A Systematic Ergonomics Approach of Maintenance Workstation

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Abstract. The transportation systems contribute very vital role in growth of country, either it may private, public or own transportation system, and to keep the automobiles or machine in good condition without any interruption consistent corrective or preventive maintenance has to be done, and this maintenance activities should take the least time and cost of maintenance along with good quality, and to achieve this it is preferred to design a good maintenance workstation with a systematic ergonomic consideration which has a great influence on time, service, comfort, quality, productivity. For the design of a maintenance workstation, systematic ergonomic procedures are considered these procedures should concern for good ergonomically design of workstation. In an actual design of workstation ergonomically approach is needed concern of the worker anthropometric data with the various parameter of the workstation like adequate posture, work table or chair height, position of the operating nobs and levers comfortable sufficient working areas that help to reduce MSD (Musculoskeletal disorder) and prevent injuries of worker along with enhancing productivity. The main objective of this paper is to propose a systematic ergonomically designed maintenance workstation. Existing workstation of Maintenance in MSRTC (Maharashtra State Road Transport Corporation) Solapur workshop, is not designed with consideration of Ergonomic principle, so the ergonomic analysis has been made for different posture of maintenance activity, and modifications in workstation has been suggested. For analysis CATIA software is used, Manikin (simulated posture of worker) has been developed based on the anthropometric data collected from MSRTC for RULA analysis under quasi-static loading and dynamic loading conditions.

1. Introduction

Ergonomics is designing a work suitable to the worker, not worker suitable for a given work so that the work is safer as well as more efficient. A systematic ergonomic approach can make employees more comfortable along with increased productivity. Ergonomics is vital because when you’re performing a work or an activity and your body is strained by a clumsy posture, repeated movements; effect on your musculoskeletal. Symptoms like tiredness, awkwardness, and pain may begin to hold by your body, which may be the primary marks of a musculoskeletal disorder. Each industry has its aim to enhance the productivity of Worker, particularly with higher frequency industrial jobs, and it is challenge for the profitmaking executives.
To enhance the efficiency and reduce the injuries and MSDs of the worker, there is need of ergonomic assessment and optimization of Industrial workplace and tools. Ergonomics improves performance along with the productivity, safety and health, and of the workers.

2. Anthropometric Measurements
The anthropometric measurement were presented in the Table 1 having different variables with 98% accuracy relating to five workers of Maharashtra, (MSRTC, Solapur) Indian, used for building a manikin in CATIA V5R19 (software).

| Sr. No. | Parameters | Subject No. | Mean |
|---------|------------|-------------|------|
| 1       | Weight (Kg) | W1 W2 W3 W4 W5 | 62.2 |
| 2       | Stature     | 165 163 168 165 153 | 162.8 |
| 3       | Eye Height  | 153 154 157 154 143 | 152.2 |
| 4       | Acrominal Height | 139 140 142 141 135 | 139.4 |
| 5       | Axilla Height | 122 121 125 120 128 | 123.2 |
| 6       | Chest Height | 119 118 120 115 124 | 119.2 |
| 7       | Tenth Rib Height | 108 107 110 102 110 | 107.4 |
| 8       | Iliocristale Height | 98 97 101 99 99 | 98.8 |
| 9       | Waist Height | 101 102 105 104 97 | 101.8 |
| 10      | Olecranon Height | 103 105 107 108 98 | 104.2 |
| 11      | Elbow height | 105 107 108 110 102 | 106.4 |
| 12      | Crotch Height | 77 72 78 80 75 | 76.4 |
| 13      | Knee Height | 47 45 50 46 47 | 47 |
| 14      | Chest Breadth | 25.8 24.6 25.7 27.8 26.3 | 26.04 |
| 15      | Hip Breadth | 28.5 27.8 28.2 27.9 26.2 | 27.72 |
| 16      | Hand Length | 17.5 18.4 19.2 20.3 19.5 | 18.98 |
| 17      | Palm Length | 10.4 10.8 10.2 11.2 10.3 | 10.58 |
| 18      | Hand Breadth (At Metacarpal-III) | 7.5 8.2 7.4 7.6 8.2 | 7.78 |
| 19      | Grip Diameter(Inside) | 4.5 4.2 4.1 4.5 4.2 | 4.3 |
| 20      | Grip Diameter (Outside) | 5.9 5.6 4.9 5.2 5.4 | 5.4 |
| 21      | Foot Length | 23.5 22.4 22.2 24.2 23.3 | 23.12 |
| 22      | Foot Breadth | 9.2 9.4 9.2 9.5 8.9 | 9.24 |
| 23      | Age (years) | 33 37 23 31 27 | 30.2 |
3. Rapid Upper Limb Assessment (RULA)

The RULA technique assesses individuals' work postures, muscle activities and forces which shows repetitive strain injuries. Its gives a resulted in the form of score form one (1) to seven (7), with colour zones as presented in table 2. Zone colour varies from green to red with respect to the score wherever higher scores point out greater levels of risk, low score of result doesn't assurance of workplace is free from ergonomic risks, and a high score doesn't promise that a severe problem present. It was established to have rated supplementary attention towards noticed postures of work or risk factors.

Table 2. Explanation of RULA score in basic mode

| Sr. No. | Score  | Colour | Meaning                                          |
|---------|--------|--------|--------------------------------------------------|
| 1       | 1 and 2| Green  | If the posture is not retained or Repeated for longer period then its acceptable |
| 2       | 3 and 4| Yellow | Additional examination is essential and modifications may also be necessary. |
| 3       | 5 and 6| Orange | Examination and modifications are desirable soon. |
| 4       | 7      | Red    | Examination and modifications are necessary instantly. |

4. Modelling and Ergonomic Analysis of Existing Maintenance Workstation

Results of RULA analysis are obtained using CATIA V5R19 software. From the video or photographs of maintenance workstation, posture is designed using the ergonomics module in CATIA V5R19 software. In MSRTC, Solapur workshop using Digital Human Modelling Technique in CATIA V5R19 software, RULA analysis of job-related disorders is performed.

This study was conducted at MSRTC, Solapur workshop Solapur District. The chosen workstation for the present study is related to maintenance department. A simple rating was given to the subject to calculate the postural awkwardness experienced. Also, the subject was asked to do his working series routinely and the process was noted through photography. limited postures of the maintenance person from his routine work are selected and simulated as a manikin in the CATIA V5R19 software. Further, the RULA analysis performed on the manikin with exact duplication to calculate the workers posture level of awkwardness. The maintenance practice involving some of the complicated postures of the worker was identified and designed using CATIA V5R19 software for ergonomic analysis. With the help anthropometric data worker, the manikin was modelled.

To select a critical posture among the activities carried out in the process of maintenance, RULA analysis has been carried out for the four postures as shown in figure 1. The results are presented in table 3, which tells us that the posture (d) is critical posture among the other posture as the score of posture is 7. (Note: score is less posture is ergonomically good, score is more posture is ergonomically not good).
Figure 1. Picture of postures while maintenance process in going on

Figure 2. Mainkin modeling with job for posture a, b, c and d.
Table 3. RULA analysis result: posture a, b, c and d.

| Posture | RULA analysis Score |
|---------|---------------------|
|         | Type of Loadings    |
|         | Static              |
|         | Intermittent        |
|         | Repeated            |
|         | Left hand | Right hand | Left hand | Right hand | Left hand | Right hand |
| a       | 7          | 6          | 6         | 5          | 7         | 6          |
| b       | 7          | 7          | 7         | 6          | 7         | 7          |
| c       | 7          | 7          | 7         | 6          | 7         | 7          |
| d       | 7          | 7          | 7         | 7          | 7         | 7          |

Figure 3. RULA analysis result of Posture (d) for static loading.

Figure 3 shows static loading of both hands of manikin and corresponding posture score 7 and colour is red. This means posture should Examination and modifications are desirable instantly. Trunk, neck and leg are the stressful parts.

Figure 4. RULA analysis result of Posture (d) for Intermittent loading.

Figure 4 shows intermittent loading of both hands of manikin and corresponding posture score 7 and colour is red. This means posture should Examination and modifications are desirable instantly. Trunk, neck, and leg are stressful parts.
Figure 5. RULA analysis result of Posture (d) for Repeated loading

Figure 5 shows repeated loading of both hands of manikin and corresponding posture score 7 and color is red. This means posture should Examination and alterations are desirable immediately. Trunk, neck and leg are the stressful parts.

From above analysis for different condition gives average score of existing workstation as a 7 which means Additional examination is essential and alterations may be necessary. As there is no proper maintenance workstation is available for the maintenance person, so it is advised that maintenance person should have a maintenance workstation designed with the consideration of agronomical principals, so we tried to the same and presented in this study as follows.

5. Modelling and Ergonomic Analysis of Modified Maintenance Workstation

A number of references permissible to safeguard workers ease and safety are possible. Repetitive work may result on the workers’ wellbeing even if the load is minor. The workplace restoration may ensure a worthy and easy work atmosphere through modifying the systematic ergonomically designed maintenance workstation. It is recommended that modifying as shown in fig. 6 can be used to make workers postures safe. This construction of the platform allows the worker to do the work with minimum expenditure of energy. Excessive stress on neck, trunk, forearm, leg, etc. is reduced considerably, which allow efficient working of worker for large duration. Further health hazards of workers can be avoided. This will automatically increase the productivity, and reduce MSD and prevent injuries of worker along with enhancing productivity.

Figure 6. Modified Posture.

Figure 7 shows Static loading on both hands of manikin and corresponding posture score 3 and colour is Yellow. Additional examination is essential and alterations may be essential. The Trunk, neck and leg parts are in Yellow colour it menaces stresses are optimum.
Figure 7. RULA Analysis result of Modified posture of static loading.

Figure 8. RULA analysis result of Modified Posture for Intermittent loading

Figure 8 shows intermittent loading on both hands of manikin and corresponding posture score 3 and colour is Yellow. Additional examination is essential and alterations may also be essential. The Trunk, neck and leg parts are in Yellow colour it means stresses are optimum.

Figure 9. RULA analysis result of Modified Posture for repeated loading.

Figure 9 shows repeated loading on both hands of manikin and corresponding posture score 3 and colour is Yellow. Additional examination and changes are essential.

According to RULA analysis the percentage score reduction comparing existing workstation with redesigned workstation is given below.
6. Conclusions
The conclusions drawn from the study are as follows.
- Performance of worker at a workstation for finishing task has a significant effect on productivity. Hence, a systematic ergonomically modified workstation plays an important role in any maintenance workstation.
- RULA analysis for existing maintenance workstation shows the overall score 7, and hence there is need of immediate Examination and modifications.
- RULA analysis for redesigning workstation shows the overall Avg. Score 3 i.e. near about 57.14% of reduction in RULA score was observed as compared to existing workstation.
- Modified workstation reveals more comfort than the existing workstation. This increases efficiency of worker along with productivity.
- Thus to reduce MSD as well as potential accidents and health problems and to enhance the performance at workplace ergonomic approach is very imperative.
- With reference to the analysis carried out, probably it is possible to increase comfort, efficiency of workers and productivity of the maintenance industry with the use of a systematic ergonomically designed workstation.

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