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Ergonomic Issues at a Railway Maintenance Workshop

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ABSTRACT

Research on human factors related to railway operation and maintenance has, to an extent, been the neglected branch of transport ergonomics. Despite the numerous reports of ergonomics programs in a variety of industries, no examples of implementing ergonomics interventions in the railway vehicle maintenance workshop have been reported.

In this study, a maintenance process at a railway workshop was studied and analyzed with special reference to working posture and maintenance repair time. The working postures of two maintenance personnel were obtained and analyzed using OWAS (Ovako Working Posture Analysis System).

From the results, it was clearly indicated that poor working posture was a frequent occurrence during the maintenance activities. It can be concluded that the introduction and implementation of ergonomics principles at the railway maintenance workshop must be considered in order to reduce the poor working postures, maintenance repair time and to improve maintainability and productivity.

Keywords: Ergonomics, railway maintenance workshop, maintenance activity

1. INTRODUCTION

It is often difficult for maintenance and service personnel to access the desired items, which makes it hard to perform the tasks within the prescribed time. This working situation leads to psychological and physical stresses, but also to accidents that result in injuries and long-term sickness. These unwanted consequences have economic implications for the organizations that provide maintenance and services, but also for their industrial customers and for society at large. Often negligence in maintenance leads to unavoidable disastrous failures leading to loss of lives and assets, and there is also little doubt that human error contributes to the majority of incidents and accidents which occur within complex systems, including the railway system (e.g. Krokos and Baker, 2007). Rail human factors' research has, to an extent, been the neglected branch of transport ergonomics, at least in comparison to aviation (cockpit & air traffic control) and road driving; it is also stated that maintenance inspections are a relatively neglected area of rail (FIGURE 1) (Wilson and Norris, 2005).

In general the work available on railways is much less than for other high-risk industries, such as offshore oil and gas (Farrington-Darby et al., 2005). No published research study has yet been found on railway vehicle maintenance. Therefore, a case study was performed to analyze and understand the maintenance task process at freight wagon maintenance and repair workshop.

FIGURE 1. Examples of maintenance activities in a railway maintenance workshop.

2. METHODS

2.1 Participants

Three maintenance personnel from a railway maintenance workshop participated in this study. Their professional experience ranged from 5 years to 35 years.

2.2 Procedure

Maintenance personnel were asked to carry out their daily maintenance repair task and prior to this, the Standard Nordic Questionnaire was used for the analysis of the prevalence of musculoskeletal problems in different body regions. The Standard Nordic Questionnaire was presented to the participants with a few additional questions regarding the working condition.

The maintenance task (changing of brake shoes) was recorded on videotape for the postural analysis with the Ovako Working Posture Analysis System (OWAS). The OWAS method was applied to analyze the work postures, and there are about 252 work posture combinations for the back, arms, legs, and for carrying load, all of which are assigned four action codes (Olendorf and Drury, 2001). The four action codes are defined as follows:

- Action category 1: change not required,
- Action category 2: change required in the near future,
- Action category 3: change required as soon as possible,
- Action category 4: change required immediately.

The videotapes for changing brake shoes were analyzed with the WinOWAS computer software for analyzing working postures according to the OWAS method. The use of computerized OWAS application makes the analysis faster and more versatile than the traditional method. According to Mattila and Vilkki (1999), the use of a computerized application is strongly recommended. The random time interval for coding a maintenance work posture was five seconds.

3. RESULTS

3.1 Nordic Questionnaire

From the questionnaire it was found that the maintenance personnel had suffered back and shoulder pain during last seven days and they also reported frequently working with the back and arm in awkward or fixed positions.

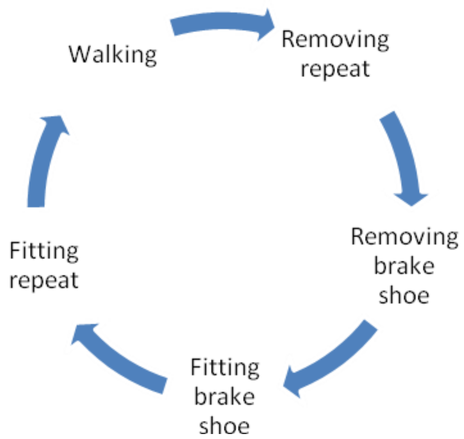

FIGURE 2. Maintenance activities of changing a brake shoe in a freight wagon.

3.2 Video analysis

The maintenance task was analyzed using the videotape. As a result of video analysis, it was found that the maintenance activities for changing the brake shoe started from removal of the repeats of the brake shoe holder and ended with the fitting of the repeats (FIGURE 2).

3.3 Postural analysis

The obtained data was analyzed according to the different maintenance activities for the changing of the brake shoe, and the proportionate share of maintenance working postures for different activities was calculated in percentages. After analyzing the working posture of the maintenance personnel, it was found that "removing repeat", "fitting brake shoe" and "fitting repeat" were the major maintenance activities, of which 32% of total observed time was only for the fitting of the repeat (TABLE 1).

TABLE 1. The proportion of maintenance activities and OWAS category for changing a brake shoe.

Maintenance activities	**% of working time**	**No. of observations (Total = 60)**	**OWAS category (no. of observations)**
Walking	7	4	2 (4)
Removing repeat	25	15	1 (8) & 2 (7)
Removing brake shoe	15	9	1 (2) & 2 (7)
Fitting brake shoe	22	13	1 (10) & 2 (3)
Fitting repeat	32	19	1 (8), 2 (7), 3 (3) & 4 (1)

The total number of OWAS observations for the maintenance task was sixty for the two participating maintenance personnel (TABLE 1). The proportionate share of postures of different body parts was analyzed and categorized into different action categories. After analyzing the posture, it was found that 16% and 5% of maintenance working time for the fitting of the repeat fell into categories 3 and 4 respectively (TABLE 2).

TABLE 2. OWAS category for the fitting of repeat.

Maintenance activity	**% working time**	**OWAS category**
Fitting repeat	42	1
	37	2
	16	3
	5	4

4. DISCUSSION

In this study, videotape was used as method as it allows the observer much longer time to look at the observed posture. The videotape can also easily and effectively be used in recalling the actual work situations when providing feedback from the posture study. Direct observation and video observation have both been validated for the use of OWAS (Long, 1993).

The maintenance task was analyzed and from results it was found that the fitting and the removing of the repeat were the major activities. Most of the working time for fitting the repeat fell into action categories 1 and 2, but it also fell into action categories 3 and 4. Categories 3 and 4 indicate a high level of postural effort that can potentially produce musculoskeletal disorders among maintenance personnel. The possible reason for postures falling into categories 3 and 4 could be that sometimes the maintenance personnel have to bend and twist their backs to reach the other side of wheel in order to see whether they have fitted the repeat correctly and firmly (FIGURE 3). According to Kumar (2001), very frequent twisting and bending of the torso should be avoided as it creates a greater biomechanical load on the back and can cause long-term musculoskeletal injuries.

From the results it was also found that all of the maintenance activities for changing brake shoes fell into action category 2 (TABLE 1), which means that a change in working posture in the near future is required. One possible explanation could be that these maintenance activities were done under the wagon which has space limitation, and while walking from one point to the other, maintenance personnel have to bend their backs in order to prevent head injuries from the bottom of the wagon (FIGURE 4). Another possible reason could be that the maintenance personnel have to work with both arms above the shoulder and bend back while removing/fitting the repeat and removing/fitting the brake. A study by Seminara and Stuart (1982) mentioned that the most common complaint reported by a group of maintenance personnel working at a nuclear power plant was the lack of easy access to the equipment requiring maintenance attention. Inaccessibility to equipment or components is associated with the placement of components in such a way that maintenance personnel find them unreachable and far beyond their visual limits for inspection purposes.

FIGURE 3. An awkward working posture while fitting repeat.

FIGURE 4. Space limitation while working/walking under the freight wagon.

The number of observations in this study was limited to only 60 observations (five minutes); however, results show that changing brake shoe consists of poor working postures which might lead to back or shoulder problems among maintenance personnel. This can be also be verified by the results from the questionnaire in which participating personnel reported back and shoulder pain. The principle of OWAS is to provide a system for analyzing and classifying working postures. Subsequent uses of OWAS have included: planning new jobs; purchasing equipment that enhances safe postural usage (Scott and Lambe, 1996); job placement for personnel; and production improvement (Carasco et al., 1995). From the OWAS analysis, the major activities for the maintenance task were found as well as how some of these activities force personnel to adopt an awkward working posture. Awkward working posture not only produces strain on the muscular system, but it also means that a longer time is taken to complete the task, compared to when the working posture is improved (Kumar et al., 2005). Although only one maintenance task was observed for few minutes, this study has identified ergonomics-related issues such as poor working posture in a railway maintenance workshop. The reason for poor working posture could be the improper facility design for maintenance (FIGURES 3 and 4). Seminara and Stuart (1982) found that the problem encountered in the layout of the facilities was the placement of equipment and components in a location that was inaccessible from a normal work position. Considering the maintenance of freight wagons, the facility design must take ergonomic factors into account in the initial stages, including the workers' anthropometric measurements when wearing cold-protective clothing, their visual access, their cognitive performance, and the placement of equipment.

5. CONCLUDING REMARKS

Regarding working posture of the maintenance personnel, it can be concluded that a maintenance task consisted of several activities, each of which consisted of some poor working posture situations which might lead to musculoskeletal injuries and thus lead to reduced productivity and increased maintenance repair time. Therefore, ergonomic guidelines or principles need to be implemented at the maintenance workshop in order to improve awkward working posture, which in turn will improve repair time and productivity.

This study contributed by providing a validated ergonomic tool for the analysis of the maintainability of the maintenance workshop. It also provides a large scope for conducting research in maintenance processes from an ergonomics point of view. There is an opportunity for the maintenance tasks to be observed in depth. A more comprehensive study can be carried out by involving large numbers of maintenance personnel from different maintenance work places in order to generalize the ergonomic issues at work among personnel. Furthermore, an in-depth analysis of the maintenance work through biomechanics such as measurement of low back compression force, forces/torque load, muscular activities using electromyography (EMG), work organization issues and psychological load could yield as yet unknown results.

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