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Ergonomic intervention through 'OCRA': an ergonomic tool, for workposture assessment of periodic overhauling activities in mechanical industries

Ergonomics is the science which deals with the perfect fit between man, machine and environment. This paper focuses on the Occupational Repetitive Action (OCRA) based working posture assessment of the industrial worker which is extremely important not only from ergonomic point of view but also to boost the comfort level of the worker. The method is based on the data for a set of joint motion including hand, arm, neck, back and the corresponding holding time in static and dynamic posture considering repetitive actions which has suggested as a preferred method to measure the risk of bio-mechanical overload of the upper limb in ISO and CEN bio-mechanical standard which provides criteria and assessment tools for risk evaluation at different levels in details. Hundred male subjects who are directly involved to the Periodic Overhauling (POH) in fabricating job are studied and assessed through the ergonomic tool OCRA. Based on statistical interpretation, the 33.33% of the subject are in low-medium risk, 50% are in the medium risk and the remaining are in the high risk. This result suggests an analytical risk assessment technique which is useful to design or redesigning the work station and strategy planning to increase the productivity maintaining worker's physical and mental condition.

Keywords: Musculoskeletal disorder, bio-mechanical overload, OCRA, occupational health hazards, work posture assessment, work load.

1.0 Introduction

In the recent era of industrialization cost reduction by minimizing the time of operation and maximizing the production is a common phenomenon. In the third world developing country like India this trend is so much accepted by the industrialist. It is true to almost all public sector or government funded organizations. Among various occupational diseases, work related musculoskeletal disorder (WMSD) is most common among industrial workers. The occupation like manual material handling, electric arc welding, oxy-cutting, hand grinding, repetitive actions with awkward posture is too common to develop WMSD. The ergonomic is of prime importance in the area of designing work place, and production sequence including healthy working environment. It has been observed during work station designing, the management seldom shows their interest in it and the ignorance about rules and regulations along with early finish craze among the workers drive them in the world of occupational diseases. It is not out of place connection that ergonomists are leaving no stone to get industry's recovery from this situation. By identifying and quantifying the postural stresses through different ergonomic tools the researchers are trying to find out the root causes and possible remedies of this problem. These findings are classified basically in two schemes i.e. instruments based and observations based. It works and it is also less expensive than the another one. OCRA is such type of ergonomic tool which can be used for assessing exposer to bio-mechanical overload of the upper limb and drawing up work diagram based on desired specificity, variability and objectives.

Different eminent researchers reflected their thoughts and experiences in their research papers both in national and international level in the field of WMSD. Sell L [1] et al stated (2014) musculoskeletal disorders (MSDs) as a multifactorial function which depends on both environmental and individual condition of workers. They basically tried to find out some way out, which would help workers to develop their working skills in a hostile working ambience. They followed tailored ergonomic learning programme and came to a conclusion to implement low stress working condition when complete involvement of workers and management is available. Vyas [2] worked on (2014) musculoskeletal disorders of among agricultural workers. Usually awkward postures, repetitive motion, application of force during work are the root causes of MSDs among farmers. Rothmore [3] et al stated (2014) their view on the musculoskeletal disorders among the workers engaged in health care, call center and transportation department. Most of the workers in these fields are suffering from upper limb and neck pain problem. The authors concluded, though there is moderate action taken

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to solve this but more effective steps should be taken to save the workers as well as to save the economic growth of the relevant industry too. Liu [4] presented (2013) his conception about the influencing factors of musculoskeletal disorders and tried to find out the interaction between them. Basically MSDs are the cumulative effect of long lasting continuous load. To find out the relationship of internal and external factors of MSDs, he proposed a quantitive mode which marked bio-mechanical load, vibration and psychosocial factors as influencing characters for developing MSDs. Ker [5] recommended (2012) the code of practice in connection with workstation designing having applied concept of ergonomics. His design enriched the quality of employer's and user's working life minimizing occurrence of workstation related musculoskeletal disorder, by increasing productivity simultaneously. Kiirkhon et al [6] stated (2010) about workplace risk and musculoskeletal disorders for the workers assigned in agricultural production sector. They experimented on the degree of MSDs where musculoskeletal problems have been treated as pain indicator which ultimately makes the basis of chronic disease. They also gave an overview on the best accepted work practice having good impact on productivity and comfort in agricultural field where high risk oriented tasks with allied factors force to incur appreciable compensation costs under the accepted regulatory framework. Muller [7] et al experimented (2010) on a very significant issue of the present time. It is known to all that the application of computer as well as its mouse as an input device is gradually increasing and most of the professionals related to this device are suffering through work related musculoskeletal disorders in finger, palm etc. which affected the worker's health as well as company's economy too. In this way all the scientists and researchers put importance on the MSD's to control through professional implementation of ergo study.

The aims and objectives of this present research are:

1. To assess the risk by identifying exposure to repetitive movements of the upper limb of industrial workers which causes WMSD.
2. To find out the possible remedies by adopting engineering 1 or management control to reduce the percentage of WMSD.

2.0 Methodology

Subject

Hundred males directly involved to periodic overhauling job (POH) in government sector in different mechanical operations like electric arc welding, oxy-cutting, fitting, manual material handling etc., having minimum three years of experience in this field with no history of medical illness as per report of local health unit and who volunteer for this research are taken as subjects of this study. They are acclimatized with this job and during study no external influence is proposed in their daily work schedule. The subjects are segregated into three types i.e. fitters, oxy-cutters and electric arc welders and each group is re-segregating as age group of less than forty years and higher than forty years.

Task

The subjects are directly related to the POH job in mechanical sector where they are engaged in fabricating operations like electric arc welding; oxy-cutting, fitting along with manual material handling etc.

Firstly, the fitter plays very important role from inspection to final dispatch during POH Besides, fitters have to stay with the welders and oxy-cutters for orienting and guiding in befitting manner.

Secondly, the oxy-cutter plays a major role during POH of the specified units. They have to cut the corroded parts and also new part from specified sheet as per marking by the fitter for perfect fitting otherwise oxy-cutter's job will go continue till perfect fit is ensured. So they have to remain attached with the job from the very beginning to the final fitting with their oxy-acetylene torch. The melting point of iron is around 3300°C and the oxy-cutters have to work in that temperature zone at a mean distance of 2.5ft. as the length of his torch is 2.5ft. The job nature, if continued for more than specified period especially during summer makes it non-humanizing under the given set of environment.

At the same time they have to monitor constantly about the catching of any fire due to flame generates from his torch or otherwise.

Thirdly during POH the electric arc welder plays very imperative role. As we all know that welding is nothing but joining of two similar or dissimilar metals with or without use of pressure and in this case each and every item made by the welders are critically examined from all safety regards. In this case any discriminency is caused for major punishment to them as it relates to the life of common public. Consequently the welders remain in tremendous mental pressure.

Parameters

Organizational data

It is the brief description of individual items related to organization i.e.

1. Duration of shift both (a) official and (b) real,
2. Other break,
3. Lunch breaks both (a) official and (b) real,
4. Non-repetitive works e.g. Cleaning, stocking etc. both (a) official and (b) real.

With the above data net duration of repetitive work is calculated by subtracting item number 2, 3, and 4 from 1. Once the net duration of the repetitive work is calculated; the following formula can be used to estimate the net total cycle time or rate in seconds.

Net total cycle time [8] = (Net duration of repetitive work × 60)/No. of pieces (or No. of cycles)

Then total time of observed cycle is calculated and finally percentage in difference between observed cycle time and official cycle time is calculated. A difference of less than 5% or equal to 20 minutes in the workday is considered acceptable.

The duration of exposure factor

The duration of exposure factor or duration multiplier is used to calculate the final OCRA checklist [8] score based on the net duration of the repetitive work.

Recovery time factor

Recovery time is considered as the period between which the upper limb is primarily physically inactive. The following can be considered as recovery time [9]:

(1) Breaks (official and otherwise): It includes the lunch break, provided it is included as a part of the paid workday.

(2) Sufficiently long periods of working activity in which the muscle groups are at rest.

(3) Periods within the cycle during which the muscle groups are completely at rest.

3.0 Result and discussion

The POH activity associated with upper limbs mostly while on work and the types of such job is repetitive in nature leading to cause of MSD's related trouble. The OCRA software is programmed to see through the muscle related development of disfunctioning when job nature is repetitive in any mode of posture and where time plays important variant with respect to force applied for this purpose.

1. Postural assessment of the subjects based on OCRA [10] method using software.

Table 1 clearly states the scores achieved during different dynamic and static technical action of the worker. Almost all the workers total score is [9] 2.5 except the fitters of age group greater than forty years where they score 3 in total.

Table 1: Frequency score of different worker

	Category of worker	*#Frequency score		
		Dynamic Technical action	Static Technical action	Total
1	Fitter of age ≤40 years	3	2.5	3
2	Fitter of age > 40 years	2	2.5	2.5
3	Oxy-cutters of age ≤ 40 years	-	2.5	2.5
4	Oxy-cutters of age > 40 years	-	2.5	2.5
5	Welder of age ≤40 years	-	2.5	2.5
6	Welder of age > 40 years	-	2.5	2.5

* Mean. # [10]

2. Force

Table 2 describes about the different scores based on duration of working and types of forces applied [10].

Table 2: OCRA Checklist [10]

Force of 3-4 (Medium)		Force of 5-6-7 (Heavy)		Force of 8-9-10 (Extremely heavy)	
Time as %	Score	Time as %	Score	Time as %	Score
5	.50	0.33	4.00	0.33	6.00
110	.50	1.00	8.00	1.00	12.00
18	1.00	1.50	9.00	1.33	13.00
26	1.50	2.00	11.00	1.67	14.00
33	2.00	2.50	11.00	2.00	15.00
37	2.50	3.00	12.00	2.33	16.00
42	3.00	3.50	13.00	2.67	17.00
46	3.50	4.00	14.00	3.00	18.00
50	4.00	4.50	15.00	3.33	19.00
54	4.50	5.00	16.00	3.67	20.00
58	5.00	5.63	17.00	4.00	21.00
63	5.50	6.25	18.00	4.33	22.00
67	6.00	6.88	19.00	4.67	23.00
75	6.50	7.50	20.00	5.00	24.00
83	7.00	8.13	21.00	5.63	25.00
92	7.50	8.75	22.00	6.25	26.00
100	8.00	9.38	23.00	6.88	27.00
		10.00	24.00	7.50	28.00
				8.13	29.00
				8.75	30.00
				9.38	31.00
				10.00	32.00

Table 3 explains clearly about the meantime taken by the workers while doing their job during different types of application of forces. It is clearly understood that no workers apply extremely heavy force during work. Force score confirms that about 67% working period they apply medium force while 33% of working hours they apply heavy force.

Table 3: Force score [10]

	Category of worker	Medium		Heavy		Extremely heavy		*Force score
		Time as %	Score	Time as %	Score	Time as %	Score	
1	Fitter of age ≤ 40 years.	92	7.5	0.33	4.0	-	-	11.5
2	Fitter of age > 40 years	92	7.5	0.33	4.0	-	-	11.5
3	Oxy-cutters of age ≤ 40 years	100	8	-	-	-	-	8
4	Oxy-cutters of age > 40 years	83	7.0	0.33	4.0	-	-	11
5	Welder of age ≤ 40 years.	100	8	-	-	-	-	8
6	Welder of age > 40 years	83	7.0	0.33	4.0	-	-	11

* Mean

3. Posture

Table 4 vividly explains about posture score for different awkward positions in respect of different body parts like shoulder, elbow, wrist and hand corosponding to holding time.

Table 4: Standard posture score as per recommended by OCRA [10]

	Body part	Time in awkward posture	Score
1	Shoulder: The arms are kept at about shoulder height, without support or in the extreme posture	Below 10% of the total time	1
		10% -24% of the time	2
		25%-50% of the time	6
		51%- 80% of the time	12
		More than 80% of the time	24
2	Elbow: The elbow executes sudden movements (wide flexion extension or prono - supination, jerking movements, striking movements)	25%-50% of the time	2
		51%- 80% of the time	4
		More than 80% of the time	8
3	Wrist: The wrist must bent in an extreme position or must keep awkard posture (such as wide flexion, extension, wide lateral deviation etc.)	25%-50% of the time	2
		51%- 80% of the time	4
		More than 80% of the time	8
4	Hand: The hand take objects or tools in pinch, hook grip, other different types of grasp	25%-50% of the time	2
		51%- 80% of the time	4
		More than 80% of the time	8

Table 5 describes the postural score [10] of the workers which is based on altered position, activities etc. of different body parts e.g. shoulder, elbow, wrist and hand.

Table 5: Posture score [10]

	Category of worker	*Posture score				
		Shoulder	Elbow	Wrist	Hand	Total score
1	Fitter of age ≤40 years.	1	-	1	1	3
2	Fitter of age > 40 years	1.5	-	1	2	4.5
3	Oxy-cutters of age ≤ 40 years	0.5	-	0.5	1	2
4	Oxy-cutters of age > 40 years	0.5	-	0.5	1.5	2.5
5	Welder of age ≤40 years.	-	-	1	1	2
6	Welder of age > 40 years	0.5	-	1	2	3.5

* Mean

4. Additional

As per guidelines of OCRA checklist [10] Table 6 explains clearly about scores for different situations for finding additional risk factors.

Table 6: Standard score of additional risk factor as recommended by OCRA. [10] (only select one question from each group)

Group	Sl. No.	Situation	Score
A	1	Gloves inadequate or interfere with the handling ability required by the task are used for over half the time	2
	2	The working gesture requires imply a counter shock with frequency of two times per minute or more.	2
	3	The working gesture requires imply a counter shock with frequency of ten times per hour or more.	2
	4	Exposures to cold or refrigeration (< 0°C) for over half the time	2
	5	Vibrating tools are used for 1/3 of the time or more	2
	6	The tools employed causes compression of the skin	2
	7	Precession tasks are carried out for over half the time	2
	8	More than one additional factor is present at the same time and overall they occupy over half the time	2
	9	More than one additional factor is present at the same time and overall they occupy over whole of the time	3
B	1	Working pace set by the machine but there is breathing spaces in which the working rhythm can either be slowed down or accelerated.	1
	2	Working pace completely determined by the machine	2

As per recommendation of OCRA check list [10] Table 7 shows the additional score of different categories of worker. As more than one additional factor is present at the same time and occupy the whole of time all the worker score 3.

Table 7: Additional score [10]

	Category of worker	Additional score
1	Fitter of age ≤40 years.	3
2	Fitter of age > 40 years	3
3	Oxy-cutters of age ≤ 40 years	3
4	Oxy-cutters of age > 40 years	3
5	Welder of age ≤40 years.	3
6	Welder of age > 40 years	3

5. Recovery

Table 8 reflects the recovery multiplier value for corresponding work having without adequate recovery time as prescribed by OCRA check list [10].

Table 8: Recovery multiplier [10]

No. of hours without adequate recovery time	Recovery multiplier
0	1
.5	1.025
1	1.05
1.5	1.086
2	1.12
2.5	1.16
3	1.2
3.5	1.265
4	1.33
4.5	1.4
5	1.48
5.5	1.58
6	1.7
6.5	1.83
7	2
7.5	2.25
8 or more	2.5

Table 9 shows the recovery scores [10] for each group of worker. The junior fitters, oxy-cutters and senior welders score 1.2. Senior oxy-cutter's mean score is 1.265. The minimum and maximum score achieved by junior welders and senior fitters are 1.12 and 1.33 respectively.

Table 9: Recovery score [10]

	Category of worker	Recovery score
1	Fitter of age ≤40 years.	1.2
2	Fitter of age > 40 years	1.33
3	Oxy-cutters of age ≤ 40 years	1.2
4	Oxy-cutters of age > 40 years	1.265
5	Welder of age ≤40 years.	1.12
6	Welder of age > 40 years	1.2

6. Duration

As per recommendation of OCRA [9] Table 10 reflects the value of duration multiplier for corresponding value of net duration of repetitive work in minutes.

Duration multiplier [9] used to calculate the final OCRA Checklist score based on the net duration

Table 10: Standard duration multiplier [9] value

Multiplier of the net duration of the repetitive work performed during the shift	
Net duration of repetitive work (minutes)	**Duration multiplier**
60-120	0.5
121-180	0.65
181-240	0.75
241-300	0.85
301-360	0.925
361-420	0.95
421-480	1
Over 480	1.5

It is clearly seen from the table 11 the duration multiplier values of different types of worker. Fitters of the age group of above forty years score the highest value of 0.855 and the lowest value i.e. 0.65 is scored by both the junior oxy- cutters and welders. The remaining workers score 0.75.

Table 11: Duration multiplier score

	Category of worker	Duration multiplier score
1	Fitter of age ≤40 years.	0.75
2	Fitter of age > 40 years	0.855
3	Oxy-cutters of age ≤ 40 years	0.65
4	Oxy-cutters of age > 40 years	0.75
5	Welder of age ≤40 years.	0.65
6	Welder of age > 40 years	0.75

Table 12 shows the classification criteria (according to exposure level) of the final OCRA index and OCRA checklist scores.

Table 12: Classification criteria [11] (According to exposure level) of the final OCRA Index and OCRA checklist scores

OCRA checklist	OCRA Index	Level	Risk
< 7.5	> 2.2	Green	Acceptable risk
7.6-11.0	2.3-3.5	Yellow	Very low risk
11.1-14.0	3.6-4.5	Light red	Medium-low risk
14.1-22.5	4.6-9.0	Dark red	Medium risk
≥ 22.5	≥ 9.1	Purple	High risk

7. Evaluation for final checklist scores for task

Table 13: Final checklist [8]

	Category of worker	Age group	+OCRA check list	OCRA Index	Level	Risk
1	Fitter	≤40 years.	18.45	4.6-9.0	Dark red	Medium risk
		> 40 years	24.305	≥ 9.1	Purple	High risk
2	Oxy-cutters	≤40 years.	12.02	3.6-4.5	Light red	Medium-low risk
		> 40 years	18.026	4.6-9.0	Dark red	Medium risk
3	Welder	≤40 years	11.284	3.6-4.5	Light red	Medium-low risk
		> 40 years	18	4.6-9.0	Dark red	Medium risk

+OCRA checklist = (Frequency + Force + Postur e+ Additional factors) × Recovery multiplier × Duration multiplier [8].

Findings through OCRA test

It is very much clear about the risk zone of different types of worker as shown in Table 13. The final check list score has been evaluated by using the revised OCRA checklist method. As in previous six steps the total segregation of score of individuals (mean value) are shown and after accumulation of those values, the OCRA checklist is prepared. Compairing these values with OCRA index, level of risk can be stated easily. In this case the junior fitters along with senior oxy-cutter and senior welder are in medium risk zone and the remaining except senior fitters are in the medium low risk level. The senior fitters are in high risk zone so special care should be taken for this group. But in each and every cases the tool recommend to look over the matter, investigate and take remidial measure immediately. Thus OCRA index indicates that precautionery measures are to be taken to protect worker from possible occurrence of upper limb-work related muscuolo skeletal disorder (UL-WMSD)

4.0 Conclusions and recommendations

The ergonomic intervention in the work nature of all three categories proves that ignorance among the workers prevails for early finish with huge variation in work force application. This ergonomic study based on OCRA application helps finding considerable number of workers suffering from WMSD specially the workers who are working in awkward postures viz. kneeling, half bent etc. Many of the workers are not feeling the pain in the body and continuing the work in same posture though there is clear indications to feel the pain in near future as an occupational disease.

Evaluations by using the ergonomic tool OCRA concludes that not only immediate implementations of ergonomic interception is required in this fabricating industry but awareness among the workers and supervisors also are needed. The management must go for plan, do, check and acts (PDCA) to redesign the workstation and other engineering controls ergonomically to humanize the work and work environment.

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