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Research Article

Industrial Work Station design: An Ergonomic Approach to Number Punching Machine

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Abstract

This paper aims to investigate Ergonomic aspect of machine design and design of a work station to kill the root cause of the problem. The use of ergonomic principles in automobile assembly and manufacturing operations has become an important part of a comprehensive health and safety process as well as an integral part of the engineering systems. Most of the automobile companies have developed an ergonomics process to manage issues related to injury and illness and to ensure the appropriate use of human resources on the plant shop floor. The ergonomics programme uses joint labor and management teams to identify and evaluate jobs and develop and implement solutions. In this paper, through a case study related to Manual number punching machine ergonomic issues, we will study the process thoroughly then identify the root causes of problems and Ergonomics job analysis sheet and guidelines are presented in a systematic manner. The guidelines provide a conceptual basis for a good workstation design. In a real world design situation, the recommendations from ergonomic job analysis or guidelines are used as a basis for the design of workstations in engine component machining and engine assembly area. The procedure for determining the workstation dimensions and layout has been explained. A case problem (Barrel Injector number punching machine) is discussed to illustrate the workstation design procedure with the application of engineering anthropometry.

Keywords: *workstation design, ergonomics guidelines, engineering anthropometry*.

1. Introduction

Ergonomics can be defined as a discipline in its own right, as the theoretical and fundamental understanding of human behavior and performance in purposeful interacting socio-technical systems, and the application of that understanding to design of an industrial workstation.

In industrial workstation design the primary concern has usually been the improvement of the performance of the equipment alone. Little consideration is given towards matching the abilities of the operator with the task requirements. Consequently, many industrial workstations are poorly designed, resulting in lost worker productivity and unnecessary injury at the workplace. An ergonomics approach to the design of an industrial workstation attempts to achieve an appropriate balance between the worker capabilities and work requirements to optimize worker productivity and the total system, as well as provide worker physical and mental well-being, job satisfaction and safety. Over the years many theories, principles, methods and data relevant to the workstation design have been generated through ergonomics research.These guidelines emphasize the requirement of healthy operator posture and they are directed towards improvement of the operator's physiological efficiency. Many painful afflictions, of musculoskeletal system, known as cumulative trauma disorders (CTD), are associated with the working posture. These are caused and aggravated sometimes by the repeated forceful exertions connected with awkward work postures.

An obstacle in the implementation of the ergonomic recommendations in a real world design situation is the human variability in size and capability. It is a challenge to the designers to come up with solutions which will optimally fit the diverse anthropometry of the users and satisfy their task demands. The objective of this investigation is to provide a systematic ergonomics approach to the design of an industrial workstation.

Several methods, such as direct observation, one-to-one interviews with experienced operators, videotaping and questionnaires are used for this purpose. Through appropriate job analysis the effects of the existing equipment or system design on employee comfort, health and ease of use can be determined.

Generally both for a modification of an existing industrial workstation and design of a new industrial workstation, the designer is constrained by the financial and technological factors, such as extent of modification,

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available space, environment, individual equipment size and their frequencies of use, task sequence and targeted population. The ergonomic guidelines and principles are meant to provide an orientation towards the physiological needs of the operator. Initially, decisions regarding the task sequence, available space, equipment are formalized.

2. Experimental Methodology

Problem solving process for ergonomics related issues –

1- Obtain relevant information on the task performance, equipment, working posture and environment through direct observation, video recording and input from experienced personnel.
2- Since the operation is manual with huge lever operating forces applied repeatedly i.e. 400 times a day, the operator is undergoing various stressful areas such as Working with the arms above the shoulder level (it can lead to the compression and entrapment of nerve in the shoulder. It also causes fatigue to the muscles of the shoulder and arm. While operating lever - Stressful posture arm, shoulder, neck wrist, back & elbow.
3- Many painful afflictions, of musculoskeletal system, known as cumulative trauma disorders (CTD), are associated with the working posture are involved. Hence automation with electro-pneumatics is thought off.
4- Identify the appropriate user population and obtain the relevant anthropometric measurements or use the available statistical data from anthropometric surveys
5- Determine the range of work height based on the type of work to be performed. Provide an adjustable chair and a foot rest for a seated operator and an adjustable work surface or platform for a standing operator.
6- Locate control or handle in the most advantageous position, e.g. two hand safety switches to operate the machine so that safety of hands is ensured.
7- Locate the switches within the normal line of sight
8- Consider the material and information flow requirements from other functional units or employees
9- Make a scaled layout drawing of the proposed workstation to check the placement of individual components
10- Develop a mock-up of the design and conduct trials with live subjects to ascertain operator-workstation fit. Obtain feedback from the interest groups.
11- Construct a workstation based on the feedback of trials conducted.
12- Get it manufactured and installed.
13- Trials on final design to improve it further if needed
14- Closure of the project if trials are satisfactory else aim for future scope and improvements actions and recommendations.

A Case Problem Definition

The systematic ergonomics approach to designing an industrial workstation described above was applied to the design of a Barrel Injector (Fig.1) number punching machine workstation.

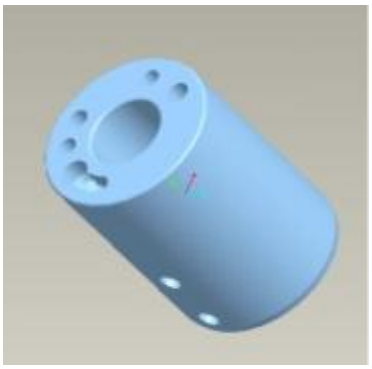

Fig.1 Barrel Injector

The injectors provide a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Principles of operation are same for all engines, but injector size and internal design differs slightly.

Currently 400 parts are punched in a day. This operation is done manually by simply pressing the lever but the working posture is un-ergonomic and causes stresses in the fingers, elbow, neck, shoulder, upper back, and lower back area. (Fig.1)

The working posture and work methods were recorded through direct observation video recording and/or input from experienced personnel (*Table I).*

Fig.2 Manual punching operation – stresses in whole body

The Ergonomic Job analysis worksheet is used to organize and record the data collected during analysis.

1. Describe the job – This consists of identifying information about the job and the job inventory. It includes complete list of environment and the workstation sketch and position of employee and the elemental description of job.
2. Identify the risk factors – Risk factors are general characteristics of physical activity which increase the chance of fatigue, over exertions or cumulative trauma.

3. Isolating Causes – This consists of linking observed risk factors to specific features of the work environment or job method.

Table 1 Ergonomic job analysis

ERGONOMIC JOB ANALYSIS WORKSHEET			
Date of Analysis: 04/08/2009	**Job Location:** Number punching machine	**Cycle:** 10 sec	**Page 1 of 1**
Job Title/Description: **Tools:** **Equipment**:Number punching arrengement lever,PPE **Parts**: Barrel Injector **Environmental Conditions:** Noisy			
Element Description	**Risk Factors**	**Causes**	**ible Solutions**
	(by element & body part)	**(by eleme factor)**	**ause & risk r)**
Pick and hold the job from the bin and Rest the job on work support	REP- 4 sec/ job. 500 jobs per shift CON- Contact on fingers and palm of both hands.	Slippage Compone quantity-500 jobs per shift	punching SPM - work support design
Hold the lever	POS---Lever above normal working height. CON -- Contact on fingers and palm of both hands.	Working with the arms above the shoulder level (it can lead to the compression and entrapment of nerve in the shoulder. It also causes fatigue to the muscles of the shoulder and arm.)	Avoid working with arm above the shoulder - change in lever design or low cost automation
Press the lever	FOR--- While operating the lever POS --While operating lever - Stressful posture arm,shoulder, neck wrist,back & elbow CON -- Contact on fingers, wrist and palm of both hands,While operating lever REP -- From the start till the end of punching stroke	Heavy Pushing force required Uncomfortable posture and high jobs quantity	change in lever design or low cost automation
Unload the job	REP- 2 sec cycle time per job. 500 jobs per shift CON- Contact on fingers and palm of both hands.		

Benefits of documentation –

a. To ensure efficient problem resolution
b. To justify ergonomic improvements
c. To facilitate future ergonomic projects.
d. To comply with Cummins policy.
e. To comply with government regulations.

A Case Problem Solution- Injector Number punching machine with low cost automation

1. Preliminary Design modifications were carried out to check the feasibility of application of electro-pneumatics.(Fig.4)
2. Preliminary design trials were successful with further improved SPM design.
3. There were two options thought off. First was to design a new work station or to redesign existing work station with little modification.
4. Design of new work station was not financially and time line wise acceptable and feasible.
5. Hence redesign of existing work station with little modification was thought off, which included low cost automation with integration of Electro-Pneumatics along with ergonomic improvements. .(Fig.4)
6. After Identification of the appropriate user population relevant anthropometric measurements available statistical data from Cummins Inc Ergonomics anthropometric standards was taken into design of table height and Safety push button switches location.(Fig.5)
7. For safe working condition machine guarding principles were used and incorporated into the design.
8. Designed in ProE wildfire 4
9. All Anthropometric dimensions as per Cummins Ergonomic policy standard design
10. Use of zero force push buttons to reduce contact stress on fingers.

Results and Discussion

a. Replacement of human operators in tasks that involve hard physical or monotonous work.
b. Safety
c. Quality improvement

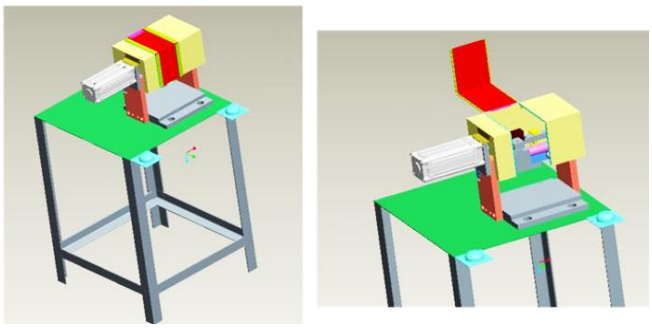

Fig.3 (a) and (b)– 3D model of automated machine with electro pneumatics and machine guarding for safety (Created in Pro Engineer Wildfire 4

Fig.4 Condition before Improvement

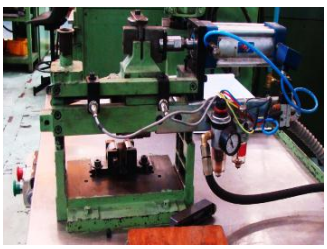

Fig.5 Condition after improvement

Conclusions

1- The manners by which industrial workstation designs or dimensions can be determined systematically are stated.

2- For the intended user population, it is necessary to determine adequate posture, work height, normal and maximum working areas, clearance and visual requirement by using relevant anthropometric data.

3- Provide an adjustable chair and a foot rest for a seated operator, so that stresses due to standing position on legs, lumber area can be avoided.

4- A case problem was described to illustrate the manner by which the proposed methodology could be applied to design various workstations available in assembly and manufacturing area.

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