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Evaluation the Risk Factors for Manual Material Handling of the Packages in Packaging Lines

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Abstract- **In the packing section in the Jowfe Oil Technology Company there are two packaging lines one for bentonite and barite and other for painting carbonate and excavation carbonate. This is a packing machine that has two openings to fix the package to them alternately. Once the package is filled with the desired weight (which is determined by adjusting the machine and it is 25kg), the packing process stop automatically and the next package is filled and so on, The package then moves on the conveyor at the end of which there are two workers who lift the package alternately to put it on the pallet. This paper focus on manual material handling of the packages and calculating the risk factors on the worker due to lifting the packages of that weight and under certain work conditions the important risk factors was determined, these were force stress, posture and repetition, the revised NIOSH manual lifting equation, OWAS analysis and RULA sheet were used to evaluate the risk factors, from the analysis, the important risk factor was the weight of the lifted package then task repetition while if the lifted weight has not this high score the posture of the worker is good.**

Index Terms: **Risk Factor, Workplace, Force, Posture, Repetition**

I. INTRODUCTION

Lee, et.al.[5] presented results of a study conducted to estimate lower back loadings in cart pushing and pulling. Experiments were conducted in the laboratory using a cart. Six subjects with different weights (ranging from 50 to 80 kg) were tested for three for different pushing and pulling forces (98, 196 and 294 newton's), three different heights of exertion (660 , 1090 and 1520 mm high) and two different moving speeds (1.8 and 3.6 km /h).It was found that, in general, pushing a cart results in lesser lower-back loading than pulling. Subject body weight affected the lower-back loadings more significantly in pulling (50% increase as body weight increased from 50 kg to 80 kg) than in pushing (25% increase). Handle height of 1090mm was found to be better than other handle heights in pushing while 1520 mm handle height was better for pulling in reducing lower – back loadings. In cart pushing and pulling, light body weight and slow cart speed are good for lowering the compressive force at the L_5/S_1 disc. The required hand force also affects the compressive force. In general, pushing results in lower compressive force than pulling for the same task conditions.

The biomechanical evaluation of loads on the body is one of tools that facilitate the assessment of manual handling tasks. A computer program has been developed to determine moments about joints during static tasks by Tracy and Corlett [8]. It differentiates between flexion/ extension, rotation and adduction abduction requirements so that the major efforts can be identified and compared with population strength data. It also evaluates loads on the spine and within low-back muscles for purposes of comparison with many manual handling studies. Posture and a variety of external forces are input to the system with a choice of two interchangeable methods.

Yates and Karwowski [10] used a psychophysical method to determine the maximal acceptable load that eight males (age 22-30 years)would lift in each of four different positions: (1) seated, two-handed, symmetrical lift from a table, to a position 38 cm forward of the edge,(2) a seated lift from a position at the subjects side, on to a table in front of the subject involving a 90 degree twist of the torso,(3)standing, two-handed, symmetrical lift from the table, to a position 38 cm forward of the edge, and (4) standing, vertical lift from 86cm to 134.5cm above the floor. The data presented suggest that the maximal acceptable lift while in a sitting position is less than the maximal acceptable lift while standing.

Verbeek [9] designed a programme in which instruction was given in the optimal adjustment of seat and desk height based on individually measured body dimensions. The programme was evaluated by means of measurement of seat and desk height before and after instruction to an experimental group in comparison with a control group to which no instruction was given. It can be concluded that instruction had a limited impact on the adjustment of furniture in order to adopt a more ideal working posture. This is probably due to the absence of

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sufficient extra help for adjustment like footrests, limitations in the concept of the ideal sitting posture, and practical and social impediments.

Measurements have been made of the comfortable and maximum torques and compressive forces which people can exert when opening jars, bottles and cardboard cartons developed by Berns [1]. Dummy containers, especially both high and low temperature extremes. This also implies that male workers may be preferable on work operations instrumented with strain gauges, were used for the purpose. Samples were obtained of both the normal and the disabled populations, the latter covering a range of disabilities and degrees of handicap. It has been shown that there is some constancy in the ratios of torques between samples percentiles (for example (95%)/(50%) ile) between men and women and between the maximum and comfortable torques, across all the jars and bottles used.

Hand pinch grips in the standing and sitting positions on a group of 46 healthy males of 20 to 26 years old were measured by Catovic, et.al. [3]. The results were as follows:1-hand pinch grip forces are higher when the subject is standing than when he is sitting.2-hand pinch grip forces, depending on the position of the arm in the working space.3-there is an effect due to the position of the arm in relation to the frontal position of the subject's thorax.4-a handle which permits all fingers to be spread in a pinch grip is capable of having an applied force 50% greater than if the thumb and either forefinger or middle finger grips the handle.

Beshir and Ramsey [2] developed linear regression equations for both males and females to show the relationship between their thermal sensation and ambient temperature. These equations define a mid-range comfort temperature for females of 77.1 ° F (25° C) WBGT, while the mid-comfort temperature for the males is 71.6° F (22° C) WBGT, The difference between the comfort temperatures of the two groups was significant at the 1%level. This would indicate that the work environment needs to be at a slightly higher temperature level if it involved primarily female workers and if one wished to maintain optimal comfort conditions. It was also observed that females tended to feel more uncomfortable than males at which entail thermal extremes, since female workers may have higher levels of discomfort.

II. METHODOLOGY

For the purpose of achieving the objective of this study, the methodology that is to be followed can be summarized as follows:

1. Determining the risk factors for the worker's health in the workplace that by knowing the task description in workplace.
2. Ergonomic Evaluating for these risk factors individually by calculating the score of risk for each risk factor.
3. Analyzing and classifying the score of risk values for each risk factor.
4. Giving engineering and administrative solutions to reduce these risk values.

III. TASK DESCRIPTION

When the product is packaged, it is transferred by a conveyor. At the end of the conveyor, there are two workers; one is standing to the left and the other is standing to the right and a pallet is between the two workers facing the end of the conveyor. Each worker lifts the package alone to place it on the pallet and the two workers lift the packages alternately until the desired number of packages on the pallet is reached.

A fork-lift takes the finished pallet away and new pallet is brought and the work is repeated in the same way, the data of lifting task as shown in (table 1) below;

Table (1) shows the details of the task description in numbers for a worker who lifts the product from the conveyor and puts it on the pallet so that another worker performs the same task alternately.

IV. ASSESSING THE WORKPLACE FOR ERGONOMIC RISK CONDITIONS

Manual materials handling is considered one of the main causes of injuries to workers in the workplace, in order to ensure a safe workplace for the health of the worker the most important and most dangerous risk factors was determined and evaluated in the packing section where they were: 1- Force stress 2- Posture 3-Repetition.

To estimate the degree of risk for these factors, each factor was analyzed alone.

A. *Force analysis*

National Institute for Occupational Safety and Health (NIOSH) published its work practices guide for manual lifting (NIOSH 1981) and revision in 1994, those two documents have been widely used to assess manual materials handling activities. The revised NIOSH manual lifting equation was used to calculate the recommended weight limit (RWL) and the lifting index (L.I) for each product as shown in (Tables 2- 3- 4)

where:

RWL = LC*HM*VM*DM *FM *AM*CM
L.I = Load weight / RWL
where:
LC: Load constant = 23 Kg (about 51 Ib)
HM: Horizontal multiplier.
VM: Vertical multiplier. DM: Distance multiplier.
FM: Frequency multiplier.
AM: Asymmetry multiplier.
CM: Coupling multiplier.

Table 1. Data of lifting task

		Packaging line 1	**Packaging line 2**
1	Product type	barite and bentonite	painting carbonate and excavation carbonate
2	Package weight	25kg	25kg
3	Package size	27*46 *8 cm(barite), 40*52*9cm(bentonite)	40*52 *9cm (for two)
4	Pallet size	60 packages(6*10)	40 packages(5*8)
5	Productivity /hour	10 pallets/ hour	15 pallets/ hour
6	Number of workers	2 workers	2 workers
7*	Frequency of lifts	5 lifts/ minute	5 lifts/ minute
8	Work shift	from 8 :00 to14 :30	from 8 :00 to14 :30
9**	Quality of coupling	poor	poor
10	Angle of twist	°90	°90
11	Horizontal location of lift center line	21cm (barite), 27 cm (bentonite)	27 cm(for two)
12	Vertical location of the hands at origin of lift	100 cm	105 cm
13	Pallet height from the floor	12cm	12cm

* *Frequency of lifts / min/ worker =
(Productivity/ min)*(Pallet size)/ Number of workers

Frequency of lifts / min/ worker for Line 1
= (10*60) / (2*60) = 5 packages / min

Frequency of lifts / min/ worker for Line 2
= (15*40) / (2*60) = 5 packages / min

**The package shape is like package that is cement package that is present in the market now "package without handles".

Table 2. Calculate RWL& L.I for barite

Multiplier	Layer1	Layer2	Layer3	Layer4	Layer5	Layer6	Layer7	Layer8	Layer9	Layer10
Horizontal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vertical	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925
Distance	0.871	0.876	0.883	0.890	0.900	0.914	0.933	0.961	1.00	1.00
Frequency	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Asymmetry	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712
Coupling	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
Product of multipliers	0.180	0.182	0.183	0.185	0.187	0.190	0.194	0.199	0.207	0.207
RWL	4.14	4.19	4.21	4.26	4.30	4.37	4.46	4.58	4.76	4.76

- The minimum value of RWL was chosen.

D1=100-12=88 D2= 88-8=80 D3=80-8=72 and so on. Note: D9= 24 D10= 16 but let D9 & D10=25
RWL = 4.14 Kg & L.I = (25 /4.14) = 6.039 ≈ 6.04

Table 3. Calculate RWL & L.I for bentonite

Multiplier	**Layer1**	**Layer2**	**Layer3**	**Layer4**	**Layer5**	**Layer6**	**Layer7**	**Layer8**	**Layer9**	**Layer10**
Horizontal	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.926
Vertical	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925
Distance	0.871	0.877	0.884	0.894	0.907	0.925	0.925	1.00	1.00	1.00
Frequency	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Asymmetry	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712
Coupling	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
Product of multipliers	0.167	0.168	0.170	0.172	0.174	0.178	0.183	0.192	0.192	0.192
RWL	3.84	3.86	3.91	3.96	4.00	4.09	4.21	4.42	4.42	4.42

RWL = 3.84 Kg & L.I = (25/3.84) = 6.51

Table 4. Calculate RWL & L.I for painting carbonate and excavation carbonate

Multiplier	Layer1	Layer2	Layer3	Layer4	Layer5	Layer6	Layer7	Layer8
Horizontal	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.926
Vertical	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910
Distance	0.868	0.874	0.880	0.888	0.899	0.914	0.935	0.970
Frequency	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Asymmetry	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712
Coupling	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
Product of multipliers	0.164	0.165	0.166	0.168	0.170	0.173	0.177	0.183
RWL	3.77	3.80	3.82	3.86	3.91	3.98	4.07	4.21

RWL = 3.77 Kg & L.I = (25/3.77)=6.63

B. Posture analysis

Ovako Working Posture Assessment System (OWAS analysis) and Rapid Upper Limb Assessment (RULA sheet) were used to assess the worker posture and calculate the risk score.

1- OWAS analysis:

The score of risk by use OWAS analysis was calculated as shown in (table 5) below:
This result is affected very much by the lifted weight,
If the score of use of strength was= 1 or 2, the result would be the reverse of that completely.
That is to say the posture of the worker is considered suitable if we excluded the effect of the lifted weight.

Table 5. Calculate the score of risk by use OWAS analysis

	The score of risk
Back	3
Upper limbs	1
Lower limbs	1
The use of strength	3
The result	Harmful-do at once

2. RULA sheet:

The score of risk by use RULA sheet was calculated as shown in (table 6) below:

Table 6. Calculate the score of risk by use RULA sheet

	The score of risk
Upper arms	2
Lower arms	2
Wrist	2
Wrist twist	1
From table A	3
From table B	4
Neck	2+1=3
Trunk	2+1=3
Legs	1
Upper limbs total	3+4=7
Lower limbs total	4
The grand score	6

This score index to the investigation and changes required soon.
This result proves obtained result from the use of OWAS analysis; here also if the lifted weight has not this high score the posture of the worker is good.

C. Repetition analysis

NIOSH equation and RULA sheet included this factor in their calculations; this factor has important effect on the recommended weight limit (RWL) and the lifting index (L.I) for each product, for example; if the frequency is 0.2 lifts/ min instead of 5 lifts/ min, the recommended weight limit (RWL) increases and lifting index (L.I) decreases clearly for all products, as shown in table (7) below:

V. DISCUSSION

1- The weight of the lifted package is much more than RWL for two packaging lines, this different between them is indexed by lifting index where L.I for barite = 6.04, L.I for bentonite = 6.51 and L.I for painting carbonate & excavation carbonate = 6.63
2- There is no significant difference in calculating RWL from one layer to another for two packaging lines, as the maximum difference in RWL for barite = 0.62Kg, the maximum difference in RWL for bentonite = 0.58Kg and the maximum difference in RWL for painting carbonate & excavation carbonate = 0.44Kg.
3- There are six multipliers that effect on calculation of recommended weight limit (RWL), as can decrease the force stress by improving one or more of multipliers.
4- From work posture analysis which was based on OWAS analysis and RULE sheet, we found that risk does not lie in the posture of the worker even with taking the twisting into account.
5- If the repetition of the task decreases, then the recommended weight limit (RWL) increases and lifting index (L.I) decreases clearly for all products, as shown in table (7) where the magnitude of workplace risk decreases.

Table 7. Comparison between RWL & L.I f= 5 lifts/min & f=0.2 lifts/min

Product type	**RWL & L.I** **If f= 5 lifts/min**	**RWL & L.I** **If f= 0.2lifts/min**
Barite	RWL = 4.14Kg L.I = 6.04	RWL = 10.05Kg L.I = 2.49
Bentonite	RWL = 3.84 Kg L.I = 6.51	RWL = 9.33 Kg L.I = 2.68
Painting Carbonate and Excavation Carbonate	RWL = 3.77 Kg L.I = 6.63	RWL =9.16 Kg L.I =2.73

VI. SOLUTION

Two types of solution to reduce workplace risk factors and getting to a safer workplace ware considered¸ these solutions were:

1- Engineering Controls.
2- Administrative Controls.

A. Engineering Controls

Engineering controls involve changing the physical workplace to eliminate or reduce ergonomic risk. The underlying stressor (risk factor such as awkward posture, force, repetition, etc.) is identified and directly addressed through physical workplace modification.

1- Make the end of conveyor adjustable to control values of vertical location of the hands at origin of lift (V) and vertical travel distance from origin to destination of lift (D) in order to reduce the effort used in the lifting task and to make the conveyor suitable to all workers with different body heights.
2- The pallet height should be more than 12cm from the floor, this reduces the value of vertical travel distance from origin to destination of lift (D) and thus reducing the effect of distance multiplier in the NIOSH equation.

3- Adding handles to the package with optimized size and shape so as to making the holding of the package easy and convenient.
4- Divide the production of the same product on more than one line thus reducing the repetition of the worker on each line without reducing the desired total daily production.
5- Use pads and cushions to reduce the lifted weight.
6- If we cannot change any of the conditions of the work, we should change the weight of each package of each product to reach RWL even if the production size reduces.

B. *Administrative Controls*

Administrative controls involve changing work organization to reduce worker exposure to ergonomic risk

1- More than two workers should perform this task in alternation so that one or two workers are not exposed to this load for long duration.
2- The pallet cannot be placed in front of the worker because of the presence of the conveyor so the workers have to twist to put the package on the pallet, the addition of another worker between the worker at the end of the conveyor and the pallet in such away was proposed that the pallet is in front of the additional worker to reduce the twisting of the two workers
3- Good training of workers for the task that requires heavy weight lifting and learning lifting techniques that suit the muscular system.
4- Repetition of the task must be reduced; more breaks for workers should be given.
5- Reduce the production rate and thus reduce the work duration for each product to reach RWL so that the worker can lift it without any risk.

VI. CONCLUSION

In this paper¸ the risk factors of lifting manual task for the worker in the product packaging line were identified and evaluated ¸where there are two packaging lines one for bentonite and barite and the other for painting carbonate and excavation carbonate. The most important risk factors for this task were the weight of the lifted package (mechanical stress) ¸ posture of the worker and the repetition of the task.

From the analysis¸ it became clear that the weight of the lifted package is the most important risk factor for the worker and then the repetition of the task¸ while the posture of the worker less risk especially if the weight of the lifted package and the repetition of the task decrease.

This study is to ensure a safe workplace for the health of the worker without exposure to work injuries by maintaining the recommended weight limit (RWL) in manual materials handling. .

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