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Design of Working Tools Based on Quick Exposure Check Method to Reduce the Risk of Work Related Musculoskeletal Disorders

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Abstract:

The manufacturing process of brick were conducted by workers who must bend down, sit, and stand to do the job. This body positions occur repeatedly, so it can cause muscular and back bone injury. This monotonous and repetitive work, plus unergonomic working tools can cause Work Related Musculoskeletal Disorders (WMSDs) to workers, and will have impact to work productivity. Because of that, analysis was conducted to assess work risk relating to worker muscular disorder in the work place by using Quick Exposure Check (QEC) to every task elements, and working position that have potential to cause WMSDs. QEC assess damage to the back, shoulder, wrist, and neck. Based on the results of the questionnaire NBM (Nordic Body Map) contained the biggest complaints in the back, arms, shoulders, and the right hand workers. Material mixing process is a process that requires the operator bent almost 90 degrees, which is considered state of the posture of the health problems that can lead to musculoskeletal disorders. Research results shows that parts of manufacturing process of brick that have potentials to cause WMSDs are material mixture with exposure level of 53.41 %. Working risk emerge because of worker's back and neck bend while working and wrist rotate while lifting load. Position improvements were conducted by making new design of working tools such as cement mixing container and brick

making table. Therefore perform the design of the stirring bath aids, materials and work desk operators to minimize the risk of WMSDs using anthropometric data. Once the design is done, the exposure value decreased to 44.31%.

Key words: Work attitude, Quick Exposure Check, NBM (Nordic Body Map Work Related Musculoskeletal Disorders (WMSDs), Ergonomic.

Introduction

Good working system has connection with work place and operational steps of work. Work place and tools Arrangement, plus body position while working will have big impact in creating integrated working system. Through improvements, industry will run effectively and efficiently (Nurmianto, 2004).

One of ergonomic problems that often occur in the work place, relating to human strength and endurance while doing the job (biomechanic), is musculosceletal or muscular strain. This problems were often occurred by workers who did repetitive movements continuously. According to United States Public Work Statistic Bureau, accident caused by Repetitive Stress Injuries (RSI), reach more than 60% (Nurmianto, 2004). Repetitive work done in the long term will increase the risk of MSDs (Musculoskeletal disorders), especially coupled with the loads and awkward postures (OHSCO, 2007).

One of the home industries that make brick, the making process of brick were conducted by one worker only for each job. Brick materials are mixture of sand, cement, pebbles, and water. By working for 8 hours a day, one worker can produce 300 bricks or 13 well rings a day. Workers who make bricks do the same activities repetitively, making bricks, arrange, condense, and drying. Worker's body position while doing the job are bent, squat, and stand to lift the product. This activity occur repetitively that able to cause muscular and back bone

injuries. Unergonomic working system will affect worker's performance. Risk analysis is one of the efforts to prevent workers from this potential risk. Work-related musculoskeletal disorders (WMSDs) are one of the greatest occupational health concerns today. Of the many types of WMSDs, low back disorders (LBDs) are the most prevalent and by themselves constitute a major health and socioeconomic problems (Sandip et.al, 2013).

One method to prevent or reduce the risk to workers is by using *Quick Exposure Check* (*QEC*) method. QEC is a method to assess work risk related to muscle, or "Work-related MusculoSkeletal Disorders (WMSDs) at work place. QEC is a method to assess working risk related to the back, shoulder/ arm, wrist, and neck. The advantage of this method is that it considers worker's condition from two point of view: observers and workers. It will reduce bias from observer's subjective assessment (Ahmad et.al., 2013). This paper explains about how to assess musculoskeletal risk related to brick manufacturing process that will give information on how to improve working system by design tool aid to reduce and eliminate muscuskeletal disturbance, so workers can improve their health, efficiency, and productivity.

Quick Exposure Checklist (QEC)

QEC is a method to assess working risk related to muscular disturbance at the workplace. This method assesses disturbance in the back, shoulder, wrist, and neck. QEC helps to prevent WMSDs, such as repetitive action, pressure force, wrong position, and work duration (Stanton, 2004). QEC examine body static and dynamic task to estimate risk level of body posture by involving movement repetition elements, energy/burden, and work length to different parts of body (Li and Buckle, 1998).

Basic concept of this method is actually to identify exposure score of certain body parts, compare to the others. It is calculated for each body part such as back, shoulder/ arm, wrist, and neck by considering ± 5 combinations /interaction. For example: body posture with duration, movement with duration (Brown and Li, 2003). One of the important characteristics in this method is assessment, conducted by researchers and workers, where risk factors were considered and combined in its implementation, with existing table score (Li & Buckle. 1998). Factors that affect injury risk are as follows:

Table 1 : Factors That Affect Injury Risk

No	Factor	Injury Risk
1.	Back	Load weight, duration, movement frequency, body position.
2.	Shoulder/Arm	Load weight, duration, task complexity, movement frequency.
3.	Wrist	Strength, duration, movement frequency, body position.
4.	Neck	Duration, body position, visual aspect.

The load assessment stages of Quick Exposure Checklist (QEC):

A. Researcher Assessments

1) Load assesment for back
   a. Back posture (A1-A3)
   b. Back movement (B1-B5)
2) Load assessment for shoulder/ arm
   a. Posture of shoulder/ arm (C1-C3)
   b. Shoulder/arm movement (D1-D3)
3) Load assessment for wrist
   a. Wrist (E1-E2)
   b. Wrist movement (F1-F3)
4) Load assessment for neck
   The very twisted neck if neck is twisting or nods in angle of more than 20^{o} or tends to approach the back

B. Worker Assessment

The next step after assessment is filling the questionnaires. The questionnaires were distributed to workers, while the researcher explains to workers when needed. The total load assessment can be calculated by combine the assessment from researcher (A_G) and from workers (H_P). *Exposure level* (E) calculated based on the percentage of the total actual score *exposure* (X) with a total maximum score (X max) [2]:

$$E(\%) = \frac{X}{X_{max}} \times 100\%$$

Where:

X = Total score, obtained from the assessment of posture (back + shoulder/arm + twists + neck)

X_{max} = Maximum total score for working posture (back + shoulder/arm + twists + neck)

X_{max} is a constant for certain type of tasks. The minimum score (X_{min} = 162) gave when the body is in a static position, sit or stand without repetition and relatively lower load. The maximum score (X max = 176) gave when the worker did manual handling such us lifting, pushing, pulling and carrying loads.

The objective and primary fuction of Quick Exposure Checklist (QEC) are :

- ✓ Identify risk factors for WMSDs
- ✓ Evaluate the risk of disruption to the area / different parts of body
- ✓ Suggest any necessary action to reduce the risk of existing disruption
- ✓ Educate workers about the musculoskeletal risks in the work place

QEC is used to assess the level of exposureto ergonomic risks. The methodincludes the assessment of the back, shoulder/upper arm, wrist/hand and neck, withrespect to their postures and

repetitive movement. Information about maximum weight handled, time spent on task, level of hand force, application of vibrating tools, visual demand of the taskand difficultiesto sustain with the work as well as the stressfulness of the work are also obtained from the worker (Qutubuddin et.al, 2013).

To obtain a picture of the symptoms of MSDs can use the Nordic Body Map (NBM) with the level of symptoms ranging from discomfort (slight pain), pain until paint full. By looking at and analyzing the map of the body (NBM), it can be estimated the level and type of skeletal muscle complaints felt by workers (Kuorinka et al, 1997). Questionnaires Nordic Body Map is one form of ergonomic checklist questionnaire. Another form of ergonomic checklist is a Checklist International Labour Organization (ILO). However questionnaire NBM is the most commonly used questionnaires to determine the inconvenience of workers, and has been standardized and well-organized. This questionnaire uses the image of the human body that has been divided into nine main sections, namely the neck, shoulders, upper back, elbows, lower back, wrists / hands, dish / buttocks, knees and ankles / feet (Kroemer, 2001).

Research Methodology

The stages of the research:

1) Collecting data from questionnaires and worker complaints
2) Calculate exposure score from questionnaires for each body part observed namely neck, shoulder, wrist, back and elbow. The risk level of injury were based on the exposure score.
3) Calculate the exposure level for some treated actions

Table 2 : Summary of QEC Action Levels

QEC Score (Total Percentage)	Action
< 40 %	Acceptable
40 – 49 %	Investigate further
50 – 69 %	Investigate further and change soon
≥ 70 %	Investigate and change immediately

4) Improve working method by working new design

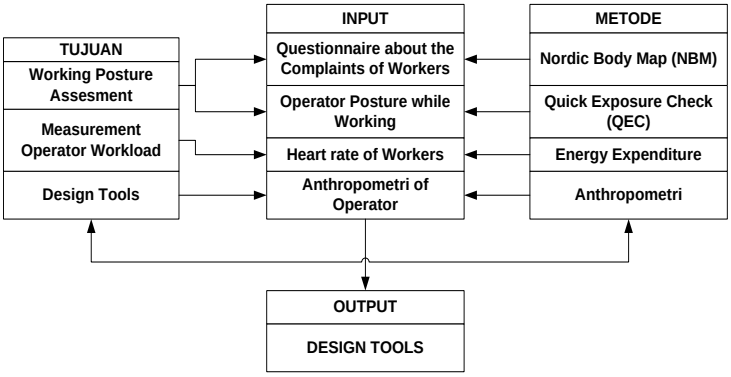

Figure 1. : Methodology of Research

Result and Discussion

Posture and working attitude were needed to calculate the possibility of working risk and work-related musculoskeletal disorders (WMSDs). It also needed to estimate the mistake of working attitude in manufacturing brick, especially on the spine and the rear waist. Figure 2 describe about the attitude and working method in brick manufacture.

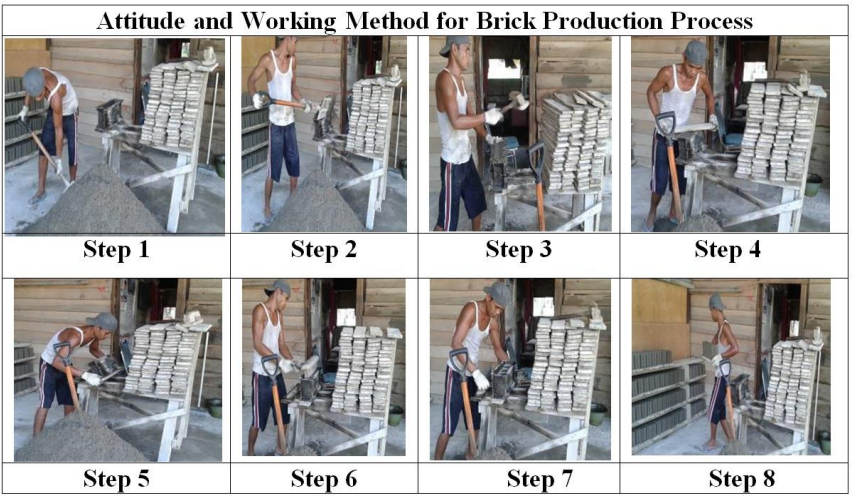

Figure 2: Working Method of Production Brick

The analysis of questionnaires and worker complaints are show in figure 3 and figure 4.

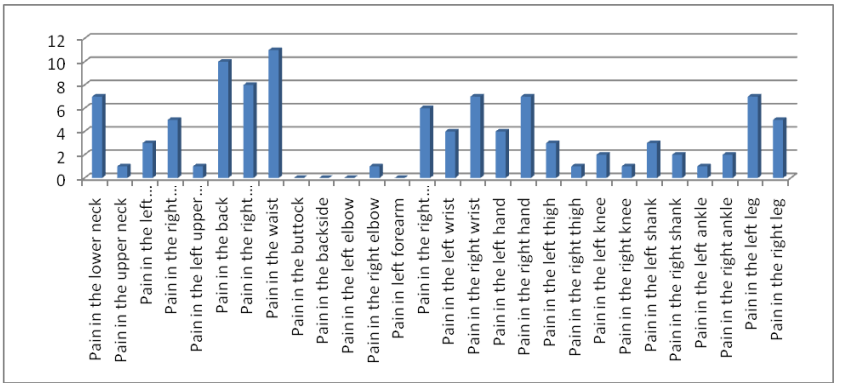

Figure 3: Grafical of Worker Complain

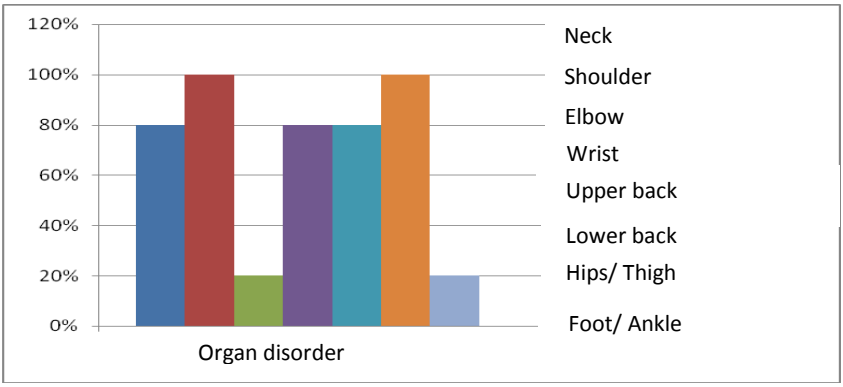

Figure 4: Histogram of Worker Complain

Table 3 show the calculation result of worker posture using QEC method, from calculation sample on QEC score sheet for attitude 1 of brick worker.

Table 3: QEC Score Sheet for Attitude 1 of Brick Worker

Exposure to Back					**Shoulder / Arm**					**Wirst / Hand**					**Neck**				
Back Posture A & Weight H					Height C & Weight H					Repeated Motion F & Force K					Neck Posture G & Duration J				
	A1	A2	A3	Score 1		C1	C2	C3	Score 1		F1	F2	F3	Score 1		G1	G2	G3	Score 1
H1	2	4	6	6	H1	2	4	6	2	K1	2	4	6	4	J1	2	4	6	8
H2	4	6	8		H2	4	6	8		K2	4	6	8		J2	4	6	8	
H3	6	8	10		H3	6	8	10		K3	6	8	10		J3	6	8	10	
H4	8	10	12		H4	8	10	12											
Back Posture A & Duration J					Height C & Duration J					Repeated Motion F & Duration J					Visual Demand L & Duration J				
	A1	A2	A3	Score 2		C1	C2	C3	Score 2		F1	F2	F3	Score 2		L1	L2	Score 2	
J1	2	4	6	8	J1	2	4	6	4	J1	2	4	6	4	J1	2	4	4	
J2	4	6	8		J2	4	6	8		J2	4	6	8		J2	4	6		
J3	6	8	10		J3	6	8	10		J3	6	8	10		J3	6	8		
Duration J & Weight H					Duration J & Weight H					Duration J & Force K					Total Score For Neck Sum Of Score 1 - 2				12
	J1	J2	J3	Score 3		J1	J2	J3	Score 3		J1	J2	J3	Score 3	**Vibration**				
H1	2	4	6	4	H1	2	4	6	4	K1	2	4	6	6	N1	N2	N3	Score	
H2	4	6	8		H2	4	6	8		K2	4	6	8		1	4	9	1	
H3	6	8	10		H3	6	8	10		K3	6	8	10		Total For Vibration				1
H4	8	10	12		H4	8	10	12											
Frequency B & Weight H					Frequency D & Weight H					Wirst Posture E & Force K					**Work Pace**				
	B1	B2	B3	Score 4		D1	D2	D3	Sore 4		E1	E2	Sore 4		P1	P2	P3	Score	
H1	2	4	6	6	H1	2	4	6	6	K1	2	4	6		1	4	9	1	
H2	4	6	8		H2	4	6	8		K2	4	6							
H3	6	8	10		H3	6	8	10		K3	6	8							
H4	8	10	12		H4	8	10	12							Total For Work Pace				1
Frequency B & Duration J					Frequency D & Duration J					Wirst Posture E & Duration J					**Stress**				
	B1	B2	B3	Score 5		D1	D2	D3	Score 5		E1	E2	Score 5		Q1	Q2	Q3	Q4	Score
J1	2	4	6	8	J1	2	4	6	8	J1	2	4	6		1	4	9	16	1
J2	4	6	8		J2	4	6	8		J2	4	6							
J3	6	8	10		J3	6	8	10		J3	6	8			Total For Stress				1
Sum of score 1-5				32	Sum of score 1-5				24	Sum of score 1-5				26					

The calculation of exposure level for each worker attitude, working method and it action are show in Table 4.

Table 4. Summary of Worker Exposure Value

No.	Product	Working Method	Exposure score	Action Level	Remarks
1	Brick	1.Mixing raw materials	53.41%	3	Investigate and change immediately
		2.Insert mixed materials to the brick mold	28.41%	1	Acceptable
		3.Flattenning the mold with a hammer	23.46%	1	Acceptable
		4.Leveling the rest of the material on the surface of the brick mold	27.27%	1	Acceptable
		5.Reversing the brick mold	23.46%	1	Acceptable
		6.Compacting the mold with a hammer	23.46%	1	Acceptable
		7.Open the mold	27.16%	1	Acceptable
		8.Carrying bricks to the drying	21.59%	1	Acceptable

The calculation of exposure level by the method of QEC show in Table 3. Table 4 show that some job positions could potentially lead to work-related musculoskeletal disorders (WMSDs) in workers. One jobs that need immediate improvement are stirring material with the exposure level of 53.41% and action level of 3. This is because the body of worker had to bend almost 90^0 and to work using the existing facilities, while for others a safe working attitude. Ergonomics is the area of knowledge dealing with the capabilities and limitations of human performance in relation to the design of machines, job and other modifications of the environment (Taiwo and Babatunde, 2013, Abdul and Olaboye, 2002, Waldemar, 1999). QEC analysis show that manufacturing bricks with current working methods can cause WMSDs so that required working method improvement and equipped by some working tools such as stirring cement and brick working table. The result of this design is expected to increase the productivity of workers as

well as the achievement of an ergonomic system of work as can be seen in Figures 5.

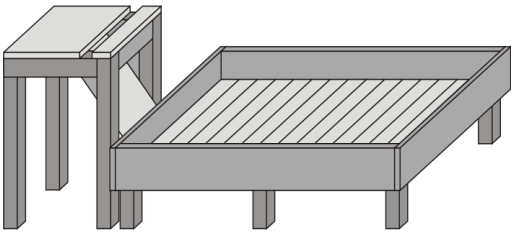

Figure 5 : Stirring Cement and Brick Working Table

After the addition of tools to work station then obtained a change in behavior that is quite significant.This can be seen from the analysis using QEC method in the following table 5.

Table 5. Comparison Value Exposure Before and After Working Conditions

Product	**Working Method**	**Before**		**After**	
		Exposure score	Action Level	Exposure score	Action Level
Brick	Mixing raw materials	53.41 %	3	44.32%	1

With the design of stirring cement and brick working table seen a decline in the value of the exposure. It's shown in figure 5.

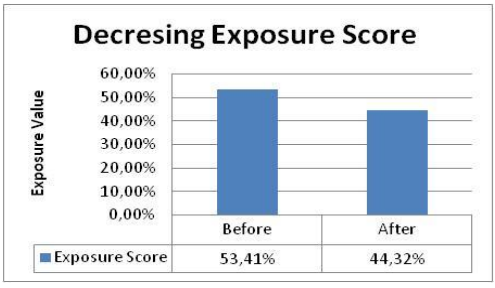

Figure 5 : Graphic of Decressing Exposure score

Conclusions

- Workers Complaint about organ motion in manufacture of brick may inhibit the work effectiveness, namely:
  - Disturbances in the shoulder area and lower back
  - Pain in the wrist area, neck and upper back.
  - Disturbances in the elbow and thigh
- Working attitudes with higher risk for the occurrence of work-related musculoskeletal disorders (WMSDs) are:
  - Brick material mixing process 53.41%.

  Risk of work occurs due to back and necks are bent at work and wrist rotating while lifting weights
- The proposed design tools are improvements in the high of cement mixing tub, improvement in high and width of the table for brick-making and design the handle of the shovel is adjusted with the height and width of the mixing cement tub, and brick molds.
- The addition of this tool is followed by changes in the worker working methods. The design of this tool aims to create comfort and work effectiveness and to minimize WMSDs in workers.

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