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ERGONOMIC DESIGN TOOL FOR BRICK OPERATOR

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ABSTRACT

Brick molding process is a job that requires human labor, this work is also done repeatedly in a long time. Work carried out repeatedly for a long time have a risk of WMSDs (Work Musculoskeletal Disorders). Human has a dominant role because in this manufacturing process, the work is done manually. Furthermore, ergonomic facilities and equipment are also very important to minimize the risk. Based on the results of the questionnaire NBM (Nordic Body Map), the biggest complaints are on the back, arms, shoulders, and the right hand of worker. The material mixing process requires the operator to bent almost 90^0. This posture can cause some health problems, such as musculoskeletal disorders. Observations using the QEC (Quick Exposure Checklist) show the exposure value of the mixing process material is 53.41%, which should be followed in the near future. Therefore, we design the material mixing tub and operator's work desk to minimize the risk of WMSDs using anthropometric data. After implementing the design, the exposure value decreased to 44.32%.

Key words : WMSDs (*Work Musculoskeletal Disorders*), NBM (*Nordic Body Map*), QEC (*Quick Exposure Check*), Anthropometry

1. INTRODUCTION

Human has a major role in the industry. The human role as an operator in the production process, especially if the production process done manually is very dominant. The more the operator activity, the greater the possibility of health risks.

In general, the more repetitions of movement in a work activity will result in greater muscle complaints. Repetitive work done in the long term will increase the risk of MSDs (Musculoskeletal disorders), especially when it is followed by a force / load and awkward posture (OHSCO, 2007). Awkward posture caused by the incompatibility of working facilities/ equipment with workers body, so workers should adjust his body by bending, twisting, and others which may result in musculoskeletal disruption.

This research was conducted on the industry engaged in the manufacture of ring wells and bricks. Man has a very dominant role in the production process because the work is done manually (manpower) and not using the machine, so that workers feel the aches and pains after work, especially in the waist, back, arms and shoulders. This is due to inadequate working facilities and working postures that do not fit, so the operator working position caused interference occurs MSDs and rapid fatigue on the operator.

Material mixing process requires the operator to bent almost 90^0, as is done on the floor using a trowel. Worker's back and body almost form an angle of 90^0, where the posture with the state of the votes can cause health problems, ie musculoskeletal disorders. This is caused by the manual working process and inadequate facilities. Therefore, this study was conducted to examine attitudes/ postures of worker in brick-making process, how much workload incurred at work, and ways to improve attitude / work posture so that the risk of MSDs can be minimized by using QEC (Quick Exposure Checklist).

2. THEORETICAL BACKGROUND

2.1. *Musculoskeletal Disorders* (MSDs)

MSDs are injuries or diseases of the nervous system or tissues such as muscles, tendons, ligaments, joints, cartilage or blood vessels. The pain from MSDs can be

described as rigid, inflexible, hot/ burning, tingling, numbness, cold and discomfort.

MSDs symptom can be viewed using Nordic Body Map (NBM) that ranging from discomfort (slight pain), pain, until very ill. By viewing 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).

Nordic Body Map is one of the ergonomic checklist questionnaires. Other checklist ergonomic is the International Labor Organization (ILO). But NBM questionnaire is the most often used to determine the inconvenience to the workers, has been standardized and neatly arranged. This questionnaire uses images of the human body that has been divided into nine main parts: the neck, shoulders, upper back, elbows, lower back, wrists/ hands, hips/ buttocks, knees and ankles/ feet (Kroemer, 2001). Information about maximum weight handled, time spent on task, level of hand force, application of vibrating tools, visual demand of the task and difficulties to sustain with the work as well as the stressfulness of the work are also obtained from the worker (Qutubuddin et.al, 2013).

2.2 *QEC* (*Quick Exposure Check*)

Quick Exposure Check (QEC) is a method to measure the risks associated diseases due to musculoskeletal disorders (MSDs) (Li and Buckle, 1999). QEC is very easy to implement, used to evaluate the workplace and work equipment design, as well as to facilitate the re-design of the workplace.. This method assesses the disruptions risks that occur on the back, shoulders/ arms, wrists, and neck. QEC help prevent WMSDs due to repetitive movements, compressive force, a wrong posture, and duration of action.

2.3 Work Physiology and Physical Work

Work Physiology is a study of factors that affect performance and fatigue during work. Work Physiology is the study of human physiology or function at work and is the basis for ergonomics science development. Physical work is a work that requires human physical energy as a power source. Physical work is often referred to as the "Manual Operation" where job performance is entirely depending on human, both of which serve as a source of energy, as well as a working controller.

In the case of this physical labor, energy consumption is a major factor and determines the lightness or heaviness of physical work. Furthermore, the determination of the classification is based on the work load increased pulse rate of work, and then compared with the maximum pulse rate because the load of cardiovascular (% CVL). The calculations are based on the formula below (Manuaba and Vanwonterghem, 1996).

$$\%\ CVL = \frac{100\ x\ (\text{work pulse rate} - \text{resting pulse rate})}{\text{maximum pulse rate} - \text{resting pulse rate}} x\ 100$$

The calculations of % CVL were then compared with the classification specified in Table 2 below:

Table 1. %CVL

% CVL	% CVL Classifications
< 30 %	No Fatigue
30% - 60 %	Improvements needed
60 % - 80 %	Performance in a Short Time
80% - 100%	Immediate Action Required
>100%	Activity not Required

2.4. Anthropometry

According to Stevenson (1987) and Nurmianto (1991), anthropometry is a collection of numerical data relating to the physical characteristics of the human body, the size, shape, and strength, and the application of these data handling design problems. Application of anthropometry can be done if the average and standard deviation of the normal distribution are available. Percentile is a value that stating a certain percentage of a group of people whose dimensions equal to or lowers than that value. (Eko Nurmianto, 1996). In order to design a product that fit with the human size that will use, it should be defined the principles that will be taken in the application of the anthropometric data.

3. RESEARCH METHODOLOGY

The stages of the research:

a) Goal setting

b) Design function analysis by using anthropometry
c) Determination of the design characteristics
d) Design image
e) Evaluation
f) Prototype

4. RESULT AND DISCUSSION

NBM (Nordic Body Map) questionnaires were distributed to determined the number of complaints on the worker's body part. The questionnaires were distributed to operators and people who work together, to get more valid results. The recapitulation of the Nordic Body Map questionnaires can be seen in the following table 2:

Table 2. Summary of NBM complaints

No	Type of Complaint	Respondents			
		TS	AS	S	SS
0	Pain / stiff in the upper neck	7	4	12	7
1	Pain / stiff in the lower neck	20	4	5	1
2	Pain in the left shoulder	10	8	9	3
3	Pain in the right shoulder	4	7	14	5
4	Pain in the left upper arm	11	11	7	1
5	Pain in the back	1	3	16	10
6	Pain in the right upper arm	0	5	17	8
7	Pain in the waist	2	1	16	11
8	Pain in the butt	28	2	0	0
9	Pain in the ass	29	1	0	0
10	Pain in the left elbow	20	9	1	0
11	Pain in the right elbow	24	3	2	1
12	Pain in the left forearm	15	14	1	0
13	Pain in the right forearm	5	11	8	6
14	Pain in the left wrist	4	13	9	4
15	Pain in the right wrist	3	4	16	7
16	Pain in the left hand	12	9	6	3
17	Pain in the right hand	9	16	4	1
18	Pain in the left thigh	12	9	6	3
19	Pain in the right thigh	9	16	4	1
20	Pain in the left knee	13	7	8	2
21	Pain in the right knee	10	13	6	1
22	Pain in the left calf	12	7	8	3
23	Pain in the right calf	15	7	6	2
24	Pain in the left ankle	11	13	5	1
25	Pain in the right ankle	14	9	5	2
26	Pain in the left leg	8	6	9	7
27	Pain in the right leg	6	11	8	5

TS = Painless, AS=A bit Pain, S=Pain, SS=Very painful

Body parts complain analysis on operators were using NBM, further stressing their health disorders (MSDs). For that, the assessment using the QEC (Quick Exposure Check) for each operator working attitude from the beginning to the end so obtained the following results:

Table 3.Summary of Worker Exposure Value

No.	Job	Exposure Level	Level Actions	Description
1.	Mixing material	53,41 %	3	Need immediate action
2.	Incorporate Material Into Moulds	28,41 %	1	Safe
3.	Compacting matter	23,40 %	1	Safe
4.	Flatten matter	23,40 %	1	Safe
5.	Reversing the Moulds	27,2 %	1	Safe
6.	Hit Moulds	23,40 %	1	Safe
7.	Opens Moulds	27,16 %	1	Safe
8.	Bringing Matter to Storage Racks	21,59 %	1	Safe

The working attitude with the greatest risk are in the mixing material process with the exposure value of 53.41% and action level 3, which means required immediate action. This is because the operator's body should be bent almost 90 degrees and work with adequate facilities, while other job has a safe criteria working attitude. Heart rate measurement is done to see the energy consumption

Table 4. Summary of Workload Calculation

Operator	Age	Work Pulse Rate	Resting Pulse Rate	Maximum Pulse Rate	% CVL	Description
1	45	106,00	85,67	175	22,75	No Fatique
2	51	108,33	80,5	169	31,44%	Need Improvement
3	48	100,87	70,21	172	30,12%	Need Improvement
4	28	98,00	70,33	192	22,74	No Fatique
5	32	99,67	68,32	188	26,19%	No Fatique
6	50	100,42	70,58	170	30,01%	Need Improvement
7	38	97,60	72,55	182	22,88	No Fatique
8	28	89,33	60,41	192	21,97%	No Fatique
9	44	99,45	75,01	156	30,17%	Need Improvement

Therefore, this study designed a mixing tub material made of wood and brick print work desk by changing the layout of equipment and materials so that desks can survive in the long term. For so requires some anthropometric data of the human body so that tools are designed according to ergonomic rules. Anthropometric data of body dimensions required to perform the design is as follows:

Table 5. Anthropometric Data Needed

No	Antropometric Data	Code	Percentile			SD
			5th	50th	95th	
1	Length of standing knee	TLB	47,76	49,4	51,05	1,6
2	Length of arm span	RT	164,95	166,6	168,24	6,4
3	Fore arm's read	JTD	72,9	74,55	76,19	1,55
4	Height of standing elbow	TSB	99,86	101,5	103,15	3,5
5	Length of arm	PLB	42,61	44,25	45,9	1,75

The size of the facilities and tools along with the main components in accordance with the concept of ergonomics obtained from the percentile calculation, while the dimensions of the other components will be adjusted to the data size of the tool, as shown in Table 6 below:

Table 6. Summary of Size Calculation

No.	Tools Working	Component	Data Used	Selected Percentile	Component
1.	Material Mixing Tub	Tub Length	Height of Standing Knee	P5	48 cm
		Tub Width	Arm Span	P95	275 cm
		Tub Height	Reach of Hand	P5	179 cm
2.	Working Table	Desk Height	Height of Standing Elbow	P5	80 cm
		Desk Length	Length of forearm	P95	46 cm
		Desk Width	Reach of forearm	P5	73 cm

Figure 1. shows the results of the design.

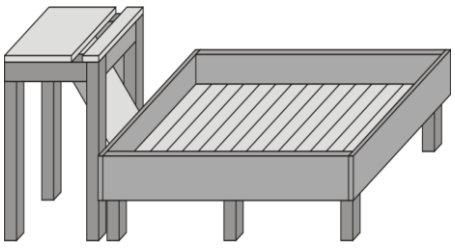

Figure 1. Picture of Design

Evaluation using observations with QEC method conducted after the draft is complete. Impairment of this exposure can minimize the risk of MSDs, ie from 53.41% to 44.32%. This is because the brick working desk is appropriate or approaching ergonomics. This can be seen from the smaller worker exposure attitude, starting from compacting to open the mold, and which has poses almost no risk of MSDs. However Nordic body map questionnaire showed that there were complaints on the right hand and right shoulder on the operator. This is due to more frequent use of the operator's right hand, so the fatigues in his right hand occur more quickly, therefore it was designed work desk by changing the layout of the equipment.

Moreover, work desk are also provided additional accessories in the form of zinc slab which is positioned under the table and addressed to the mixing tub. This is because the material scattered and spilled onto the floor when the operator enter and condense the material, so that the operator had to shovel the materials that are spilled on the floor. Extra bases on the workbench causes the spilled material will flow back into the cement mixing tub so that no material is wasted. Comparison of working attitudes before and after the design can be seen in Figure 2 and Figure 3, which shows the condition before and after the design.

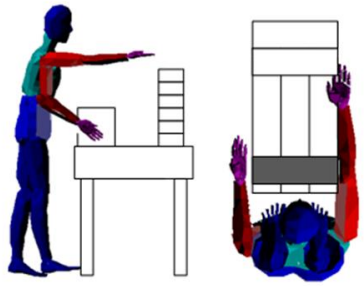

Figure 2. Condition Before The Design

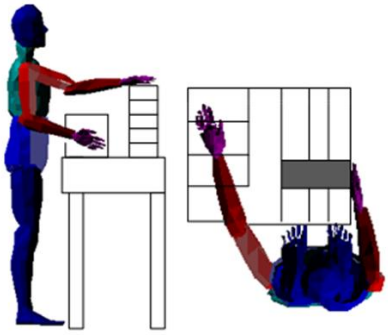

Figure 3. Condition After The Design

The image above shows the working attitude when the operator reaches a slab of wood that serves as the base of the printout. At this time the work desk made extending to the fore, so as to reach the operator must leaned forward, reaching out using the right hand. The frequent use of right hand while working on a right-hand lead to fatigue occurs sooner. This is also supported by the results of the questionnaire Nordic Body Map. Therefore, the layout of the wooden slab was changed to the left so that the operator can reach it with his left hand. Wooden slab is positioned on the left so that the operator is not too far reaching, as their previous condition. This is to minimize the use of the right hand and to avoid fatigue.

5. CONCLUSIONS

- Operator working attitude in initial conditions showed symptoms MSDs, where there are complaints on the waist, back and right-handed operators.
- Working posture assessment using the QEC, shows the right hand is dominant operator to use when working so that the right hand is faster experiencing fatigue
- Observations using the QEC indicates the material mixing process requires immediate improvement with the risk level of 53.41%.
- Four of the nine workers have %CVL> 30%, which means that improvements were necessary to the present working attitude because it caused fatigue occurs sooner based on the amount of energy consumption is issued.
- The mixing material tub design lowers the risk level MSDs be 44.32%.
- To deal with complaints at the right hand of the workers, redesign was conducted on the equipment layout of the work desk, by moving wooden slab that previously was in front of operator to the left, so that workers can reach by using the left hand.

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