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Research Article

Application of P-SVR Methodology for comparison of Postural Severity of various tasks on compressor assembly line

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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 processes for operator comfort and to find out quantitative value of severity of work based upon postural video analysis. In a compressor manufacturing unit, different processes were studied for different activities like assembly, testing, material handling, inspection, disassembly, cleaning, etc. These processes were evaluated for the severity of work postures involved considering the elemental time and frequency of various postural severities. For reducing work severity, using P-SVR analysis, we can find out the work elements with highest postural severity and the longest duration. The scope of this paper is limited to highlighting the work elements where modifications in the processes can bring down the P-SVR index value leading to work simplification.

Keywords: *posture state variation, video analysis, elemental breakdown, work 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 force, 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.

Varsha Karandikar, Shriram Sane (2014) defined Posture-State Variation Report (P-SVR) methodology of postural analysis described here helps in evaluating the job difficulty level of work cycle quantitatively. For improving work content, the element of work with highest severity of score and with the longest duration can be highlighted.

Samata Mujumdar, Varsha Karandikar, et al (2013) discussed the use of ergonomic principles in automobile assembly and manufacturing operations has become an important part of a comprehensive health and safety process as well as an integral part of the engineering systems. Most of the automobile companies have developed an ergonomics process to manage issues related to injury and illness and to ensure the appropriate use of human resources on the plant shop floor.

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Table 1: P-SVR Analysis Summary

	Number of Elements	Time spent in Sec	Time spent in hrs	P-SVR Index Value
Disassembly	268	1135	0.32	4.9
Assembly	740	4600	1.28	4.5
Cleaning	85	912	0.25	4.2
Miscellaneous	398	2994	0.83	4.1
Material handling	464	2279	0.63	3.2
Inspection	98	461	0.13	2.9
Testing	90	1395	0.39	2
P-SVR Index value for the entire process				**3.9**

In the following paper the process of compressor assembly was studied in order to locate the work elements 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 severity changes. Entire activity included- Assembly, Cleaning, Disassembly, Inspection, Material Handling, Testing & some miscellaneous activities. The method used is called P-SVR [Posture – State Variation Report].

2. P-SVR Methodology

This involves analysis of video recording of a subject based upon changes in postural severities. Elemental breakup of given task is done on the basis of changes in postural severity level as they occur. The steps can be enumerated as follows.

- Video Recording of activity
- Elemental break up based on changes in postural severity level
- Calculation of P-SVR index value
- Comparison of different operations on the basis of P-SVR Index value
- Mapping of areas for improvement in order to reduce postural severity for operator

Video analysis is used to determine elemental severity of work elements which are defined on the basis of changes in postural severity. The postural severity values for these work elements are quantified using any of the existing postural severity analysis methods. These work elements can be reviewed a number of times at different speeds and can be used for classifying the severity of the postures and frequency of repetition. The video is observed to find out the frequency and duration of severity level of work postures in the entire work cycle. RULA, REBA or any other method of analyzing postural severity based upon static observations can be used to analyze work severity. The analysis of frequency, duration and P-SVR index for every activity is found out. For improving work content we can find out the work elements having the highest postural severity score and having the longest elemental duration. This work element can be analyzed further and improved upon to simplify the overall work content.

3. Case Study - Application of P-SVR Methodology in a Compressor Assembly unit

Data collection and analysis

This analysis was carried out for various activities carried out on a compressor assembly line by an operator. The time duration was about 13776 seconds (3.83 hours) during which was broken down in 2143 elements based on major postural severity changes. It means that the postural severity was changing on an average every 6 seconds. The data is analyzed to find out the duration of the severity of postures as well as frequency of a particular severity. The benefit of the P-SVR method is that one can make the analysis in different ways to find out the areas where improvements are required on priority basis. The factors which can be considered are: Operators, Processes, Equipment being used etc.

3.1. Analysis based upon the P-SVR value

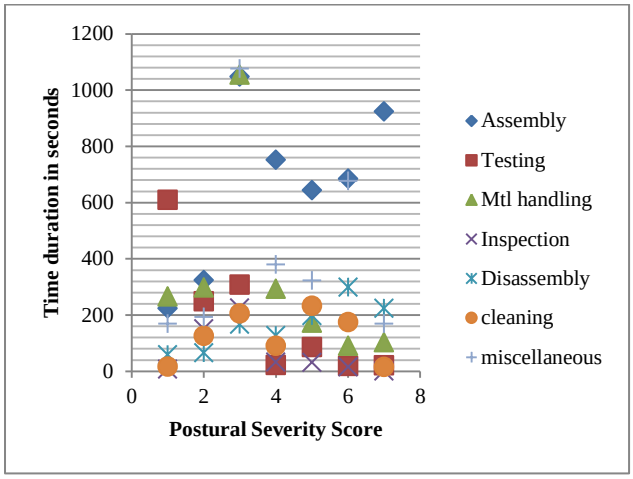
It can be seen that out of different tasks being undertaken by the operator, work involved in disassembly was having postures involving maximum severity. This was because of the fact that lot of these activities were carried out in squatting posture; the other reason was that this also involved loosening hardware which was not easily approachable. Though appropriate tools are available on shop floor the P-SVR value is maximum, it means that during onsite maintenance; dismantling will be much more difficult and un-ergonomic. Hence there is a need to employ Design for Assembly technique, when the compressor will be redesigned or during the Value Engineering exercise.

This is a clear indication as to how the P-SVR methodology helps in pin pointing the areas of improvements to simplify manual work content. The next severe activity based upon P-SVR value was assembly work which is a natural offshoot of the above described disassembly operation. This indicates that the basic design of assembly needs to be looked into to simplify postural complexity of an operator. This can be done by having Design for Assembly concepts implemented whenever Value Engineering / Value Analysis is carried out or by having appropriate manipulators so as to avoid bending of trunk, neck or twisting of arms during assembly work. The lowest value of P-SVR is for testing related work since it just involved visual inspections when the operator was either standing or moving.

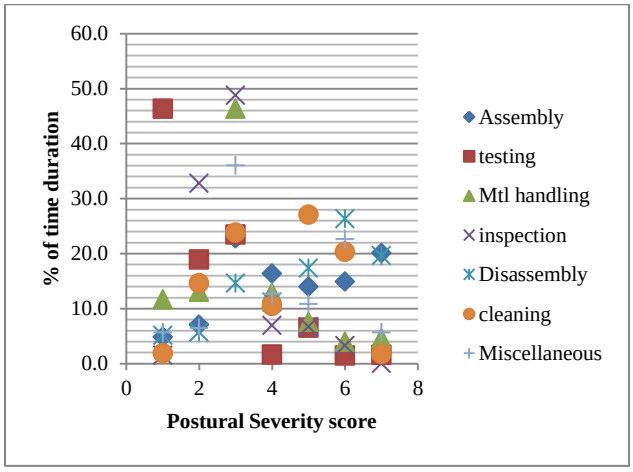
3.2. P-SVR Analysis based upon RULA considering the time spent on different activities

The highest value of P-SVR index is 4.9 for disassembly as mentioned in Table 2. For the same activity it can be

seen in Graph 2 that the percentage time spent for postures of highest value of Postural Severity Score which is 7 is second maximum which 19.6%.



Graph 1 - Time spent in seconds Vs Postural Severity Score for different activities



Graph 2 - Graph of % time spent Vs Postural Severity Score for different activities

Table 2: P-SVR Index values for different activities

P-SVR Index Value	
Assembly	4.5
Material handling	3.2
Miscellaneous	4.1
Disassembly	4.9
Inspection	2.9
Testing	2
Cleaning	4.2
Average P-SVR Value for the total assembly work 3.9	

Hence this is the area where one should concentrate to simplify the work content. For simplifying the work content, one has to concentrate on modifying the areas where the postural severity index is maximum.

Snapshot 1 - Disassembly (Postural Severity Score-7)

As mentioned above it is an indication that the postures involved in the disassembly needs to be improved considerably by minimizing the squatting and other difficult postures (refer Snapshot 1). On the other hand the value of P-SVR index is lowest for the testing activity which is 2. Testing activity involves leakage testing by dipping compressor in water tank once compressor is assembled (refer Snapshot 2). It can be seen that for this activity the maximum postural severity score value of 7 which does not occur in the work cycle. The second highest value of postural severity score of 6 it is hardly 3.3% of time. This is an indication of the fact that the activity of testing is not strenuous to the operator.

Snapshot 2 – Testing (Postural Severity Score -3)

It can be seen that using P-SVR method, one can find out the duration of times spent under different severities of postures which can help in simplifying the operations considerably, minimizing worker fatigue and possibilities of WMSDs. Using the P-SVR methodology one can analyse the data in many other ways leading to guideline for improving work comfort. As we have analysed the data on the basis of time spent under different severities of posture P-SVR method can also give the data about the frequency of different severities. This is represented in Graph 3 and Graph 4. Graph 3 gives the presentation of number of occurrences for different postural severity

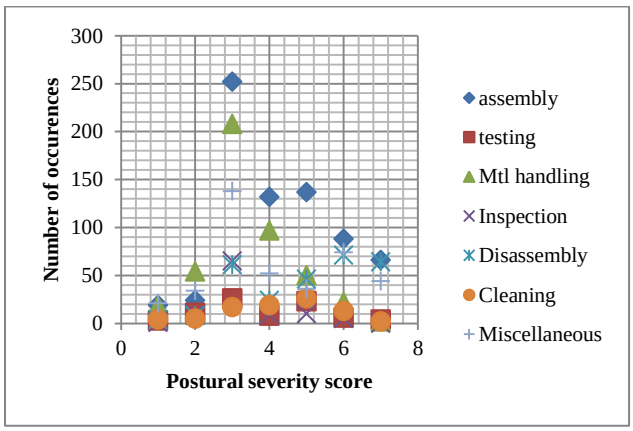
Table 3: Time spent in different severity of posture for different activities

Time spent in seconds Vs Postural Severity Score								
Postural Score	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Assembly	223	324	1048	752	644	685	924	4600
Testing	609	249	308	22	86	19	21	1314
Material Handling	265	297	1054	293	172	90	103	2274
Inspection	7	151	225	32	31	15	0	461
Disassembly	58	65	166	127	197	299	223	1135
Cleaning	16	126	205	90	233	175	15	860
Miscellaneous	169	193	1076	379	323	676	169	2985
Total	1347	1405	4082	1695	1686	1959	1455	13629
% of total	9.9	10.3	30	12.4	12.4	14.4	**10.7**	100

Table 4: Percentage Time for Postural severity values for various activities

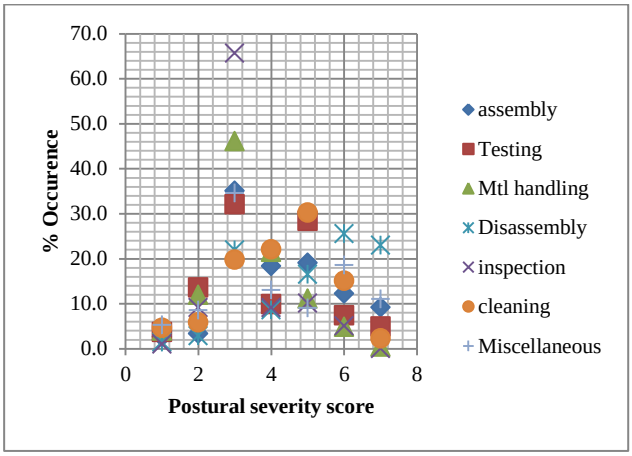
% Time Vs Postural Severity Score								
Postural Severity Score	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Assembly	4.8	7.0	22.8	16.3	14.0	14.9	20.1	100
Testing	46.3	18.9	23.4	1.7	6.5	1.4	1.6	100
Material Handling	11.7	13.1	46.4	12.9	7.6	4.0	4.5	100
Inspection	1.5	32.8	48.8	6.9	6.7	3.3	0.0	100
Disassembly	5.1	5.7	14.6	11.2	17.4	26.3	19.6	100
Cleaning	1.9	14.7	23.8	10.5	27.1	20.3	1.7	100
Miscellaneous	5.7	6.5	36.0	12.7	10.8	22.6	5.7	100
% of total	**9.9**	**10.3**	**30.0**	**12.4**	**12.4**	**14.4**	**10.7**	**100**

scores for various activities carried out during the assembly of compressors. Even in this analysis it can be seen that the frequency of occurrence is maximum for the highest score of 7 for the disassembly activity and the second highest value for this highest score is for the assembly work. It is a clear indication that these are the activities which need to be simplified in order to improve the worker comfort.



Graph 3 – Number of Occurrences Vs Postural Severity score

Table 3 and Table 4 show that assembly task has maximum time of about 4600 seconds, and has second highest value of postural discomfort with P-SVR value of 4.5. If we concentrate on the areas where the postural severity score is maximum or the second highest [924 and 685 seconds for assembly] we shall be helping the worker in simplifying the postures to a great extent. In short from Table 3 and Table 4, we can say that the P-SVR methodology provides a way to map the work severity in totality to highlight the areas where process improvements are essential to have operator comfort leading to higher productivity.



Graph 4 – Percentage Occurrences Vs Postural Severity score

Conclusion

The P-SVR methodology provides opportunity for comprehensive mapping of postural severity which is not possible using existing methods of postural analysis. Due to this one can locate the problem areas exactly. As it can be seen from Table 3 (Time spent in different severity of posture for different activities) out of the total duration of 13,776 seconds, in order to improve the postural severity

index one has to concentrate on 10.7% and 14.4% of time, where the postural severity indices are high.

P-SVR methodology makes the review of observations possible. Due to the fact that the postural analysis has been converted in quantitative parameters, comparison of different jobs on the basis of postural severity is possible. 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 as well as output.

The P-SVR method can be used to decide upon the comparative job difficult level involved in different operations. Since this method does holistic analysis of human postures in a work cycle, the P-SVR indices quantify the job difficulty level. As discussed above, this method provides detailed analysis to locate exact areas where improvements are required in order to minimize postural discomfort and thereby improve efficiency of operations.

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