The 4th ICIBA 2015, International Conference on
Information Technology and Engineering Application
Palembang-Indonesia, 20-21 February 2015

Design of Ergonomics Ladle Appliance for Metal Casting Process

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Abstract

The ladle appliance is a tool used to pour liquid metal into mold in the metal casting process. Two workers with use a certain posture do this process manually. This activity may cause musculoskeletal disorder at whole workers body part. It was indicated that more than 55% of worker experiencing pain in back, neck, arm and leg. Objective of the research is to propose an ergonomic design of ladle tools for reducing unnatural posture such that it can avoid musculoskeletal disorder. Rapid Entire Body Assessment method was used to identify work posture and NIOSHs lifting equation was used to determine the optimal method in pouring activity. Result of the research show that ergonomic ladle designed can reduce musculoskeletal disorder on workers body part about 29%.

Keywords : *Ergonomics, Musculoskeletal Disorder, lifting equation, REBA, Ladle*

1 INTRODUCTION

Recently metal is one of the raw materials that are still needed in manufacturing industry. In 2013, Ansari Bukhari state that growth of metal, iron and steel industry increased by 12.74% (antaranews.com,2013). Therefore, the metal industries should conduct an improvement to adapt in the condition. CV. Sispra Jaya Logam is company that produce raw material metal. One main activity is metal casting process that is by pouring liquid metal into mold manually. It used manual a tool that called Ladle. The tool is like spoon and made from iron. The weight of Ladle is 10 kg and after filled with liquid metal, it is becomes 40 to 60 kg. When using ladle many parts of body are at risk of musculoskeletal disorder. It is caused by unnatural posture and heavy load while working. Musculoskeletal disorder is a disease caused by repetitive activities, static activities and lacks of rest (Hagberg, 1997). Maximum pressure accepted by human muscle is about 30 to 40 Newton (Grandjen in Tayyari, 1997). Therefore, load that can be held by human must be calculated to avoid muscle overwork.

Many methods used to analyze posture. One of them is Rapid Entire Body Assessment method that effective to analyze all part of body (Budiman&setiyaningrum, 2004; McAtamney, 1993). Another method is NIOSH lifting equation. It is a measure tool to analyze manual material handling. This method is used to analyze load that can be lifted by body especially the spine (Sari, 2011; Kroemer at.al, 1994).

The purpose of this study is to redesign of ladle for casting metal that can reduce musculoskeletal disorder on workers body part.

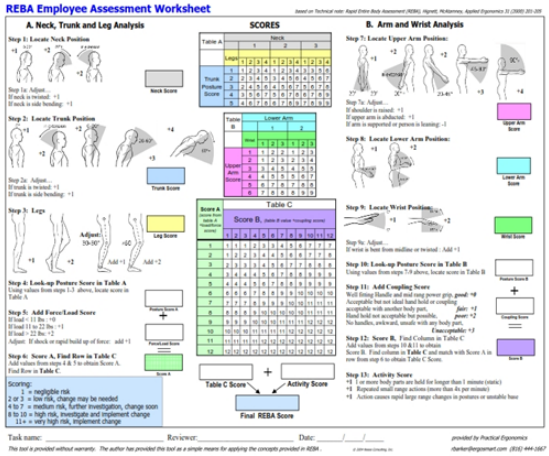

Figure 1: REBA Employee Assessment Worksheet

2 RESEARCH METHODOLOGY

2.1 Scoring Method of REBA

Scoring posture in REBA method is divided into 13 steps which is each parts has a different assessment criteria. The steps can see in figure 1.

2.2 Method of Recommended Weight Limit

Recommended Weight Limit trial in NIOSH's is useful to provide the workers when safety lifting loaded. There are 7 factor variables to calculate RWL, which is (Tayyari,1997):

1. Load Constant (LC) : The LC is the maximum load that can be lifted safely, that is 23 kg

2. Horizontal Multiplier (HM). HM calculated from:

$$25/H \tag{1}$$

   H : The horizontal location of the hands from the midpoint between the ankle.

3. Vertical Multiplier (VM), VM calculated from :

$$(1 - 0.003|V - 75|) \tag{2}$$

V : The vertical location of the hands from the standing floor.

4. Distance Multiplier (DM), DM calculated from :

$$(0.82 + 4.5/D) \tag{3}$$

D : The vertical distance travel between the location of the hands at the origin and the destination of the lift.

5. Asymmetry Multiplier (AM), AM calculated from :

$$(1 - 0.0032A) \tag{4}$$

A : The angular displacement of the load from the sagittal plane, measured from the origin and the destination of lift.

6. Frequency Multiplier (FM) : The average frequency rate of lifting, measured in lifts per minutes. Look at the table of Frequency Multiplier.

7. Coupling Multiplier (CM) : quality of worker's grip when lifting process. Look at the table of Coupling Multiplier.

The formula used to measure RWL is:

$$RWL = LC\ x\ M\ x\ VM\ x\ DM\ x\ FM\ x\ AM\ x\ CM \tag{5}$$

The formula used to measure Lifting Index is :

$$LI = Lifting\ Load/RWL \tag{6}$$

3 RESULT AND DISCUSSION

3.1 Design of Ergonomic Ladle

Distance reduction of liquid metal containers adjusted to the size of the knee height so that the workers can always be in the upright position when using this tool. The width of the handle on the operator 1 also made changes since the previous tool grip is too wide so that the arm away from the body of workers in lifting process.

3.2 REBA Score

REBA score in casting workstation is 8 for operator 1 and 10 for operator 2. It means that the score shows the high risk level. It is caused by use of unnatural posture while working such us squat posture and stoop posture. In ergonomics, good posture while working is when spine bent no more than 20 from the axis of the upper body, while head is not look down or look up more than 20 of the axis perpendicular to the collar bone and shoulder in a relaxed while working (Humantech,1995). After redesign, REBA scores obtained 3 for operator 1 and 4 for operator 2. That means there is a decrease in the risk of worker's posture.

REBA score obtained in smelting workstation is 10 for both of operator. That score included in the high risk level, this is caused the unnatural posture while working such us squat posture and stoop posture. In ergonomics, good posture while working is when spine

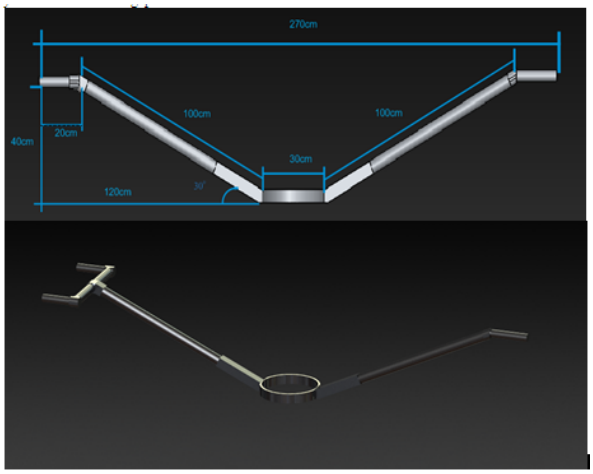

Figure 2: Design of New Ladle

Table 1: REBA Score in Casting Workstation

	Casting Workstation			
	Before		After	
	Op 1	Op 2	Op 1	Op 2
REBA Score	8	10	3	4
Action Level	3	3	1	2
Level of Risk	High	High	Low	Medium

bent no more than 20 from the axis of the upper body, while head is not look down or look up more than 20 of the axis perpendicular to the collar bone and shoulder in a relaxed while working (Humantech, 1995). After redesign, REBA scores obtained 3 for operator 1 and 4 for operator 2. That means there is a decrease in the risk of worker's posture.

3.3 Recommended Weight Limit

Load received by the operator 1 is 30.9 kg and operator 2 is 29 kg. All of RWL in both of workstation under load lifted workers with the result lifting index value greater than 1. The lifting task greater than 1 present a risk of musculoskeletal disorder (Tayyari,1997).

4 CONCLUSION

Based on the research, it can be concluded :

1. New ladle designed can reduce musculoskeletal disorder on workers body part about 29%.

2. Recommendation load of new design is 18.5kg for each worker.

Table 2: REBA Score in Smelting Workstation

	Smelting Workstation			
	Before		After	
	Op 1	Op 2	Op 1	Op 2
REBA Score	10	10	3	4
Action Level	3	3	1	2
Level of Risk	High	High	Low	Medium

Table 3: Value of Recommended Weight Limit and Lifting Index

			RWL	LI
Smelting Workstation	Before	Op 1	11,36kg	2,72
		Op 2	11,92kg	2,43
	After	Op 1	20,9kg	1,1
		Op 2	20,7kg	1,1
Casting Workstation	Before	Op 1	10,9kg	2,83
		Op 2	10,4kg	2,78
	After	Op 1	18,5kg	1,24
		Op 2	20,3kg	1,13

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