Improving the Interior Design of an Overhead Cane Cabin: A Steel Industry Case

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ABSTRACT

An overhead crane cabin can be considered as a complex work system that consists of a crane operator, operator’s seat, and specific control equipment. This study aims to attract attention to the crane operators who perform various activities such as loading and unloading of coils in a constrained area. The results of observations and use of Rapid Entire Body Assessment (REBA) and Quick Exposure Check (QEC) methods for an overhead crane cabin that is used in a steel industry are summarized. The critical problems are identified as the poor design of the operator’s seat and location of the controls. Interior design is improved as to eliminate awkward work postures and insufficient vision angle that had a risk to cause musculoskeletal disorders (MSDs) for the crane operator.

INTRODUCTION

Traveling or stationary cranes that are used to lift, move, and position loads are operated/controlled by a crane operator who is in a cab or on the ground. Machinery, equipment, products, and solid or bulk materials in several industries mainly in construction and heavy industry are handled by using hoisting attachments, such as hook, sling, electromagnet, or bucket. However, awkward postures during the operation are usually a consequence of improper cabin design and work procedures. Poor visibility of the task, limited room in the crane cabin, excessive forces required to operate levers/pedals, and improper seat designs are some of the characteristics of a poorly designed cabin. Since, awkward posture of any body part can result in increased risk of fatigue, pain, or injury, the work area of a crane operator should be assessed constantly and required actions must be taken.

Based on the accessible literature, there are limited number of studies that focus on the crane cabin design. A checklist for evaluating cab design was provided in [1] and seven construction equipment was assessed and all of them were identified as to have problems with the operator’s seat. A manually-operated Electrical Overhead ¹Borusan Mannesmann Gemlik 16601 Bursa, Turkey
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Travelling (EOT) crane cabin was considered in [2] and aim was defined as to remove the anthropometric mismatch, improve the visibility of the operator. Also the layout of the components and controls within enclosed workspace were improved to minimize the risk of MSDs. Through anthropometric characteristic analysis, crane operators’ biomechanical and visual problems can be minimized and to improve safety and prevent crane related fatalities and injuries, there is still a need for more objective, theoretically justified and consistent models [3]. It was stated that the critical characteristics of existing crane cabins could be linked to visibility and posture (seat and armrest problems). A crane prototype that aimed to improve ergonomic characteristics of the cabin while increasing process safety was provided [4]. Integrated visual systems for the detection of work environment was studied [5]. Six crane cabin types were examined based on operator-control devices interaction, safety and anthropometric adjustment [6]. The anthropometric convenience of existing crane cabins, and possibilities for improvements of their design from the ergonomic point of view were considered [7]. Crane cabin interior space dimensions were studied by using a sample of 64 crane operators’ anthropometric measurements [8]. Eight experienced crane operators had performed a simulated crane operation task on a computer by use of a short or a large handle joystick and task performance, wrist and forearm postures, upper extremity muscle activity, perceived exertion and perceived comfort were measured [9].

It is important to take actions to avoid work-related MSDs. Since crane operators fall into the risky group, this study aims to summarize the results of REBA and QEC that is utilized for a crane operator in a steel industry. Improvements for new seat design, relocation of control units, and interior space are discussed.

METHOD

Full factorial design and Taguchi method was used in design of experiments and based on the detailed questionnaire from 27 crane operators, the anthropometric data of 50 percentile Indian male, ergonomic assessment, redesign and evaluation of crane cabin was made by use of rapid upper limb assessment (RULA) for the existing and the proposed crane cabin [10]. Nordic questionnaire among 120 crane operators was utilized and then postures and movements of operators were measured by using inclinometers for an 8 h shift [11]. Physical exposure in case group operators is identified to be more awkward and extreme postures in the back and head are observed.

REBA has been developed for a practitioner’s field tool, specifically designed to be sensitive to the type of unpredictable working postures found in health care and other service industries [12]. However, basic principles are also used to assess workers at manufacturing area. Main steps of the method is summarized by with a REBA assessment worksheet [13]. QEC is based on epidemiological evidence and investigations of OSH practitioners’ aptitudes for undertaking assessments [14].

The Problem in Concern

An overhead crane at steel industry is considered in this study. It is known that working at height has risks. A crane operator who is spending 6 hours in the crane cabin during the 8 hour shift is observed along with the company’s physician. The initial assessment of current crane cabin constitutes that the cabin does not meet ergonomic
factors. Seat did not have lumbar support and an adjustable armrests. Further, the locations of the controls and levers were not adjustable. The vibration could be felt from the equipment through the floor. On the other hand, the posture of the operator has a risk of static stress. Therefore, operator is observed during performing coil loading and unloading. Figure 1 represents the main problems in the crane cabin. The posture of the crane operator is further analyzed by use of REBA and QEC. When performing steel col handling on the ground, crane operator constantly needs to bend. The location of the display is not appropriate because the glare makes it harder to type and control data.

![Figure 1. Representation of the main problems in crane cabin.](image)

(a) Posture of the crane operator   (b) Location of the controls   (c) Location of the display

RESULTS

When crane operator is involved in steel coil loading unloading tasks on the ground, he needs to bend and check the warehouse area and locations of the coils. The task constantly requires high attention and use of controls within the crane cabin. REBA score is obtained as 8 (Figure 2). Since the scores 8 to 10 represents high risk, further investigation is required and changes to improve the system should be implemented.
QEC is conducted to confirm REBA analysis and consider factors such as vibration, driving and like. Table 1 provides the results of QEC for the crane operator. Neck is identified as the body part that has the highest risk.

Table 1. QEC results for the crane operator.

| Score          | Exposure level |
|----------------|----------------|
| Back (static)  | 22  Moderate   |
| Back (moving)  | 22  Moderate   |
| Shoulder/arm   | 26  Moderate   |
| Wrist/hand     | 26  Moderate   |
| Neck           | 18  High       |
| Driving        | 1   Low        |
| Vibration      | 4   Moderate   |
| Work pace      | 1   Low        |
| Stress         | 0   Low        |

Crane operator is analyzed during checking the warehouse area. REBA score is calculated as 5 as represented in Figure 2. The level of MSD have a medium severity level. Therefore, further investigation is required and changes should be made soon.
DISCUSSION

A crane operator’s seat should be designed as to eliminate the potential for MSD. The basic guidelines for the crane cabins of cranes should be met. To improve the crane operator’s seat, an investment is made and a seat with a backrest is provided as stated in Figure 3 (a). The design also supports the lumbar area of the back. However, new seat still does not have a support for the arms to avoid restricted use of control levels. Therefore, manual controls are located in the reach of a seated operator. The elements that might distract operator are located aside or behind.

Figure 3 (b) represents the new design display. With the use of a low cost glass protective, the glare problem is solved. A platform to place the keyboard and mouse is relocated under the display. A digital counter is placed above the operator that provides information about the weight of the coil that is being handled. Further, a camera system is set up to track the operations on the ground without the necessity of bending. Related investments are completed within 6 months period. But compared to the possible costs related with MSD of a worker (compensation payments, medical payments, legal expenses, loss of productivity, etc.), it can be stated that due to the low cost of the arrangements Return of Interest (ROI) of the investment is expected to be less than 1 year.

With the improvements, most of the lateral parts of the cabin is made of glass. To enhance leg space and visibility, a new design is adopted for the floor of the cabin as represented in Figure 3 (c). The new design has a potential to enable the operator avoid bending during operations and have injuries caused from working in the restricted area.
CONCLUSIONS

Laboratory and epidemiological research confirm the relationship between awkward posture and the development of fatigue and MSD. Collecting and analyzing postural data in real life cases can be time consuming. On the other hand, due to the importance of musculoskeletal symptoms and injuries, a crane cabin design should be in concern especially for heavy industries. This study attracts attention to making observations and conducting methods such as REBA and QEC with the help of a company physician. Although there is currently a lack of quantitative data describing postural stresses among operators, it is known that main problems arise from the mismatch of the anthropometric data or inappropriate layout. After identifying the problem, required actions can be taken. As presented in this study, most of the solutions can be obtained at low cost and can pay back in short periods of time.

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