Study of Milling Machines Using RULA

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ABSTRACT

In laboratories and workshops, milling machine is one of the most important common machines to use. Students and lab assistants of Jadavpur University spend a great deal of time working on milling machine. The design of a machine is proved to be successful only when it is ergonomic. Thus the analysis on the correct posture of work becomes important. Undergraduate students of Production engineering and Lab assistants were subjected to Rapid Upper Limb Assessment(RULA) while working on milling machine to test if the design of the machine is ergonomic or not. The assessment concludes that posture while working on milling machine is not ergonomic. Thus the necessity to make it ergonomic increases. A few remedies have been suggested here after a detailed study of the work. Application of these remedies will reduce the risk of working on a milling machine in a workstation to a certain extent.

Key words: RULA, Milling Machine, Students, Lab Assistants, Posture

INTRODUCTION

Lab Assistants and students of Production Engineering Department, Jadavpur University, spend a significant amount of time working on the motor-driven and manually operated milling machine in the department's Manufacturing Laboratory. In Milling Machine forming operations are done. Learning to adapt to the correct working posture is equally important to learning to operate the machine in a workshop or laboratory. A correct working posture and knowledge thereof can prevent potential injuries amongst the students and enable them to identify causes of the same, when they start working in the industry. A scientific evaluation of the postures adopted by a pool of students should also determine if the current setup of the laboratory needs up gradation.

A sample of students and Lab Assistants of Production Engineering Department, Jadavpur University, working on the milling machine was studied with RULA (Rapid Upper Limb Assessment). This ergonomic tool evaluates the loads sustained by the musculo-skeletal system due to postures, force exerted and muscle use which are responsible for work-related upper limb disorders. In this evaluation, a risk score is obtained which lies between one and seven. [1] Higher scores signify greater levels of apparent risk. A low RULA score does not necessarily guarantee that the work place is free of ergonomic hazards, and a high score does not assure that a severe problem exists. It was developed to detect work postures or risk factors that deserve further attention.

METHODS

SUBJECTS

Subjects were 7 males and 1 female lab assistants & undergraduate students of the second year of Production Engineering Department who have experience of working on the Milling Machine. A history of discomfort, if any, experienced while working on the Milling Machine previously was obtained through the questionnaire.

Experiment

All subjects were asked to perform a milling operation on a standard milling machine (Fig. 1). The milling conditions were kept constant for all subjects. Feed was given manually .The positions of the right hand, neck, trunk and legs were analyzed in this study.

Operation of Milling Machine

Milling is a cutting operation that removes metal by feeding the work against a rotating cutter having a single or multiple edges.

Working Principle: The work piece is held on the worktable of the machine. The table movement controls the feed of work piece against the rotating cutter. The cutter is mounted on a spindle or arbor and revolves at high speed. Except for rotation, the cutter has no other motion. As the work piece advances, the cutter teeth remove the metal from the surface of work piece and desired shape is produced.

Horizontal Milling Machine Construction: The main parts of the machine are Base, Column, Knee, Saddle, Table, Overarm, Arbor Support and Elevating Screw. (Refer to Fig 1).

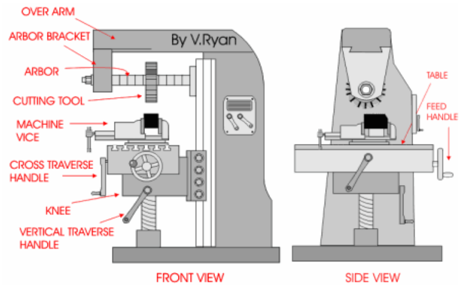

Fig 1: Front and side view of a standard milling machine

Analysis of the Problem (Refer to Fig 2)

In milling machine the problem arose while moving the table vertically by rotating the vertical transverse handle. At that time the person has to bend his trunk more than 60 degree (for a short heighted person) and within 20-60degree (for a tall person) which adds 3 and 4 points respectively to the trunk score. Even the trunk has to be bend or twist or both. In case of just bending or just twisting, the total score is 5 and in case of both the total trunk score adds up to 6.

Next in that stressed position, to keep an eye on the job, the neck generally has to be in extension which directly adds 4 to the neck score .And if the neck is bended or twisted or both then the neck score might range up to 6.Depending on the position of the legs, the trunk posture score ranges between 7 and 9 referring from the table B. Now this action is repeated more than 4 times per minute, that adds 1 to the score B. Again, more or less, 4kg intermittent load is there. Even that adds 1 to the score B. So total score B is 7+.So the grand score from Table C comes to be 7.

So as per the RULA method a score of 7 indicates immediate investigations and changes.

Fig 2: Vertical feed given by rotating the vertical transverse handle

RESULT

The age, anthropometric data and scores C (upper limb) and D (neck, trunk, legs) along with the grand score of the 6 subjects is shown in Table 2.

GRAND SCORES

The grand scores are obtained by adding posture scores to the muscle use and force scores. The mean grand score of the subjects was 6.09. Minimum score found was 3 and maximum was 7. 66.67% of subjects yielded a maximum score of 7. 9.52% of subjects were found to yield a grand score of 6. 4.76% of subjects were found to yield a grand score of 5. 4.76% of subjects were found to yield grand score 4. 14.28% of subjects yielded grand score 3. Grand scores 5, 4 and 3 were obtained while rotating the feed handle. Grand scores 6 and 7 were obtained while rotating the vertical transverse handle and cross transverse handle.

SCORE C

Upper limb score C had a mean value of 5.48. 19.05% of the subjects were found to obtain score C of 7. 42.86% of subjects obtained score C of 6. 14.28% of students obtained a score C of 5. 14.28% of subjects obtained score C of 4. 9.52% of subjects yielded score C of 3.

SCORE D

Neck, trunk and leg score D had a mean value of 5.9+. 52.38% of subjects obtained a score of 7+. 9.52 % of the subjects obtained a score of 7. 4.76% of subjects obtained a score of 6. 14.28% of subjects obtained a score of 5. 4.76% of subjects obtained a score of 4. 9.52% of subjects obtained a score of 3. 4.76% of subjects obtained a score of 2. Scores of 2,3,4,5 were obtained while rotating the feed handle. Scores 6, 7, and 7+ were obtained while rotating the vertical transverse handle and cross transverse handle.

Table 1: Anthropometric data and scores c and d with grand score of RULA

S. No.	Age	Height (cm)	Score C	Score D	GRAND SCORE
1	20	154.6	6	7+	7
2	20	154.6	3	3	3
3	54	163	4	4	4
4	45	176	7	6	7
5	54	163	6	7+	7
6	43	162	7	7+	7
7	47	167	6	7+	7
8	20	155	6	7+	7
9	41	164	6	7+	7
10	45	176	4	5	5
11	20	154.6	6	7+	7
12	47	167	4	2	3
13	45	176	6	5	6
14	20	154.6	5	7	7
15	43	162	3	3	3
16	41	164	6	7+	7
17	43	162	5	7+	7
18	20	155	7	7	7
19	41	164	7	7+	7
20	47	167	5	7+	7
21	20	154.6	6	5	6

DISCUSSION

A population of 8 subjects (7 male and 1 female), who performed the milling operation on the milling machine was studied with RULA.

In this study, the minimum score obtained was 3 and the maximum score was 7 and the average grand score was 6.09. The high scores indicate that the postures adopted by the lab assistants should be subjected to prompt investigation and rapid change in design of the machine. The mean upper limb score was 5.48. Almost 50% of subjects work across the midline of the body which causes the arm to stretch. This stretching of arms mostly occurs during rotating the cross transverse handle and vertical transverse handle. The wrist is found in the neutral position in a very few subjects. Ideally, the wrist should be in a neutral position if the operator stands at a sufficient distance away from the machine. The mean neck, trunk and leg score

(Score D) was 5.9+. The operator has to look at the job while working and most of the subjects twist their neck and/or trunk to the left and bend their trunks. Mostly all the subjects stand with their weight unevenly balanced with more weight on right leg than the left.
By using RULA we can conclude that the posture adopted should be subjected to investigation as soon as possible and the suggested remedies should be put forward in the new design as the subjects might be adapting the incorrect work method. The milling machines in the laboratory are used by large number of students of varying height and body built.

SUGGESTED REMEDIES: This problem may be overcome by 2 methods:

<u>RAISING THE HEIGHT OF THE VERTICAL TRANSVERSE HANDLE</u> (Refer to Fig 3)

The vertical transverse handle may be raised to the elbow level of a standard Indian man. Average elbow height of Indian male is 103.8cm and that of an Indian female is 95.6cm. The height of the vertical transverse handle pivot is 62cm of the subjected milling machine in the laboratory and the height of the table is 110cm. The rise in height of the vertical transverse handle is suggested. But, the height of the table is suggested to be kept the same or if possible a little bit lowered so that it suffices the purpose of keeping the feed handle height to be at the elbow level as the feed by the feed handle is equally important. The feed handle along with the table is 110cm high from the ground. A slight rise might me allowed as this machine can be given automatic feed as well, where the need for manual feed is omitted. The vertical transverse handle, which cannot be automatically controlled, should be raised to an approximate height of 95.6-103.8 cm. The machine is not proving to be ergonomic as this vertical transverse handle that has to be controlled manually is at a very low and inconvenient height compared to the average elbow height of an Indian giving rise to high posture scores. So raising the height of this handle might prove to be helpful.

Fig 3: Side and front view of standard milling machine showing the required dimensions

Manual control has the following disadvantages:-

AUTOMIZATION OF ALL THE PROCESSES :

a. Human intervention required.
b. Probability of errors increase.
c. Chances of damage of products increase
d. Human labour is costly

Automation and mechanization has the following advantages:

a. Human intervention is somewhat reduced to nil.
b. Easy operation and one time investment.
c. High precision and accuracy. Errors are reduced to minimum.
d. Damage of products is reduced to a minimum.

So, considering the advantages of automation and mechanization, as well the disadvantages of manual control, the former is suggested as a remedy. As no or a minimum human intervention is required in this case, posture problems of human are ruled out.

By this method we might be able to somewhat reduce the high trunk posture score.

STATEMENT OF RELEVANCE

In industries, workshops, laboratories, working on milling machine are one of the most important activities. While providing cross and vertical feed and depth of cut, the trunk is in an extremely stressed condition. So it becomes important to make a detailed analysis of the problem and suggest some remedial measures to prevent the workers and students from health problems.

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