Ergonomics in Machine shop

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Abstract

Most of the leading manufacturing companies are facing the problem of lower operator efficiency and operators victims of MSDs i.e. Musculoskeletal Disorders. Ergonomics plays an important role in workers' productivity. Workstation layout and work design are two major factors of ergonomics of worker's efficiency. Now, manufacturers found that instead of investing lots of money on man, machine, material, method, improving ergonomics of workplaces is cost saving also leading to remarkable increment in worker performance ultimately enabling greater efficiency. Ergonomics found great need when demand is high and manufacturers need more output within short period. This study was conducted in machine shop of manufacturing of engines. Ergonomic study of this workstation was done by precision preventive measures and improvements. Analyses were done by studying each element of motion by accurate visual inspection. Results from this study reveal that there is need to modify workstation layout according to ergonomic principles. The main objective of ergonomics leads to various quality control concepts being implemented in the manufacturing industry and help in improvement of quality standards by presenting a method with work instructions and a control plan. The calculation of stress and load factor on operator due to poor ergonomics is based on the NIOSH equation. Analysis of MSDs and operator stress level can be calculated. All these results from the analysis are used for the implementation of essential ergonomic measures and regulations leading to performance improvement.

Keywords: *Musculoskeletal Disorders, ergonomics, NIOSH, sustainable.*

1. Ergonomic Studies:-

For improving the productivity in manufacturing industries, efficiency of workers plays an important role. Productivity of workers greatly relies on the ergonomic design of the workstation. Efficient ergonomics in the workstation design reflects better interaction between man-machine systems. Lot of research has been done on analyzing and improving ergonomics of workstation, facility layout and tool design for the sake of increasing productivity. Studies regarding operator performance and comfort in repetitive assembly task have been done in the past. Workstations may function with less efficiency, if anthropometry data mismatches with workstation design. Methodology has been proposed to analyze and classify the assembly workplace layout configuration with respect to both technological and environmental parameters. Effect of workstation design, assembly design and working postures on assembly line shows working postures have significant effect on assembly line. Study of discomfort experienced by operators during process has been studied and analysis of working postures has been done in software to find out awkward postures. Analysis of work stress during process among Indian workers has been carried in manufacturing industries of India.

This study is conducted on a metal part assembly workstation. Objective of this study includes performance evaluation of workers during assembly process. In the primary phase study regarding the workstation layout, process design and product specification had been carried out. Further motion study is done for the ergonomic study by observing the worker. This is analyzed for each motion element of the worker's body posture and movement of other body members relative to each other. Results of motion study revealed various fatigue causing and time consuming factors related to worker and workstation layout.

2. Objective:-

- Study of Ergonomics and its applications in the industry.
- Understanding the basic essentials and code of conduct.
- Understanding the various assembly processes line by line.
- Checking of existing ergonomic studies and probable development of the same.
- Analysis of operator working and procedures at machine shop workplace.
- Improving the operator efficiency to the required quality standards.
- Issue root cause identification and corresponding action plan.

3.Necessity of Ergonomic Studies:-

As previously stated, the exposure to poor ergonomic conditions does not result in fatal injuries. The development of serious disabling injuries, although possible, is not very frequent either. The most usual outcomes of adverse ergonomic characteristics of work are many different types of not so dramatic disorders, frequently referred to as musculoskeletal disorders. They are the most commonly reported work-related illnesses in the working population [1, 2]. One of the few things that they all have in common is that they cause pain, and because of this they significantly affect the worker's ability to perform a work and thus their productivity. Furthermore, the evidence shows that they have a huge impact on work-related absence and a high proportion of days lost all around the world. In summary, ergonomic-related disorders represent a considerable economic burden to employers, employees and to society as a whole [3-5] and therefore should be a major concern for industrial and production engineers.

4. Musculoskeletal Disorders [MSD's]:-

Musculoskeletal disorders (MSDs) at work are a persistent problem in industrial nations costing a lot of money and causing much suffering to workers. MSDs are an unintended output of many work systems due to incorrect working conditions. In 2003 Sweden's total costs for work related sickness and absence were over 110 billion Swedish crowns (SEK) – an increase of almost 50% in just 4 years. The economic costs alone for work related injuries and disorders have been estimated by some European nations at between 2.6% and 3.8% of gross national product with about half of this cost being attributed to MSDs (EASHW, 2000b). In the US over 1 million people annually seek medical treatment for Back and upper limb MSDs and "Conservative estimates of the economic burden imposed, as measured by compensation costs, lost wages, and lost productivity, are between $45 and 54 billion annually" (NRC and Panel on musculoskeletal disorders and the workplace, 2001). Poor ergonomics in manufacturing not only results in direct costs associated with injury treatment and compensation, but also in indirect costs related to factors such as absenteeism, costs of administration, employee turnover and training, poor employee morale, as well as reduced productivity and quality (Alexander and Albin, 1999; Oxenburgh et al., 2004; WSIB, 2001).

Indirect costs could be several times greater than the direct costs and are often not measured by companies (Hagberg et al., 1995), which may lead them to underestimate the depth of the problem. For "…in 1997, the overall economic losses resulting from work-related diseases and injuries were approximately 4% of the world's gross national product." - World Health Organisation 1999 3 Introduction" the afflicted workers the consequences of injury are much more personal and include considerable loss of physical, psychological and economic well being (Pransky et al., 2000; Tarasek and Eakin, 1995). While much research has been done on intervening to reduce MSDs in the workplace (Westgaard and Winkel, 1997) the problem appears to be continuing, arguably, unabated. Work related musculoskeletal disorders (MSDs) are a heterogeneous group of disorders that, by definition, have a work-related cause and can include a wide range of body parts and tissues (Hagberg et al., 1995). MSDs are also difficult to diagnose with precision (Van Tulder et al., 1997).

MSDs form the final outcome of a chain of events over the course of the development of the production system. These disorders can be seen as unintended side effects due to the production system that have negative consequences for both the operator and system performance. This thesis focuses specifically on musculoskeletal disorders which form the single most expensive work related ill health category (WHO, 1999). The solution pathway for MSDs deals with many of the same issues that must be handled when trying to solve other work-related health problems. Thus we use MSDs as a kind of 'model' that might be applied more generally to other problems as well

5. Analysis:-

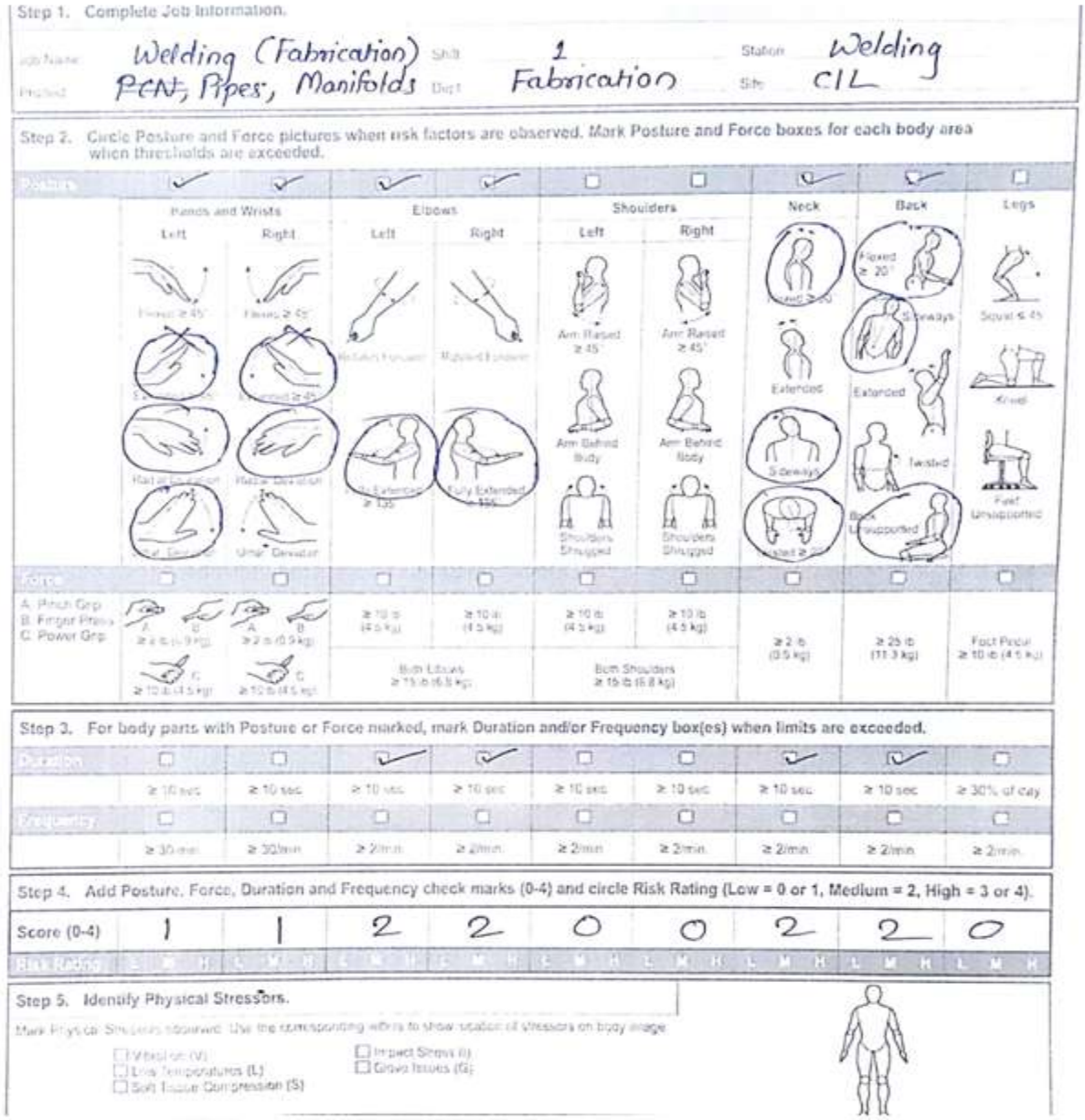

Fig.1 Identification of body stressors

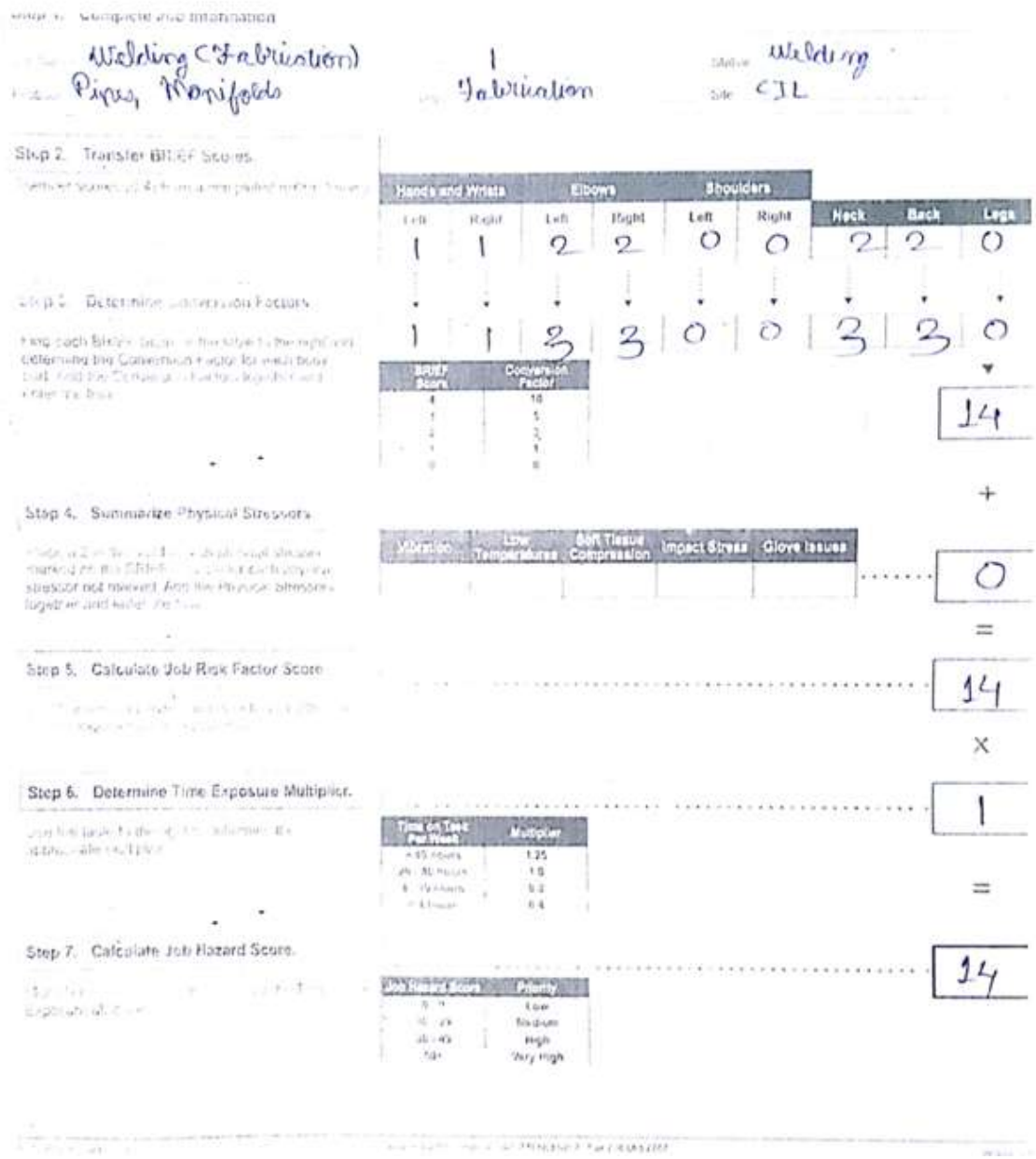

Fig. 2 Resultant Value Calculation

The analysis based on Ergonomic studies was evaluated with the help of BRIEF™ survey sheets developed by HumanTech®. BRIEF™ is *Basic Risk Identification of Ergonomic Factors.* It has systematic arrangement of actions and postures to be inspected visually and taken note of.

NIOSH Equation: *National Institute of Occupational Safety & Health* have developed an equation which can be used for the evaluation of the score which determines the extent of risk with respect to the work which might lead to MSDs.

MSD(*Musculoskeletal Disorder):* Musculoskeletal disorders are the injuries or pain caused in human musculoskeletal system involving the joints, ligaments, muscles, nerves, tendons, and structures that support limbs, neck and back. They occur due to incorrect working condition, repetitive working postures which are inappropriate leading to prolonged injuries and acute pain which might lead to permanent disability. This can in turn decrease the productivity and performance of the worker.

Duration and Frequency: The duration of every action performed at the workstation and frequency i.e. number of repeated cycle of an action per unit time at the workstation which affects the ergonomics score, also the risk factor evaluation.
Physical Stressors: Major aspects which are inherent due to respective working environment can become the reason for the MSDs or Work related problems known as Physical Stressors. Vibration at the workstation, Impact Stress at the during the action, Low Temperature at several workplaces, Glove Issues, and Soft tissue Compression during operations are the several examples of Physical Stressors.
Time Exposure: Time contributed to each task at the machine station in the respective working environment with specific working action can play a vital role in affecting the Risk Factor. It is determined in terms of multiplier factor for the Shifts in industries which determines the role work shifts play in the manipulation of Risk Factors and Performance.
Job Hazard Score: This aspect is the deciding factor for the evaluation of Ergonomic score which identifies the Risk Level and Necessity of Ergonomic Consideration at the respective workstation. It determines the extent with levels i.e. Low, Medium, High and Very High based on the analysis.

Make - Machine Station	Operation	Ergonomic Score (Before)	Ergonomic Score (After)
BU04			
1. YBM 600N	CNC Machine - Tier Tube Lube Pump	13	11
2. Welding Station	Welding – Pipes, Manifolds	16	9
3. Brazing Station	Brazing – Components	15	8
4. Semi Cooling	Semi Cooling – PCN	21	17
5. Flow Test Machine	Flow Test – PCN	20	11
6. Washing Station	*Washing - PCN*	17	14
BU05			
Cell 1			
7. BFW	Facing & Parent Boring Rotary SPM	5	5
8. VENUS NutRunner	Tightening	8	4
9. Baker Gauge	Various Parameter Check	24	18
Cell 2			
10. Deburring Station	Deburring and Oil Hole Polishing	32	27

11. Fiber Laser Marking Machine	V-Mark Laser Marking	20	18
12. WIDMA – Manual O/P	Balance Pad Milling	30	26
Cell 3	Bush Press		
13. VENUS Bush Press	Honing Parameter Check	30	20
14. Baker Gauge	Honing	30	20
15. NAGEL Honing Machine		28	20
Cell 4	Boring		
16. WIDMA Bush Boring	Oiling for Threading	31	16
17. Oiling Station	Milling – Slot	19	12
18. AMS Milling			
Cell 5		25	20
19. VENUS Loosening System	Loosening – Connecting Rod	20	8
20. Washing Station	Washing – Connecting Rod	19	13
TOTAL :	**BU04 & BU05**	**423**	**297**

Scope of Improvement:

1) YBM 600N-

- Precaution paint /sticker at the step hinge holder due to instability. Slipping might occur when stepping over it.

2) Welding-

- Back support needs to be provided for better working posture.
- Distance between operator and station needs to be reduced for better accessibility and controlled operation.
- Height of operator bench needs to be adjusted to an appropriate level to avoid hunching of the back.
- Shielding mask for welding needs to be made hands free. Holding on to it by hand makes it difficult for the operator to work efficiently and could cause complications in the wrist.

3) Brazing-

- Back support needs to be provided for better working posture.
- Separate holders for gloves, glasses and lighter needs to be provided to avoid storage of these in the common components/raw materials rack.
- Trays need to be provided for storage of components before and after the operation for better handling.
- Masks need to be provided to avoid inhalation of fumes which arise during the operation.
- Irritation in the eyes due to improper fitting goggles. Hence fitting needs to be proper to avoid this.

4) Semi-cooling PCN-

- Lock hole extrusion needs to be displaced or removed to avoid injury.
- Sticker or paint needs to be provided for precaution.
- Holders need to be provided for the gun and pipe arrangement.
- Distance between the machine and operator needs to be optimized for better ergonomic posture.

5) Flow Test-

- Holders need to be provided for storage of gloves to avoid misplacement.
- Cover sheet needs to be provided for the motor present under the station to avoid injury to the feet.
- Additional step needs to be provided for increasing the working height of the operator. This will help to minimize the pressure on the shoulders.

6) PCN Washing-

- Holders need to be provided for the gun and pipe arrangement.
- Distance between the machine and operator needs to be optimized for better ergonomic posture.

7) BFW Facing and Parent Boring SPM-

- Additional steps need to be provided for easier access to main control.
- Pressure gauge at the bottom needs to be displaced to avoid injuries.
- Holder needs to be provided for pressurized air cleaner to reduce actions and improve posture.

8) Venus Nutrunner-

- Machine enclosure needs to be displaced towards the inside to avoid leaning by the operator.
- Junction box should be inside the enclosure as it is used frequently to minimize walking time.
- Fixtures bolted to the ground could be removed to allow station displacement.

9) Baker Gauge(various parameter check)-

- Step provided needs a cover to avoid injury to the shin.
- To avoid twist in the lower back the height and length of the step needs to be increased.
- Provision of podium or an additional surface for placing the mouse and keyboard.

10) Deburring & Oil hole polishing-

- Platform needs to be provided for appropriate height needed for working.
- Cover needs to be provided for the steps as they could hurt the shin of the operator.
- Stickers need to be provided to indicate unsafe surfaces or rounding of surfaces could be done to avoid injury.
- Cylindrical holder needs to be provided to avoid keeping the pneumatic cleaner in the working box.
- Height of the holders need to be adjusted for smoother functioning.

11) Laser Marking(V-mark)-

- Sensors placed on top of the conveyer need to be placed inside to avoid injury via collision.

12) Balance pad Milling-

- Steps need to be provided for avoiding neck related disorders.

13) Venus Bush press-

- Additional steps to be provided for avoiding shoulder shrugging.

14) Baker Gauge(Honing parameter check)-

- Additional steps to be provided for avoiding shoulder shrugging.

15) Nagel Honing machine-

- Distance between operator and station to be reduced to avoid strain on forearms and elbows.
- Steps to be provided for easier access to the station while manual working takes place.

16) Widma Bush boring-

- Additional bench needs to be provided as component placement is difficult and reach is less.
- Height adjustment is needed for prevention of elbow and neck disorders.

17) Oiling for Threading-

- Holders need to be provided for appropriate storage of cleaning guns.

- Height of steps need to be increased.

18) AMS Slot Milling-

- Steps needed for easier reach during placement of component into the machine.

19) Loosening Connecting rod-

- Addition of steps for improving elbow and shoulder shrugging issues.

20) Washing Machine-

- Steps are necessary at loading and unloading of components.
- Steps need to be narrow as pathway where the machine lies is small.
- Holders needed for pneumatic cleaner as no spot is present for holding it.
- Stickers needed at ON/OFF button.

General Suggestions for BU04 & BU05:

- Wooden flooring could be provided at places where workers need to stand frequently. This helps in curbing in lower back and leg disorders.
- Stickers /painted surfaces could be provided to highlight unsafe surfaces which might cause injuries if left unchecked.
- Body fitting uniform could be provided to avoid hazards caused due to clothes interfering with machine operations.
- Anti-rust coat for better working conditions at stations which need them(fabrication section).
- Trays in the storage trolleys(moveable by hand) need to be rearranged and placed at an appropriate height to avoid back related injuries.

6. Conclusion:-

Considering the scores being indicators of the progress made, it can be deduced that the scores calculated after the implementation of suggestions could be far less compared to the previous scores. This shows the necessity of ergonomic considerations at the various work places.

7. References:-

[1] “Ergonomic analysis of an assembly workstation to identify time consuming and fatigue causing factors using application of motion study” by Gurunath V. Shinde and V.S. Jadhav
[2] “An Experimental Study on assembly workstation considering ergonomically issues" by Ibrahim H. Garbie
[3] “Ergonomics and Musculoskeletal Disorders” by In-Ju Kim
[4] “The Importance of Ergonomics in Industrial Engineering” by Ana Suárez Sánchez