ASSESSMENT OF WORKER POSTURE IN HERBICIDES PRODUCTION AND BREAK TIME DETERMINATION USING OCRA INDEX METHOD

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Keywords: Musculoskeletal Disorders (MSDs), OCRA index, Repetitive task

Abstract. Workers in the packaging process of pesticide factories constantly do repetitive jobs on belt conveyors, eight hours per shift. Results of preliminary observations used Nordic Body Map (NBM) questionnaire shown that there was the severity of Musculoskeletal Disorders (MSDs) on the upper body of the workers. The purpose of this research was to analyzing and evaluating the risk of exposure of those repetitive tasks, determining rest time and also determining suitable work posture. Occupational Repetitive Actions (OCRA) index used to determine the risk level of musculoskeletal disorders and rest time. The occupational repetitive actions (OCRA) index is the most precise method for analyzing and evaluating the risk of exposure to repetitive tasks. There were six activities observed in the packaging process. The highest OCRA index result was inserted cardboard sheet with 17,55 right-hand risk value and 16,51 left-hand risk value. Improvement proposed in this study was the design of the work method with rest time calculation and posture correction. Decreasing of OCRA index after improvement result was at 11,11% to 76,37%.

Introduction

The packaging process in Herbicides producer company required many workers, those parts are arranging bottles, check aluminum seals, check the bottle cap, insert cardboard sheets, arrange the dosing cap, and move finished product. Results of preliminary observations used Nordic Body Map (NBM) questionnaire shown that there was the severity of Musculoskeletal Disorders (MSDs) on the upper body of the workers. Previous studies in the packaging process have been carried out. Evaluation of working posture and musculoskeletal disorders prevalence in packaging workers used the RULA method. The result from that research showed a non-significant relation between body parts scores and self – reported pains in the regions in all subjects [1]. Ovako Working Analysis System (OWAS) was used to check the risk level of working posture in the packaging section. CATIA was used to design the new working facility [2]. To assess the exposure of upper limbs to musculoskeletal disorders (MSD's) in the sequential packaging of a product, and the analysis of risk factors used the OCRA checklist method [3].

Workers in the packaging section worked repetitively and continuously for eight hours per shift. Among the most relevant safety issues in terms of workload and working environment is the presence of repetitive tasks [4]. The ISO 11228-3:2007 explain about the ergonomic standard committed to handling low loads at high frequency in the working environment, and defines the repetitive task, as the task characterized by repeated work cycles. High repetition of movements in manual tasks can lead to work-related musculoskeletal disorders, with specific regard to the upper limb. Musculoskeletal disorders are among the most common occupational problems [5]. Important typical effects of time-on-task during tedious monitoring tasks or other repetitive tasks can be vigilance decrement, slowing in the reaction times or an increase in error rates [6]. According to the World Health Organization, musculoskeletal disorders are the leading cause of workplace disability in developed countries [7].

For detailed risk assessment, the ISO 11228-3:2007 provides a specific method named OCRA (Occupational Repetitive Action). OCRA has been introduced by [8] and later completed, developed and updated from his research group [9]. It is generally used for the design or in-depth analysis of workstations and tasks. Since its introduction, OCRA has been used many times from ergonomists and researchers in order to improve the ergonomic design [10]. Ergonomic measures of upper extremities (i.e. hand activity and hand-arm vibration exposure) are integrated into assembly line design problems [11] with linear models that allow ergonomic and productivity measures to be treated as a mixed-integer programming model.

Cognitive status and repetitive low-risk work assignments were analyzed using the OCRA method and combine the result with Electrodermal Activity (EDA) [12]. Boenzi [13] evaluated workload risk in the car seat assembly process by the OCRA index and found both optimal break and job rotation schedules used integer programming models. This study has not broken down the work in detail and did not show the right and left-hand chart. And so there is no recommendation for proper body posture for workers. In another research using Occupational Repetitive Actions (OCRA) index to reduce the risk level of Repetitive tasks carried out by packaging workers in fertilizer producer company and the recommendations are resting schedules used declaration from ACGIH [14]. In this study, We determine the risk level of the repetitive task through the established OCRA method by observing the right and left-hand chart. The aim of this study is determining the risk so that recommendations can be made in the form of scheduling adequate time breaks used integer linear programming and a suggested posture was simulated using CATIA.

Methodology

Workers in the packaging section of herbicide production must work repeatedly for 8 hours per work shift, where workers have their respective duties, there were 6 different tasks ranging from arranging empty packaging bottles to moving finished products. To assess the OCRA index of this work, the assessment procedure for monotask work [15]. Steps in applying OCRA index method in this research are as follows:

1. Make The right and left-hand chart to breakdown the technical actions in detail
2. Calculating Actual Technical Action (ATA). First, Determine the Number of Technical Action (nTC) in the cycle is obtained from the right and left-hand chart. Second, evaluate their frequency (f) per minute, considering the cycle time (tc) in seconds. Then, determine Net Duration of Repetitive Task Duration (D) in minutes of repetitive tasks per shift. The last step was to determine Actual Technical Action (ATA).

$$f = nTC \times \frac{60}{tc} . \qquad (1)$$

$$ATA = \sum f \times D \ . \qquad (2)$$

3. Calculating RTA, there are several factors considered. That Were constant frequency (CF) the value is 30, force factor (Ff) that uses the Borg-10 scale, postural factor (Fp), stereotypy factor (Fs), additional multiplier (Fc), the duration of the repetitive task (D), recovery period (Fr), duration factor (Fd)

$$RTA = \sum_{x=1}^{n} [CF\ (Ff \times Fp \times Fs \times Fc \times D] \times (Fr \times Fd) . \qquad (3)$$

4. Model for calculating Occupational Repetitive Actions (OCRA) index

$$OCRA = \frac{ATA}{RTA} \qquad (4)$$

5. Classify the result of OCRA index
   the risk level according to Table 1, which explains the risk level according to the OCRA index value produced. According to ISO 11228-3 [16]. the higher the OCRA index value the higher the risk caused.

Table 1 Risk Classification

OCRA Index Value	Risk Classification
≤ 1,5	Optimal
1,6 - 2,2	Acceptable
2,3 - 3,5	Uncertain or very low
3,6 – 4,5	Light
4,6 -9,0	Medium
> 9	High

6. Make optimal break time scheduling model

In particular, recovery periods have a strong impact on the OCRA index value. Break time is time which allows recovery of musculoskeletal function for one or more muscles/tendon groups. There are several criteria that must be taken into consideration [17], namely:

1. Providing as much time lag as possible, for example, 1 time after 50 minutes after doing repetitive work with a duration of no less than 7-10 minutes.
2. Avoid giving breaks during the final hours of work shifts.
3. If there is a visual control on the job, then the visual control can also be used as a recovery period.

For each hour of repetitive work, the OCRA method showed that ten minutes is the minimum duration of rest. Therefore, according to [2], the OCRA method carried out hourly observations to determine the number of hours worked with an inadequate recovery period in work shifts.

Taking into account the type of work shift observed, if n-hours is the given time span, then A is the total shift time of the work in hours, with at (t = 1, 2, ..., n) representing the hourly rest time Eq. 5. Furthermore, if the lunch break is included in the work shift, then given a slot equal to B. In the OCRA method, not only lunch breaks are considered as recovery periods, but also hours before and after that. Break time is also possible at one hour before the last shift. Therefore, the first step is to determine the optimal placement of lunch breaks to maximize the recovery period. In this case, the model gives a limit not to put lunch breaks at the beginning or end of the work shift. Therefore, if the time slot j of the work shift is defined as the end of the lunch break slot, then the value range j (2, ..., n -1) is set. Furthermore, bj-1 and bj are defined as the fraction of j-1 and j slot times from work shifts, including lunch breaks, as in Eq.6, Eq. 7 is a calculation of the value of lunch if lunch breaks are included during breaks in work shifts.

$$\sum_{t-1}^{n} a_t = A \ . \qquad (5)$$

$$\begin{cases} b_{j-1} + b_j = B \\ b_{j-1} \geq 0 \quad ; \forall j(2, \dots, n-1) \ . \\ b_j > 0 \end{cases} \qquad (6)$$

$$a_{j-1} + b_j = Lunch \ ; \forall j(2, \dots, n-1) \ . \qquad (7)$$

In the end, one hour for repetitive work requires an exact recovery time of one hour, including a break period of at least ten consecutive minutes [8]. Therefore, given the overall duration of the rest period given, namely C, and with the assumption that the rest of the rest is given the same length, i.e. ct for each t, then the next step is to determine all the allocation breaks, so as to maximize the number of hours worked with the right recovery period, as in the Eq. 8. Determination of optimal rest time in OCRA index-based scheduling must maximize the number of hours worked with an adequate recovery period in shifts so that the objective function can be written as in Eq. 9.

$$\begin{cases} c_t \geq \frac{x_t a_t}{6} & \forall t \neq (j-1, j) \\ \sum_{t=1}^{n-1} c_t = C & \forall t \neq (j-1, j) \\ x_t \in \{0,1\} & \forall t \end{cases} \ . \qquad (8)$$

$$OF\ break = \max\{xt\ , b_j\} \sum_{t=1}^{n-1} xt + Lunch\ . \quad (9)$$

There are often several company policies that can limit the number of accepted solutions. That was the lunch break can only be placed in the time slot j = 5.6, then, in this case, there are only ten optimal solutions that can be accepted, as illustrated in Table 2. However, according to [2], the presence of a number of restrictions from organization and production actually makes resting scheduling problems easier to solve with an enumerative algorithm, because optimal resting schedules are obtained with a limited amount.

Table 2 Optimal Break Window Schedules

t =		1	2	3	4	5	6	7	8
Scenario	A	X	X	X		Lunch			
	B	X	X		X	Lunch			
	C	X	X			Lunch		X	
	D	X		X	X	Lunch			
	E	X		X		Lunch		X	
	F	X			X	Lunch		X	
	G		X	X	X	Lunch			
	H		X	X		Lunch		X	
	I		X		X	Lunch		X	
	J			X	X	Lunch		X	

7. Make recommendation body posture correctly and simulation it using CATIA
8. Calculate the number of OCRA index after the recommendation

Result and Discussion

Determining the OCRA Index

Data were collected in each packaging worker. The right and left-hand charts were created to find out the number of technical actions of each hand on each job. The step to make right and left-hand charts were breakdown the technical actions in detailed and classify the type of movement, measure total technical actions and the time to do it. Then, calculate the Actual Technical Actions (ATA) based on Equation 2. In collecting data processes, net durations were 435 minutes in a shift every task. Calculating the overall number of actual technical actions are shown in Table 3. The total number of technical actions of the left hand is higher than the right hand in some tasks. This is because in some activity the Left hand is more actively working than the right hand.

Table 3 ATA and RTA Calculation Every Task

Activity	**Number of ATA**		**RTA**	
	Right Hand	**Left Hand**	**Right Hand**	**Left Hand**
arranging bottles	9657,724	9657,724	1428,19	1438,90
check aluminum seals	45543,624	49046,980	4930,66	3407,68
check the bottle cap	30526,316	22894,737	2991,80	2273,49
insert cardboard sheet	31598,063	37917,676	1800,57	2295,99
arrange the dosing cap	37374,702	37374,702	2780,31	2100,73
move finished product	16466,877	16466,877	1914,96	2249,07

After completing the ATA calculation, the next step is to calculate the number of Recommendation Technical Actions (RTA) with several factors considered appropriate Equation 3. Table 3 is a recapitulation of the calculation of RTA values for each part of the packaging work in 1 shift. The highest score of RTA was the right hand of check aluminum seals activity and the lowest was the right hand arranging bottle activity. After calculating the number of ATA and RTA, the last step is to calculate the OCRA index value according to the Eq. 4 and carry out a risk evaluation. OCRA index will be identified as shown in Table 4.

Table 4 OCRA Index Result Before and After Improvement

Activity	OCRA Before Improvement		OCRA After Improvement	
	Right Hand	Left Hand	Right Hand	Left Hand
arranging bottles	6,76 (Medium Risk)	6,71 (Medium Risk)	1,60 (Acceptable)	1,63 (acceptable)
check aluminum seals	9,24 (High Risk)	14,39 (High Risk)	5,09 (Medium Risk)	10,33 (High Risk)
check the bottle cap	10,20 (High Risk)	10,07 (High Risk)	9,07 (High Risk)	5,90 (Medium Risk)
insert cardboard sheet	17,55 (High Risk)	16,51 (High Risk)	9,09 (High Risk)	9,73 (High Risk)
arrange the dosing cap	13,44 (High Risk)	17,79 (High Risk)	9,37 (High Risk)	13,14 (High Risk)
move finished product	8,60 (Medium Risk)	7,32 (Medium Risk)	6,81 (Medium Risk)	6,51 (Medium Risk)

The result from the calculation OCRA index, known that the highest index is left hand in arranging the dosing cap activity and the lowest index is left hand in arranging bottles. The classify from OCRA index shown that the risk is a medium risk until the high risk. With the result that, so packaging process in herbicide production must be improved.

Improvement Process

The level OCRA Index was affect working time [17] and work posture [14]. In allocating optimal rest periods, the first step that needs to be done is to place lunch breaks. In accordance with Figure 1, the lunch break time for this company is in the time slot j = (5.6) on one shift for eight hours of work. Therefore, it is possible to bring up 10 alternative scheduling of optimal rest time remaining that are acceptable, as in Table 2. However, if it is assumed that work time slots of more than two hours are not allowed and work time slots that last less than 50 minutes also not allowed [11], it can reduce the number of optimal solutions for the resting schedule received to 3, as shown in Table 5.

Figure 1 Recommendation of Giving Break Time

Table 5 Optimal Breaks window schedule based on case study

t =		1	2	3	4	5	6	7	8
Scenario	E	X		X		Lunch		X	
	H		X	X		Lunch		X	
	I		X		X	Lunch		X	

By using that recovery time, the net duration of each task to 420 minutes. Besides that, an improved awkward posture could be done for all tasks in the packaging process. An awkward posture is about shoulder movement, elbow movement, and wrist movement. It can be changed to an optimal corner to reduce the risk level. This improvement attempted to decrease OCRA index value or reducing the risk level. The posture redesign was simulated with CATIA. One of the example simulation with CATIA shown in figure 2. OCRA Index was calculated again based on the new posture redesign and break time determination. The calculation was finished if the result of the OCRA index is lower than before improvement. OCRA index value after improvement is shown in Table 4.

The result from the calculation OCRA index after improvement, knowing that there was reducing the number of OCRA index before and after improvement. The highest index is left hand in arranging the dosing cap activity and the lowest index is the right hand in arranging bottles. The classify from OCRA index after improvement showed that the risk had variation from acceptable risk until the high risk.

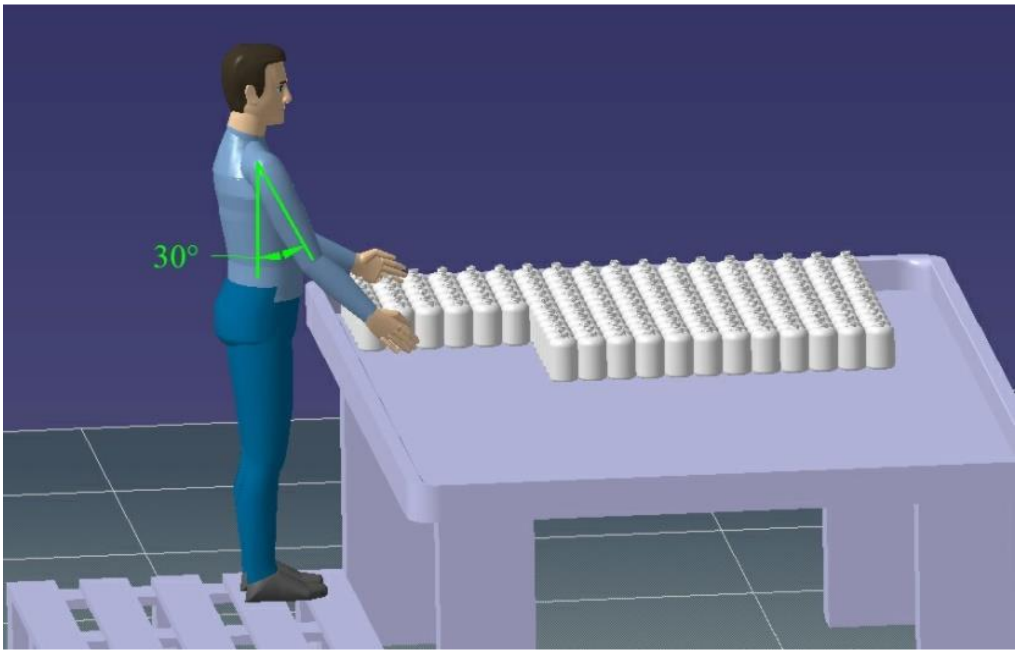

Figure 2 Simulation Arranging bottles with CATIA

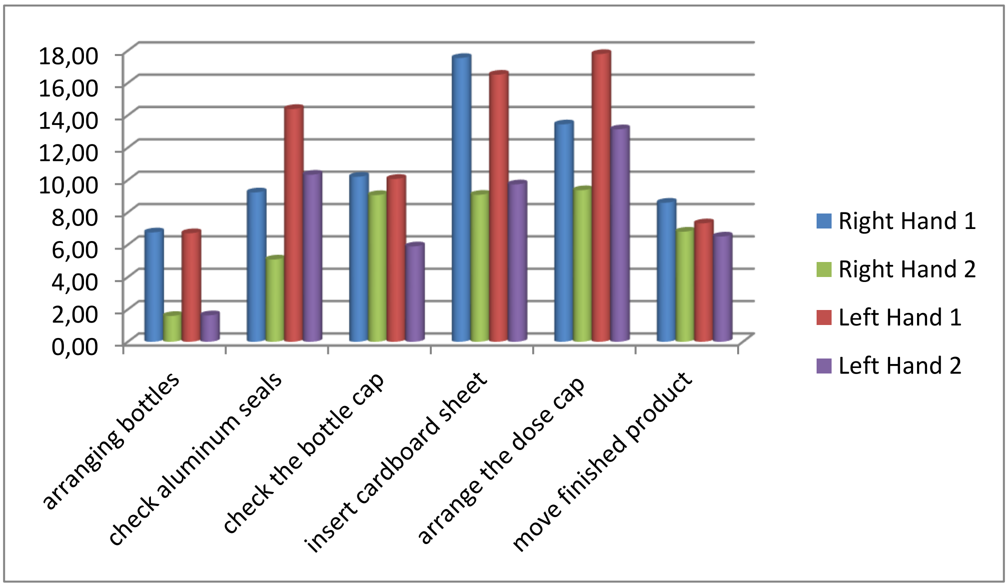

Figure 3 Comparison of OCRA Before and After Improvement

A decree of OCRA Index value after improvement is shown in Fig. 3. Thus, the proposed improvement of working methods may reduce the risk level. Although the improvement process had been done and OCRA index decreased, but the value of OCRA index still high. The advanced recommendation is added total of workers to decrease the number of OCRA index. The results of this study are expected to assist companies in evaluating the work system to reduce the risk of injury and fatigue caused by the work system applied.

Conclusions

Based on the result of the discussion above, The propose of the research at finding the optimal break in work environments that has characteristics high repetitive, low load manual tasks with the high frequency of repetition. Workload risk and acceptability are evaluated by the OCRA method. Optimal resting time scheduling is done by an enumerative algorithm through linear integer programming models that are able to provide optimal resting schedules, so as to reduce the risk of injury caused. Based on the recommendation OCRA index was recalculation, it is known that there is a decrease in the OCRA index value for all task in packaging process compared to the previous OCRA index value. Percentage the decrease from 11,11% until 76,37%.

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