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Research Article

Mapping Postural Severity of various manual tasks using P-SVR© [Posture – State Variation Report] method

Varsha Narayan Karandikar[a*] and Shriram Madhukar Sane[a]

[a]Department of Industrial and Production Engineering, Vishwakarma Institute of Technology, Pune 411037. University of Pune, India

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Abstract

The scope of this paper is to describe the newly defined Posture – State Variation Report [P-SVR] method of postural analysis to highlight the areas for improvement in work posture for operator comfort and to find out quantitative value of severity of work based upon postural video analysis. A compressor manufacturing process was studied for different activities like assembly, testing, material handling, inspection, disassembly and cleaning. These processes were evaluated for mapping severity of postures involved considering the elemental time and frequency. P-SVR method can be used as an extension of any method which is based on static observations of postures for analyzing the severity of work content and which is based upon either random or periodic photographic analysis. The scope of this paper is limited to highlighting these areas, where modifications in the processes can bring down the index of postural severity.

Key Words: *P-SVR© [posture state variation report], ergonomic analysis, elemental breakdown, work posture severity.*

1. Introduction

Different methods for determining the musculoskeletal disorders due to severity of postures have been studied by Marie-Eve Chiasson, et. al. (2012). These are the Quick Exposure Check (QEC), the Ergonomic Workplace Analysis, Hand Activity Level threshold limit values method (HAL), the Job Strain Index (JSI), the OCRA index, the EN 1005-3 standard, the Rapid Upper Limb Assessment (RULA), the Rapid Entire Body Assessment (REBA). These methods are based upon observation by an expert and his perception of work severity.

Lynn McAtamney, and E. Nigel Corlett (1991) gives the details of RULA which is a survey method developed for use in ergonomic investigations of workplaces where work-related upper limb disorders are reported. The assessment commences by observing the operator during work cycles in order to select the tasks and postures for assessment. Selection may be made of the postures held for the greatest amount of the work cycle or where highest load occurred – as envisaged by an observer.

While discussing the method of Strain Index, Jose Miquel Cabecas (2007) mentions that the Strain Index method (Moore and Gard, 1995) suggests estimating the intensity of exertion using a 1-5 rating scale with verbal descriptors (light, somewhat hard, hard, very hard, near maximal) measuring external force and normalizing the data based on Maximal Strength data (as a percentage of Maximal Vital Capacity) and using Borg CR-10 scale.

While undertaking ergonomic analysis of the work of manual spray painting Gunnar Bjoring, Goran M Hagg (2000) limited the measurements to the arms and shoulders of the workers, using postural analysis and interview technique.

Peter Budnick (2013) reported that RULA has a strong focus on posture, but a weak focus on repetition and duration. This shortcoming has been overcome by the P-SVR methodology, which considers both these factors. P-SVR will lead to further enhancement of techniques like RULA, REBA, etc. in occupational ergonomists tool box.

In this paper the process of compressor assembly was studied in order to decide the areas where improvements are necessary to simplify the physical work content and reduce operator discomfort. The duration of the study was around 4 hours [13,776seconds] during which there were 2143 postural changes. Entire activity included- Assembly, Cleaning, Disassembly, Inspection, Material Handling, Testing & some miscellaneous activities. This was done using P-SVR method of postural analysis.

2. P-SVR Methodology

Under this method of ergonomic analysis, analysis of video recordings of a complete work cycle is carried out to determine severity of the postures. This is used to find out the frequencies of different severities of postures as well as the time spent in every severity of posture.

*Corresponding author **Varsha Narayan Karandikar** is working as Asst Prof and **Shriram Madhukar Sane** as Prof.

In P-SVR method of ergonomic analysis, any technique of postural severity analysis like RULA - Rapid Upper Limb Analysis or REBA - Rapid Entire Body Analysis or any other method based on instantaneous photographic records, either random or at certain time intervals, can be used in order to analyse the instantaneous severity of the postures.

In this method the postural analysis of entire video recording for any work cycle is carried out. The analysis of the frequency of occurrence of different postural severities as well as total elapsed time for each severity level is done. This analysis gives the P-SVR index which is the weighted value of different levels of work severities for complete work cycle.

Process to determine P-SVR Index value

- Video Recording of activity to represent postures of operator for complete work cycle.
- By observing the video, elemental break up of work cycle based on major postural change is done, noting the time spent at each severity of posture.
- Data is compiled to have frequencies of occurrences for different severities of postures as well as for the cumulative elapsed time for these severities.
- Based on elapsed time for each postural severity level, weighted average of severity of postures based on time is calculated which gives the P-SVR index value.

Mathematical model for P-SVR Index Value:

$$P - SVR\ index\ value = \sum_{\substack{i=1\\j=1}}^{\substack{j=m\\i=n}} SS_i * TT_{ij} \div \sum_{\substack{i=1\\j=1}}^{\substack{j=m\\i=n}} TT_{ij}$$

SS= Severity score for working posture

TT = Elapsed Time for individual element

i = 1, 2, 3 …., n, where n is the observed highest value of the postural severity index as per the postural analysis method used

j= 1, 2, 3 …... m, where m is the number of elements for a particular score

3. Case Study of P-SVR analysis for a foundry

The case study given below is about two jobs in a foundry, namely poring of molten metal and the painting of cast components by dipping process.

The initial impression about these jobs was that the pouring job is very difficult in comparison with the dip paint application job, due to the weight to be moved and seemingly easy posture of the operator during dip painting process.

On the other hand the dip painting process involves dipping of castings weighing about 150 gm in the paint, which is stored in a container near the operator. After dipping process the components are stored in a tray which is kept in front of the operator. Once the tray gets filled up, the operator stands up, lifts the tray and carries it to oven for drying. The operator takes another tray from a stack of the empty trays, keeps it on the ground near to the heap of

Fig 1 Dip painting process

Fig 2 Dip painting process

Fig 3 Dip painting process

Fig 4 Dip painting process

unpainted components and sits down to start the dipping process again. The dip painting process is represented in figure numbers 1, 2, 3, 4.

In this dipping process the dipping of cast components in paint was repetitive in nature. A tray contained 70 pieces and the severity of the postures varied according to the location of the parts to be stored in the tray. After every 70 pieces the tray was changed.

On the other hand the process of poring involved the traditional work of lifting the ladle from furnace place to the area near moulds. The ladle is lifted by two persons. Once the ladle is located on the mould it is tilted and molten material is poured in the mould. Empty ladle is taken back to the area near furnace for new material. Photograph numbers 5, 6 and 7 are related to this job.

Fig 5 Pouring process – molten metal poured into laddle

Fig 6 Pouring process – pouring in mould

Fig 7 Pouring process – movement of laddle

P-SVR methodology was applied to find out the relative difficulty of these two jobs. The results are as follows.

Table No. 1: P-SVR analysis for Repetitive Elements

Repetitive elements			
RULA Score	Frequency	Elapsed Time	RULA* Elapsed Time
1	0	0	0
2	0	0	0
3	39	36.196	108.588
4	21	16.589	66.356
5	5	4.881	24.405
6	0	0	0
7	6	5.413	37.891
	71	63.079	237.24
P-SVR [Posture State Variation Report] Index			3.760998

Table No. 2: P-SVR analysis for non-repetitive Elements

Non-Repetitive elements			
RULA Score	Frequency	Elapsed Time	RULA* Elapsed Time
1	0	0	0
2	0	0	0
3	18	79.956	239.868
4	6	6.164	24.656
5	1	0.79	3.95
6	1	0.967	5.802
7	21	182.101	1274.707
	47	269.978	1548.983
P-SVR [Posture State Variation Report] Index			5.737442

Table No. 3: P-SVR analysis for total job of dip painting

Results considering Repetitive elements			
RULA Score	Frequency	Elapsed Time	RULA* Elapsed Time
1	0	0	0
2	0	0	0
3	213	260.936	782.808
4	111	89.109	356.436
5	26	25.195	125.975
6	1	0.967	5.802
7	51	209.166	1464.162
	402	585.373	2735.183
P-SVR [Posture State Variation Report] Index			**4.7**

Table No. 4: P-SVR analysis for total job of pouring

Results for Pouring Process			
RULA Score	**Frequency**	**Elapsed Time**	**RULA * Elapsed Time**
1	**0**	**0**	**0**
2	**0**	**0**	**0**
3	4	62.857	188.571
4	0	0	0
5	0	0	0
6	0	0	0
7	15	176.688	1236.816
	19	**239.545**	**1425.387**
P-SVR [Posture State Variation Report] Index			**6.0**

4. Results and discussion

From the photographs and the description of the process given above one gets a feeling that the job of painting by dipping process should be much easier that the pouring process. Till now in this unit there was no way to evaluate the relative difficulty level of different jobs based upon ergonomic principles. By the application of the P-SVR methodology we could get the relative values of the P-SVR Index. In order to get the overall work severity we analysed 14 operations of dipping out of 70 in a tray which represented different operator postures while painting jobs spread over the tray are, so as to get representative value of postural severity.

It can be seen that the P-SVR Index for the pouring process is 6, while for the dip painting process it was found to be 4.7. Hence the job of dip painting is just about 20% less difficult than that of the pouring. The P-SVR method of evaluation of postural severity makes it possible to have relative evaluation of different tasks, on a common quantitative scale.

The reasoning for the said values is as follows:

- The painting job is short cycle, though the process seems to be simple.
- The operator is working continuously without any rest.
- The posture of the painting operator is occasionally inconvenient, with front or side bending depending upon the location where painted casting has to be stored in the tray.
- Though the operator of pouring process is working with lot of weight to carry, there is considerable rest observed after pouring operation, when the ladle is empty, till it gets filled.

5. Conclusion

The P-SVR methodology leads to mapping of postural severity of complete work cycle considering elemental time and frequency. Using P-SVR methodology one can locate the problem areas exactly. Due to this problem areas can be located and improved exactly leading to workman comfort and improved performance level.

Using P-SVR method, review of elemental analysis is possible. Due to the fact that the postural analysis has been converted in quantitative parameters irrespective of analyst the results are expected to be the same.

The benefit of the P-SVR method is that the postural analysis can be carried out considering different factors like Operators, Processes, Equipment being used or any other factor. Hence this method is useful for an ergonomist to convince both the workers unions as well as management representatives about improvements required to have higher job comfort leading to higher output.

The P-SVR method can be used to decide upon the comparative job difficulty involved in different operations. Since this method does holistic analysis of human postures, the P-SVR indices give clear idea about the job difficulty level.

As discussed above it can be seen that this method provides comprehensive analysis of work posture severity to locate exact areas where improvements need to be undertaken in order to minimize postural discomfort leading to increased level of productivity.

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