Ergonomic optimisation of machining operations of power transmission shaft

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Abstract: Workstation efficiency and operator satisfaction are two main factors which influence the overall productivity of a production unit. Considering ergonomic factors while designing a workstation will help to develop a better environment for working and will help to avoid unsafe working conditions. This paper describes a study conducted in a machining station to find out the various factors which may result in serious health issues to the operator and reduction of productivity. According to the study various modifications are made by considering ergonomic factors and results show that efficiency and operator satisfaction have been improved after implementing the recommendations.

1. Introduction
1.1 Ergonomics
This is an interdisciplinary scientific approach of applying human physiological, psychological and biomechanical limitations, capabilities and characteristics to the design of human-machine interfaces and workstations. Workstations and operators are the key factors in a manufacturing unit. Design of the workstations will directly influence the productivity of the operators. It is therefore critical that they are designed to be as ergonomic, flexible and efficient as possible. Design of a workstation should suit a number of persons, and it is to be designed according to the anthropometric data of the region. It is a known fact that the ergonomically ideal layout of workstations and workplaces not only stimulates the efficient manufacture of the product, but also has direct benefits with respect to reducing the psychological demands placed on employees.

2. Literature Review
The paper gives detailed description about the influence of ergonomics in the productivity, health and safety of the workers and work satisfaction. It details the importance of considering anthropometric data while designing the workstation. The work station designed by considering the ergonomic factors will reduce the chance of various musculoskeletal disorders. Various Cumulative Trauma Disorders like Tendon disorders, Neurovascular disorders, and Nerve entrapment disorders are also detailed in this paper [1].

The second paper titled “Fundamentals of ergonomics in theory and practice” presents the historical background and a clear definition of the term ergonomics. It details about the context of ergonomics and modern view of ergonomics as a science. Ergonomics consist of various factors which are networked together to represent the interacting system, which shows the overall view of ergonomic system. As a conclusion it describes the various challenges in implementing ergonomic practices [2].

The third paper referred titled “An ergonomics study on assembly line workstation design” describes an ergonomic study conducted in an automotive component manufacturing unit. Twenty workers were taken as participants of the study, anthropometric data and dimensions of the workstation were taken and checked whether it was suitable for a comfortable working condition [3].
The fourth paper titled “Scientific approaches for the industrial workstations ergonomic design: a review” presents a modern and scientific methods used for ergonomic workstation designs. Now a days computer modelling softwares are widely used for workstation designs. Virtual model of the plant layout is made to check the various ergonomic factors and also it is very helpful for the close observation of the work condition and dimensions [4].

The fifth paper titled “Evaluation of work posture by RULA and REBA: A case study” describes a research study conducted at a small scale industry to check the possible occurrence of various musculoskeletal disorders (MSD). RULA (Rapid Upper Limb Assessment) is a survey method developed for use in ergonomics investigations of workplaces where work related upper limb disorders are reported and REBA (Rapid Entire Body Assessment) is a postural analysis tool sensitive to musculoskeletal risks in a variety of tasks [5].

The sixth paper referred title “RULA: a survey method for the investigation of work-related upper limb disorders” describes the development and application of RULA method for ergonomic analysis. It provides a detailed description about the step by step application of this method and how the corresponding values are given. According to the final value obtained we can find out that whether process will result in any MSDs [6].

3. Methodology
3.1 Research goal
Two main objectives of this research are: a. to study and ergonomically optimise the secondary machining operations of power transmission shaft, b. study the work practices and check whether any modifications are required to the workstation.

3.2 Sample and data collection
This study was focussed on the workers from an automotive spare parts production company, who operate CNC machines. The people working in the first shift are considered for study. There are both male and female operators in the study group. The main data were obtained through personal interviews and direct observation. Each person was personally interviewed to understand the level of satisfaction in their jobs and also to find out the tasks which were felt difficult for them.

Operator motion study was conducted initially, to check for any inefficient motion or work practices. By repeated observation, incorrect work practices or inefficient workstation conditions were determined. For the selected operations RULA method was used. Those operations which reported ‘investigate and implement change’ was analysed further and proper modifications were made to avoid MSDs.

3.3 Rapid upper limb assessment (RULA)
RULA is a survey method developed for ergonomic investigation of workplaces where work related upper limb disorders are reported. This method gives a quick assessment of postures of body parts, muscle function and other external loads experienced by the body. This method is simple and efficient to use and does not need any special equipment. A standard coding system is used to represent the level of influence of current postures in the operator health and according to the final result corresponding suggestion are mentioned.

RULA method is applied in three steps, the body segments to be evaluated are divided into two and these are evaluated separately and according scores are calculated. In the last step these two values are combined together to get the final value. In the first stage upper arm, lower arm and wrist are monitored and score is provided for the level of wrist twist by considering the amount of load carried and frequency of work. In the second stage posture score for the neck trunk and legs are calculated and recorded. In the third stage these two scores from stage one and two are combined together to form the grand score.
Grand score shows the level of action required for the particular work. If the grand score is 1 or 2 it indicates that the posture is acceptable, if score is 3 or 4 it shows that further investigation is required and changes may be required, if the score is 5 or 6 investigations and changes are required soon and if the score is 7 or greater investigation and immediate changes are required [6].

4. Motion study
A detailed ‘motion study’ was conducted and five distinct activities were identified:

They are:

i. **Raw material collection**
The first activity is collection of raw materials for part machining. These may be forgings or semi-finished items from previous machines.

ii. **Loading and unloading**
Part is loaded for subsequent operations, and unloaded once the operation is completed.

iii. **Visual inspection and measurement**
Inspection is carried out after placing the part on a fixture.

iv. **Oiling and protective covering**
Rust oil is applied to finished parts and some parts are provided with a protective covering.

v. **Transferring of parts**
Parts ready for shipment are transferred to the conveyor on pallet.

According to the detailed analysis of the motion study 4 major issues were identified for modification.

i. **Height of inspection table**
Height was found to be less, resulting in an uncomfortable body posture, to take readings. The angle of vision was more than 70°, whereas ergonomic standards stipulate an angle within ±30°.

![Figure 1. Table and height gauge.](image1)

![Figure 2. Height measuring.](image2)

ii. **Manual transfer of parts**
The parts are stacked inside cartons, which weigh 18kg, 30kg, and 41kg.

iii. **Manual chip removal**
Production time is lost due to shut down for manual chip removal. Also, the body posture and effort required were found to be against ergonomic considerations.

iv. **Oiling of finished parts**
The method was found to be unhygienic and inefficient.

In order to check the impact of these issues on the health and safety of the operators RULA study was conducted for these issues. According to the survey it was found out that position of height gauge was inadequate. This issue scores 7 in RULA assessment and it implies that investigation and corresponding implementation is required. For manual burr removal and material handling also the RULA score was 7.
5. Discussions
The study shows that the operators lack in knowledge of ergonomics and manual material handling. Each problems was separately considered and analysed. According to the study, proper modification were made. Firstly the height gauge positioning is considered and a design modification is executed for the table. Anthropometric data of the current location is taken and according to that values the position of the height gauge is changed by providing a special stand for the current table and the height gage is placed on that.

![Figure 3. Modified table.](image1)

Due to this modification visual angle is corrected and a convenient space is obtained to place the various snap gauges and plug gauges.

![Figure 4. Height checking.](image2)

Regarding chip removal, it was estimated that this activity reduced plant efficiency as much as 30%. RULA score for removal process also shows that this work practice will result in serious health issues. Establishment of conveyor system is recommended.

RULA score for manual material handling also shows that it is injurious to the health of the operators and there is severe chance for the occurrence of back pain and leg pain. As a result the number of absenteeism will be increased and operator morale will be reduced. It was recommended that a trolley should be provided for material handling purpose.

A proper oiling mechanism has been designed and established so that oil will never get soaked in the cotton gloves. It is designed in such a way that the parts are horizontally placed and the part will be fully immersed in oil.

![Figure 5. Modified oiling mechanism](image3)
This mechanism works like a ‘siso’ and a counter weight mechanism is provided for ensuring the part is fully immersed in the oil. When a new part is placed for oiling the previous part which is in the oil will automatically come up and the new part will go down.

6. Conclusion
Evaluation of ergonomic factors in a workstation shows that they give only a moderate consideration to the ergonomic factors. It is observed that even a simple modification can make a lot of improvement in the system. Ergonomic improvements can result in overall improvement in efficiency and employee morale in a production plant.

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