

Ergonomic Evaluation of Work Stations Related With the Operation of Advanced Manufacturing Technology Equipment: Two cases of study

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Abstract: This paper presents two cases of study where ergonomic evaluations were conducted in work stations related with the operation of Advanced Manufacturing Technology (AMT) equipment: Computer Numerical Control (CNC) Milling Machine and (CNC) Lathe. The Marley and Kumar (1996) Body Map format among 10 workers was conducted for pain in discomfort study and Hignett and Mc Atamney (2000) REBA method was used for ergonomic evaluation. Shoulders, middle back, hand and arm pain was identified. The evaluation results indicated a medium risk level for both work stations according to REBA. Recommendations for changes in equipment components and the work station are presented and it is found that models that would help identify and evaluate ergonomic aspects related with AMT equipment are desirable among decision makers, owners and users.

Keywords: Advanced Manufacturing Technology, Ergonomic Evaluation, REBA, Cumulative Trauma Disorders

1. INTRODUCTION

This section presents the problem description, the objectives of this investigation its justification and finally the justification and the scope.

1.1 Problem Description

The work stations studied in this work use AMT equipment, such as the CNC lathe and the milling machine, which allow carry out several machine procedures on metallic or plastic parts achieving designs with high precision meeting specifications provided by engineering.

The companies studied, have no availability of medical data, records of complaints, accidents or injuries concerning these operations; nonetheless, the Marley and Kumar (1996) Body Format was conducted among 10 workers of the manufacturing area. Results are shown in Figure 1.

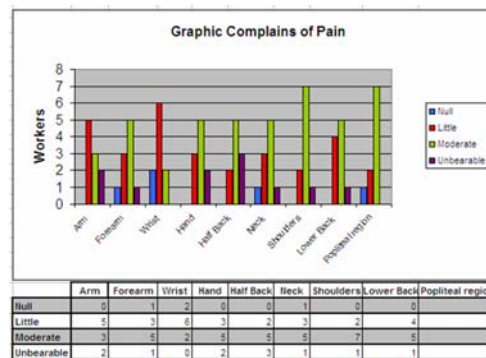


Figure 1. Evidence of Pain and Discomfort

As noted, the manifestation of pain classified as "moderate" is found mostly on the shoulders, lower back and popliteal region, and evidence of pain classified as "unbearable" in the middle of back, hand and arm. Therefore, presence of pain and discomfort among workers is observed when this equipment is operated. It was also observed, stressful body postures and repetitive movements of hands and arms. As a result an ergonomic assessment in these two case studies is proposed.

1.1.1 Objectives

The objectives in this work are divided into four specific and one general goal, which are explained below:

1.1.1.1 General Objective

To apply anthropometric and ergonomic principles and methods in two work stations which operate with AMT equipment: a CNC lathe and a Milling Machine respectively.

1.1.1.2 Specific Objectives

Specific objectives are:

Identify relevant anthropometric dimensions in human-machine interaction that could be related to stressful postures.

To conduct an ergonomic assessment by REBA method (Rapid Entire Body Assessment), determining the level of risk present in the operation and the recommended level of action.

To propose ergonomic interventions on work stations aiming to reduce the levels of risk for musculoskeletal disorders and finally recommend actions to continue the proposed study including the application of Ergonomics in this kind of work stations and AMT equipment ergonomic evaluation.

1.1.2 Justification and Scope

The results of this study concerns to AMT equipment such as CNC lathe and Milling Machine, analyzed under particular conditions, however, work stations with similar operational characteristics can be evaluated following the methodology proposed.

2. LITERATURE REVIEW

Work stations that use Advanced Manufacturing Technology suffer of a lack of attention in terms of health and safety, according to Karwowski and Salvendy (1994, 2005). In this way, health and safety aspects of AMT systems have been relegated in equipment evaluation and selection processes, so it has been difficult to determine the magnitude of its potential impact in this field according to Ayres and Miller (1985), Masterson (1987), Zimolong and Duda (1992). This is due to insufficient and / or incomplete information. Also, this is partly attributable to a high percentage of cases with AMT accidents are not recorded and reported, as Nicolaisen (1985), Karwowski et al. (1988) and Karwowski and Salvendi (1994) (2005), Sugimoto and Kawaguchi (1985) inform and therefore, it is difficult to link these events with this type of technology.

Studies related to the topic are scarce. Among them may be mentioned the studies done by Sugimoto (1987) for the Ministry of Labor in Japan on health and safety robots. Chan and Courtney (2001), present assessments of work stations with hybrid manufacturing systems where robots and humans interact, and in which ergonomics and safety aspects have been neglected, Vieira and Kumar (2007) inform about work related low back disorders among CNC workers and welders, McEwan (1998) Yu et. al. (1999), report that injuries related to machinery were the most frequent.

According to all above, also Sugimoto (1987), Helander (1984) and Chan and Courtney (2001) agree there is a general misunderstanding of the nature of automation and the AMT with false beliefs about the safety of it and its components and therefore, modest attention is given to these topics.

3. METHODOLOGY

Materials and methods are described in this section, in the first instance refer the characteristics of the equipment used and then describe the methodology applied to the study.

A (SONY Digital Handycam) video camera was used to record and take photos to the worker to identify stressful body postures during the operation; also we used a measurement tape and a computer to run REBA commercial software.

3.1 Registration of the operation on videotape

A video camera was used to observe and record the operation in both work stations analyzing the images and then assess the angles required by the software REBA more

objectively. Similarly, video recording helped us to assess the frequency and duration of worker's body postures. Front, sagittal and superior views were taken.

3.2 Description of the Operation

The operation of the lathe initiates when the operator walk to grasps a metallic plate, then he attaches it to the machine, and fastens it with tools and clamps involving considerable effort. Longitudinal and transverse movements begin to make the turning. Both hands in this action are always on the levers and the operator is simultaneously watching the visual display or the work piece, this requires high levels of control and coordination. (See Figure 2)

The operation with the milling machine starts when the operator twists his trunk to grasp the material in the work table located behind him, and then he places the material at the base of the machine and set the work piece using clamps, then uses several manual levers to shape the piece. Each lever is used for specific machining purposes such as perform a deep cut in a straight line or semicircular cuts among others. (See Figure 3)

3.3 Description of Work Stations

In relation with the lathe work station, due to the tool room, work table, and material are located far from the lathe, the operator needs walking around the workstation preventing in some way sustained static work load, but increasing energy expenditure. The vertical and horizontal reaches are in the normal range zone and remain within the midline of the body. However, the main visual displays are located out of the normal visual areas for two eyes.

In relation with the milling machine workstation, it has two areas: the machine table and auxiliary work table. Vertical and horizontal reaches are found in the normal range zone of movement but also in the maximum range zone and in some cases out of the maximum reach zone due to the fixed location of control devices and levers, particularly levers that are at the top of the machine.

3.4 Application of the REBA Method

Pictures (Figure 2 and Figure 4) and results of REBA (Figures 3 and Figure 5), for right side of the operator's body are shown below for the most critical operations.

CNC Lathe Work Station:

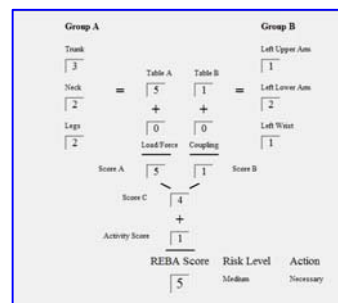


Figure 2. CNC Lathe's Operator Figure 3. Scores for REBA (right side)

CNC Milling Machine Work Station:

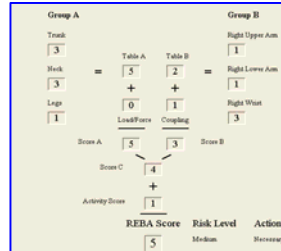


Figure 4. Milling Machine’s Operator

Figure 5. Scores for REBA (right side)

4. RESULTS

This section presents the results obtained in this evaluation.

4.1 REBA Results

As shown in the score sheets (Figure 3 and Figure 5), the risk level is medium for both activities and ergonomic intervention may be necessary.

Referring to the milling machine workstation, the right wrist is the most affected with a score of 3 because it has to be rotated in order to operate the right lever, producing also mechanical stress.

About the lathe workstation (Figure 3), REBA’s results shows that the most affected body parts are the trunk with a score of 3, and legs with a score of 2 since the operation needs to be monitored constantly so that the operator’s trunk must be bend to observe the part he is working with.

5. CONCLUSIONS AND RECOMMENDATIONS

This section concludes about the results obtained, and contrast the goals outlined in this work.

An ergonomic analysis was performed in which those relevant anthropometric dimensions involved in man-machine interaction were identified. Furthermore, the REBA method was effective determining the risk and action levels for these operations. Recommended ergonomic interventions for these workstations are listed below:

About the Milling Machine Workstation:

1. The most appropriate location for human operator in this case would be found in front of the machine. To achieve this, it is recommended that the main right lever dimension could have an adjustable length or an extension device, in this way the operator does not need to stand aside for its manipulation twisting and bending his trunk.

2. Rearrange work station lay-out. Actual physical distribution of work station implies trunk twisting and bending also lifting and walking activities are executed. In this way

rearrange the distribution of physical elements of the work is highly suggested aiming to diminish stressful postures and static work load.

About CNC Lathe Work Station:

An adjustable height and position of the visual display would be effective to reduce neck and trunk twisting and bending.

In these cases a cushion floor mat would be suitable for the operator in order to reduce foot fatigue; also a chair for a sit-stand posture would be helpful.

Bring to a close, the application of ergonomic principles would help to increase machine performance and productivity, but mostly help human operator to be comfortable and secure. Since at present time the vast majority of the companies acquired Advanced Manufacturing Technology in order to be competitive, ergonomic and safety aspects must be considered one of the most effective ways to accomplish this competitiveness and decision makers' owners and users need models that helps identify ergonomic aspects in AMT work stations.

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