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Ergonomic Assessment and Low Cost Workstation Design for Hand Drilling and Tapping Operation on Sewing Machine Body Cast

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Abstract—*Work Related Musculoskeletal Disorders (WMSDs) are very common with Industrial workers and operators. Small scale industries cannot afford to invest on costly workstations for their operator's comfort and safety. The paper aims to design a low cost workstation for small scale industries which manufacture sewing machines. Observations were made to compile data, based on posture of operators which after analysis showed a score of 7 for Rapid Upper Limb Assessment (RULA). The analysis also showed a score of 9 for neck, legs and trunk. The operators were facing back, legs and neck related pains on frequent basis. Not only the posture opted by the operators increased the risk of WMSDs in them, but also hampered the quality and quantity of the products produces. The design was made with the help of a 3D modeling tool and an ergonomic posture analysis software. Anthropometric data of 50th percentile was referred for measurements of the manikin created in the software in order to make the design suitable for as many differently size operators as possible. In the new design of workstation, dimensions were optimized based on the ergonomic analysis and anthropometric data. Ergonomic analysis on new design of the workstation showed improvement in posture of the operator with a new improved score of 4 for legs, trunk and neck. The new design of fixtures and table is fabricated using readily available wood which is low in cost and also prevents the body cast from getting scratched. The workstation has potential to increase the productivity and quality of the product as well as reduce the risk of WMSDs in the operators.*

1. INTRODUCTION

In Indian small scale industries the workers or operators are not given much well designed workstation. Many small scale industries that fulfill the need to keep some old fashioned products still in the market face a lot of financial problems while manufacturing the products. These industries cannot afford to provide high class latest tools and workstations to their workers. Result of this low budget manufacturing system is short term or long term injuries to the workers or the operators. Such workers deal with WMSDs and many of them have to face major long term problems which affects their lives. WMSDs arise due to working in wrong postures for long durations of the day. These wrong postures are a result of working with ill designed or no workstations, also using poorly designed tools contribute to the same.

The observations were taken from a small scale industry's workers. This industry outsources body cast of sewing machine and according to the specifications the drilling and tapping is done by the in-house workers using hand tools and no workstations. The postures used by the workers were recorded using a still camera and posture analysis was done. The analysis proved that bad posture has been contributing to the back, legs and neck pains among the workers doing that job. Apart from the injuries to the workers the quality and quantity of the products manufactured were also affected.

2. METHODOLOGY

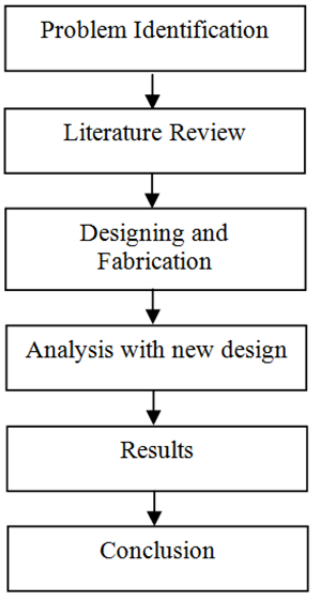

Fig. 1. Flow diagram of adopted methodology

The problem is with the posture adopted by the workers to perform the operations using hand tools. The problem has to be rectified by designing a new workstation which was earlier not available with the workers. The results have been taken out by re-analyzing the posture of the workers with the new workstation.

3. LITERATURE REVIEW

Many researchers have worked towards encouraging better postures of working in order to reduce Work Related Musculoskeletal Disorders (MSDs). Many assessment methods have been used to calculate an ergonomic score which indicates the severity of the risk involved with the body postures. The actions are taken on the basis of score which is calculated on the basis of ergonomic assessment.

Segment	Score Range	Color associated to the score					
		1	2	3	4	5	6
Upper arm	1 to 6						
Forearm	1 to 3						
Wrist	1 to 4						
Wrist twist	1 to 2						
Neck	1 to 6						
Trunk	1 to 6						

Fig. 2. Body Segment-wise range of score and color coding [5]

Biman et al. [3] in his research work has developed and elaborately explained the working and significance of step by step approach towards workstation design. The steps are in the following sequence:

1. Obtain information regarding equipment, posture and environment.
2. To decide which type of population to be considered.
3. According to the type of work, to decide the working height and its range.
4. To identify the most frequently used hand tools.
5. To provide elbow room and clearance at waist level.
6. To keep the display panels in the line of sight.
7. Consider the direction and type of information and material flow.
8. To make a scaled layout in order to propose a new workstation.
9. Run trials on the new workstation (in software or in real)
10. Fabrication and actual implementation of the designed workstation.

Kushwaha et al. [5] has designed a workstation for shipping crane, which has been done by taking a small sample sized questionnaire based survey. The research had multiple objectives, which are to investigate prevalence of MSDs, to analyze body posture, to suggest new design of workstation in order to reduce the risk of MSDs, and to verify the effectiveness of the modifications using RULA test. The researcher has taken 50th percentile of the population so as to benefit maximum population of crane operators. The analysis part is done by RULA assessment on CATIA V5 software.

4. PROBLEM IDENTIFICATION AND OBJECTIVES

A short survey was done among the workers of the company, which showed that there was reporting of back, legs and neck pains among almost all the workers working with hand drilling and tapping operations. Some photographs were taken of a worker performing the operation on two different positions on the sewing machine body cast. These photographs were used as the source of posture angles to be put into the software and analyze the ergonomic score.

Fig. 3. Posture opted by the worker for vertical hole tapping in sewing machine body cast.

In Fig. 3 the posture shows that the worker without a working table is bound to opt for such posture. The worker has to apply a force equivalent of approximately 5kg on to the tap in order to turn it by generating a couple. Also there is no clamp on the floor on which the body cast is kept, so the worker uses his foot to manually clamp the body cast. The posture has been built in the software using a manikin and by manually feeding the angles to it. The manikin available with the software was not according to the Indian anthropometric data so the dimensions have also been fed to the software, as per the following measurements, shown in Table 1.

Table 1. Measurements for the human builder as per Indian Anthropometric data.

Measurement	In millimeters
Stature	1648
Axilla Height	1265.5
Chest Height, standing	1180
Waist Height, omphalion	970
Crotch Height, standing	765
Acromion-radiale length	312
Radiale-stylion length	243

The above mentioned measurements are based on Indian anthropometric data for 50th percentile of the population, so as to make such design of the workstation that fits for almost all the workers.

The manikin which is built as per the desired measurements has been used for the posture analysis and to calculate an ergonomic assessment score of "9" for legs, trunk and neck of the manikin. This score was analyzed on the basis of bent neck, twisted forearms, bent trunk repeated load of 5kg. A score of "9" indicates that the risk of MSD is high onto the worker and an immediate action should be taken in order to improve the assessment score.

The objective is to design a workstation which improves the posture of the worker while performing hand drilling and tapping operations. The design should have proper fixtures to hold the body cast into position as well as prevent it from damaging of the surface finish, as the body cast is pre painted by the vendor company.

5. WORKSTATION DESIGN

The designing of the workstation has been done in order to improve the posture of the workers operating on it. The design should also be cheaper so that a small scale industry can afford it. Some criteria have been made in order to make the design successful.

The criteria are as follows:

- Improve the posture and ergonomic assessment score should be reduced
- Proper fixture for the body cast with clamping device
- Proper jig to guide the tool and reduce human effort
- Low cost which a small scale industry can also afford

Fig. 4 shows significant dimensions of the workstation which are taken on the basis of Indian anthropometric data. The workstation height is taken as per the height of Indian male of 50th percentile of the population, in such a way that the hand tool is grabbed by the worker without straining arms, neck, trunk and legs. As per the body cast, fixture and tool dimensions the work table height is taken as 765mm. The width of the workstation is as per the demand of two fixtures (for vertical and horizontal drilling) which is taken as 700mm.

The material which has been used to fabricate the workstation is low cost wood, which can absorb the shocks due to machining operations. Inside the fixtures a lining of rubber sheet has been given in order to prevent the surface finish of the prefinished body cast.

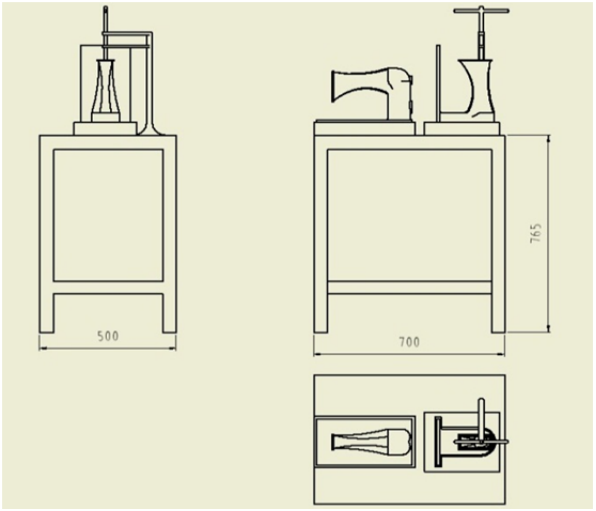

Fig. 4. Significant dimensions of the workstation.

6. RESULTS

The new design of workstation which has been fabricated is implemented and also the 3D model designed in the software is analyzed with the same manikin onto which the earlier analysis was done without the workstation. The Fig. 5 shows the manikin and the new workstation in software environment.

Fig. 5. Manikin and workstation in software environment.

The new analysis report gave ergonomic assessment score as "4" for the posture of worker with the workstation. This score is based upon no neck bending, no trunk bending and no legs bending. The arms working across the mid line and repeated load of 5kg is applied by the worker on to the hand tool. The new assessment score showed improvement in the posture and thus reducing the risk of injury in workers. The comparison of scores is shown in the Table 2 below.

Table 2: Comparisons of ergonomic assessment scores.

Body segment	Without workstation		With workstation	
	Posture A	Posture B	Posture A	Posture B
Neck	2	9	1	4
Trunk	5	9	1	4
Legs	1	9	1	4

7. CONCLUSION

The results show a significant improvement in the assessment score of the posture. The new design of the workstation with its ability to hold the tool and guide it along with the fixture which assists to hold and clamp the body cast can prove to be very successful in reducing the risk of MSDs in the workers operating on these workstations. The low cost of it will be able to increase the usability of it low budget manufacturing firms.

This design of workstation is simple and low in cost, along with which it will increase the quality of products manufactured as it increases the precision. If the workers are comfortable in performing the operations and have lesser pain and fatigue in their body, the quantity of the products manufactured per unit time will also increase. All such factors contribute to the profit and wellbeing of the industry, which should be an equipment of interest for the industry administrators.

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