Palmar	88.5	88.5	2.51	3.08	5.75	5.75

Table5: Measurement of Strength

Task	**Skala Borg**		**% Strength**	
	Right	**Left**	**Right**	**Left**
b	1	2	3.22	7.14
Printing	1	1	11.11	11.11
Burning	1	1	3.57	4.76

Table 6: Data Checklist OCRA

	Milling		**Printing**			
Factor	R	L	R	L		
Recovery	5	5	4	4		
Frequency	3	4	10	10	4	4.5
Force	7	7	7	7	3	3
Posture	6	12	2	2		
Add	0	0	0	0		
Score	17.8	23.8	19.55	19.55	1[illegible]	
Zona	purple	purple	purple	purple	pu[illegible]	

OCRA checklist calculation is to get the level of risk that occurs at repetitive work station, then continued by calculating OCRA Index. The OCRA index is the final stage of the OCRA method. The tools are designed to reduce operator complaints after doing their work. Figure 2 shows the flowchart of the OCRA Index calculation.

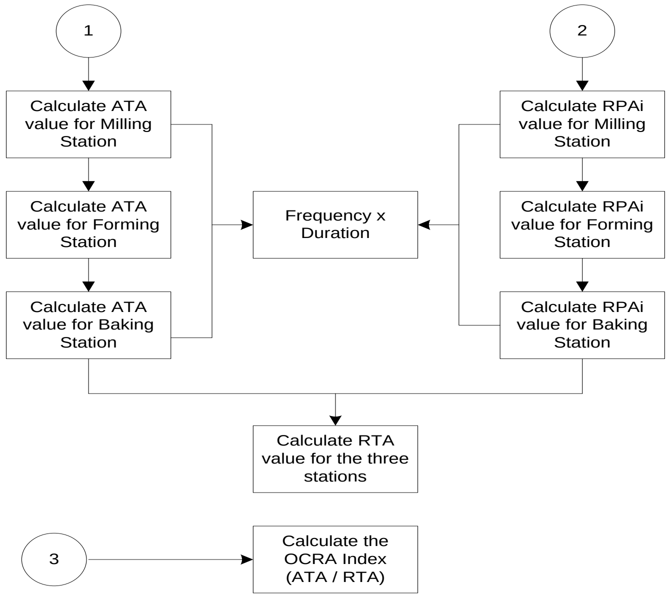

Fig. 2: Flow Chart of OCRA Index Calculation

Keterangan:
ATA : The number of actual technical actions
RPA : The number of partial technical actions
RTA : The number of reference technical actions
Frekwensi : Number of technical actions
CF : Frequency number constant = 30
Fom : Power multiplier
Rem : Multiplier of repeats
Dum : Multiplier duration
Rcm : Multiplier of recovery

The results of the OCRA Index calculations are shown in Table 7 and Table 8 below.

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Table 7: Calculation of Manual OCRA Index

Activity	**Right**		**Left**	
	ATA	**RPA**	**ATA**	**RPA**
Milling	9210	1349	13201	1173
Printing	8085	1512	8085	1512
Burning	11308	1269	12336	1511
RTA	1052		915	
OCRA Index	8.75		14.42	
Risk	Rata-rata		Tinggi	

Table 8: OCRA Index

Score OCRA Index	**Area**	**Risk**
2.2	Green	Acceptable
2.2 - 3.5	Yellow	Very low
3.6 - 4.5	Light Red	Low
4.5 - 9	Red	Mean
> 9.1	Purple	High

A tool designed in the form of an ergonomic trolley rack. This trolley made of iron using anthropometry data of the worker's body to conform to ergonomic rules. In working environments, ergonomic factors are taken into account in product and process development because they are a key component of the human-machine interface (14).Table 9 is an anthropometric data of the operator's body dimensions.

Table 9: Anthropometric Data

No	**Measure Data**	**Code**	**Percentil**			**SD**
			5^{th}	**50^{th}**	**95^{th}**	
1	High elbows standing	TSB	101.19	102.83	104.48	5.64
2	Width of shoulder side	LB	37.5	39.14	40.79	2.74
3	High reach of the hand	TP	261.59	262.19	263.52	8.54

Fig. 3: Design Result

The design results were evaluated to see how much risk reduction and repetitive activity can be minimized with the help of the tool OCRA Index calculation results indicate that working conditions and working facilities are still not ergonomic in the initial conditions. This can be seen from the amount of unbalanced technical action between the upper right gesture with the upper left, as well as the repetitive work.

In this study, a tool is designed to reduce occupational risk. This design aims to developed a new way of working, to reduce repetitive work so that will reduce technical action and minimized the operator lift load. The result of risk reduction after the design of the assistive tool is as follows:

Table10: The Decreasing in Repetitive Work Duration and Number of Technical Measures

Before					After				
Posture	**Hand gestures**	**Duration**	**Duration Percentage**	**Index**	**Posture**	**Hand gestures**	**Duration**	**Duration Percentage**	**Index**
Elbow	Take a dough pan from the floor	1.199	41	0.7	Elbow	-		24.06%	1
	Put the baking pan into the oven	1.467				Put the baking pan into the oven	1.467		
	Take the pan out of the oven	1.483				Take the pan out of the oven	1.483		
	Put a baking pan on the floor	0.908				-			

Table 10 shows that there are some actions that can be eliminated with the proposed tool. Table 10 also shows a decrease in the repetitive work duration, from 41% to 24.06%. Thus the designs that have been made have been able to meet the purpose and function.

5. Conclusion

OCRA is a method for analyzing upper body movements that are repetitive and at risk of muscle complaints. Working posture assessment using OCRA method, shows that operators use the right hand more often while working, this causes the right hand fatique quickly. The highest risk is found in 3 work stations, namely milling, forming, and baking stations. The design of trolley racks can reduce repetitive work, and also minimize the technical action duration from 41% to 24.06%. The trolley rack is designed from a durable material, which is using paint-coated iron to prevent corrosion, for the durability of the working facility.

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