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Ergonomic assessment and workstation design of shipping crane cabin in steel industry

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A R T I C L E I N F O

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A B S T R A C T

Ergonomics plays vital role to improve health and productivity at workplace and in last two decades it find importance to redesign workplace. All Indian industries had taken initiative to redesign their workplace to overcome various musculoskeletal disorders (MSD) and work related injuries. In this context, the project has been carried out in an integrated steel plant located in central India where most of the crane operator was continuously suffering from muscular pain in different body parts. Risk of MSD was identified by detailed questionnaire from 27 crane operator. It was revealed that almost all crane operators were continuously suffering from some kind of MSD. Based on the anthropometric data of 50 percentile Indian male, ergonomic assessment, redesign and evaluation of crane cabin was carried out in CATIA-V5 software. To check the compatibility of the design, rapid upper limb assessment (RULA) for both existing as well as modified crane cabin was performed. This study shows that intervention of ergonomics in workplace reduces the mismatch between man and machine and makes workplace comfortable for work.

1. Introduction

Ergonomics is the scientific study of man–machine interaction at workplace. The basic objective of ergonomics is to fit man and machine together to improve the worker's performance, reduce stresses and fatigue at work. Application of ergonomics is very significant in area where manual activities directly affect physical and mental health of the employee (Parkes et al., 2005). Handling of shipping cranes is one such activity in which physical and mental health plays a very vital role. A crane operator has to perform various activities, such as continuous monitoring of shipping operation i.e. loading and unloading of heavy steel billets & plates, adjustment of end effector by using specific control levers embedded in a closed cabin. The task of crane operator is highly repetitive. This paper presents case study that deals with ergonomic analysis and redesign of crane setup which belongs to 1960s. Fig. 1 shows the view of crane cabin & it is observed that the main controllers are not designed with ergonomic principles and they are placed on either side of the table such that it is not possible to handle levers within the vertical section in sagittal plane passing through shoulder joint (Violante et al., 2000; Chaffin and Anderson, 1999). Position of controls is such that it is not possible for a crane operator to use levers at one position. In seated position, operator was unable to move both arms freely. As controllers are placed on either side of the table, it is not feasible to provide the chair with arm rest. However a wooden stool has been provided in cabin, which was inaccessible for most of the time. This stool has too much sitting height (0.92 m) so that sitting at such a height without any back support is unsafe & uncomfortable. Movement of the Crane generates vibrations, which makes the stool positioning unstable. Apart from operational difficulties, long term exposure to vibration causes lower back pain and sciatic problem (Zhang et al., 1991; Zander et al., 2004). This design does not fulfills operator's biological needs, as determined by the ergonomics guidelines and physical requirements of the equipment.

1.1. Assumption

Following assumptions were made for ergonomic analysis and redesigning of the crane cabin setup

1. The workers answered the questionnaire as accurately as possible.
2. This study is limited by its small sample size.

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Fig. 1. Shipping crane cabin.

Table 1
Sample properties.

	Mean	Standard deviation	Max	Min.
Age (year)	41.48	7.86	54	28
Weight (kg)	64.18	8.1	76	52
Experience (year)	10.44	5.52	23	2
Stature (cm)	162.3	4.8	167.3	157.5
Standing average eye level (cm)	151.4	6.45	157.8	144.9
Forward arm reach (cm)	81.3	4.3	85.6	77
Normal sitting height (cm)	78.4	5.2	83.6	73.2
Sitting average eye level (cm)	72.5	2.3	74.8	70.2

1.2. Objective

The present study had the following objectives.

1. To investigate the prevalence of musculoskeletal disorder of crane operators.
2. Analysis body posture & workstation with ergonomics aspects.
3. To improve the working condition by suggesting new workstation.
4. To verify effectiveness of the modification by RULA test.

2. Musculoskeletal disorder (MSD) analysis

Musculoskeletal Questionnaire has been used to assess the nature and severity of musculoskeletal symptoms. A multiple choice-type questionnaire was constructed on similar lines of earlier researcher (Martin et al., 2005; Wilder et al., 1994; McAtamney and Corlett, 1993; Kuorinka et al., 1987) for identifying and elaborating the problems faced by 27 crane operators in maneuvering the controls during work. The questionnaire inquire about the history of experience of musculoskeletal problems in nine body positions (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles/feet) over the past weeks and over the past year (Dickinson et al., 1992). Anthropometric measurements of crane operators were carried according to the guidelines of Anil and Shrawan (1998). Referring to Table 1, it shows anthropometric dimensions of sample (27 crane operator). A modified Borg scale (David, 2005) of range 1–10 was used to rate the exertion and pain experienced by crane operator. Over both the time frames, neck pain, upper back pain, lower back, thigh/hip and knee pain were most frequently reported (Table 2). MSD analysis of crane operator clearly indicates (Fig. 2) that 100% of crane operators continuously suffer from some kind of MSD. This study clearly demonstrates that the existing crane cabin design does not provide any comfort, convenience of use or safety from high risks of MSD.

3. Posture analysis

The real-time observation of the crane operator postures was carried out to identify the most repetitive working postures (Luttmann et al., 2000). Durations of the postures were recorded and work–rest cycles of the operators were analyzed. It was observed that forward bending looking down posture (Fig. 3a) takes 58% of the total time, bending right and looking down-right posture takes 11% of the total time, bending left and looking down-left posture (Fig. 3b) takes 11% of the total time, looking up posture takes 9% of the total time, stretching out for the Walky-Talky/Mouse takes 1% of the total time, and reclining on the stool without back support takes 10% of the total time.

In order to identify severity of posture, postural analysis was carried out by RULA. RULA examines the risk factors and all risk factors are combined to give a total score that ranges from 1 to 7 (Gnanavel and Soundararajan, 2008). The data displayed is combined with a color indicator zone. The color of this zone changes

Table 2
Observed prevalence rates for MSD.

Area of body affected	Occurrence in last 12 months (% of sample)	Occurrence in last week (% of sample)
Neck (NEC)	62.9	74.0
Shoulders (SHO)	44.4	51.8
Elbows (ELB)	33.3	25.9
Wrists/hands (WRI)	29.6	22.2
Upper back (UPB)	66.6	85.18
Lower back (LOWB)	51.8	77.7
Hip/Thigh (HIP)	66.6	81.48
Knee (KNE)	59.25	70.37
Ankle/feet (ANK)	22.2	48.14