# Design of Workplace in Assembly Unit Using Ergonomic Principles


**V. Manivelmuralidaran, M. Balaji, and V. Arun**

## 1 Introduction

Ergonomics is commonly used to decrease occupational injuries by finding the tasks and postures that creates continuous musculoskeletal stresses. K. H. F. Morrel at 1949 coined the concept of ergonomics, who derived it from Greek word 'ergo' which means work and 'nomos' which means law. According to International Ergonomics Association (IEA), the term ergonomics is concerned with the understanding of human interactions and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance [1].

Productivity improvement by worker is one of the important objectives of industries, particularly involved in assembly workstations. Assembly workstations are characterized by repetitive works. These works in these workstations are considered to be fatigue and tiresome. This in turn tends to reduce the worker productivity and larger rate of absenteeism [2]. Manufacturers of varying industries found that along with investing huge amount of money on man, machine, material and methods, incorporating ergonomics principles in design of workplace is cost saving [3, 4].

This study is conducted on assembly and collection workstation which has suffering from high cycle time. Fixed workstation involves three set of sub-assemblies, collection of fasteners and a final main assembly for the completion of single process. The objective of this research article is to avoid the long reaches and in providing the adjustable workstation with individual seating which will enable to work in sitting or standing position, thereby the time taken for operation is also reduced.

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## 2 Literature Review

Workplace with good design reduces injuries and make the workers to work effectively and efficiently to manufacture the good quality products [5]. Workstation with efficient design is essential to for mass production and flexibility in an effective way, thus allows the organization to increase their quality level and production indicators [6]. Improper planning in the design of workstation makes the workers to accommodate into working conditions that were not designed for them [7]. Handling heavy loads, repetitiveness of work, awkward and static postures are the factors that allows the assembly line workers to risks of musculoskeletal disorders [8]. Researchers pointed out that working at shop floor is a complex task with high level of responsibility, working for a prolonged period of time results in higher risk of musculoskeletal disorders [9]. Thus, the poor performance is given by the workers suffered from the high risk because of inappropriate match between the workstation and the anthropometry. During the time of assembly works and repetitive manual handling tasks, workers are susceptible to the risk of injuries. A workplace should be designed by incorporating ergonomic principles will yield high productivity and worker efficiency [10].

Ergonomics is traditionally used to decline the number of occupational injuries by finding the tasks and postures that develops the musculoskeletal stresses, and thus, good ergonomic design is used to enhance the organization productivity [11, 12]. One of the basic principles of ergonomics, fit the machine to the man or else fit the man to the machine [13]. Success for major industries depends on how quickly the products are delivered to the customers. The industries must implement new technologies and concepts to achieve success [14].

Optimizing the safety, health and comfort of the human in the working system is the main aim of the ergonomics; thus, it is necessary to implement safety and health policy to protect the workers [15, 16]. Fixed workstations of the assembly line have restrictions on anthropometric dimensions of the operators who are involved in assembly operations. Further, it affects the stress on musculoskeletal system of the operators [17]. The normal time required to do a specific task by a qualified and well-trained person is determined by the method of time study [18, 19].

The innovation in taking up this work is to incorporate the ergonomic principles in workplace design, and this modification has not been attempted in the organization. Hence, the design changes of the workplace has been suggested, and it is evident that the modification brings increase in production of the products that has been presented.

# 3 Methodology

## *3.1 Objectives*

The objectives of the present research study are to design workplace with ergonomic consideration. This is needed to improvise the working performance of the workers to increase the production. The second objective of taking up this research is to reduce the operator fatigue. There are number of workers facing occupational health problems due to prolonged working in the standing position. It is essential to redesign the workstation to reduce the occupational health problems. The third objective is to ensure a good workflow which facilitates the improvement in production.

By incorporating the ergonomic principles in workstation design, this objective can be achieved, and it is evident from the literature [20, 21]. This project initiated with the study on existing workstation with five workers, by identifying the major problems faced by the workers during their normal working time. The problems were analyzed, and then a better solution is implemented. Decision analysis process starts with the study on current process and identify the major problems. Then, the analysis of the problem will be done to find the better solution, and the data collected for the process. Layout design will be done, and it will be validated and implemented. The implemented solution reduces the fatigue problems faced by the workers, and the result shows the improvement in productivity.

# 4 Existing Workstation

An assembly and collection workstation which are used to assemble fasteners was selected for the study. Through the measurements of the existing workstation, it was decided that the workstation was not designed by considering the ergonomic principles, and hence, the workers were not using the proper working posture during the time of work.

The task was performed in standing position for about 9 h abandoning the lunch and break time. Due to this reason itself, some of the workers cannot expose their effort properly after completing their half day work. The assembly table height was fixed as 3.37 ft with the inadequate table surface area (5.25 $\times$ 3.12 ft). The footrest was not designed to provide a proper support to the workers, it looked like an attached bar along the front bottom of the table. The collection table height was fixed as 3.1 ft with the surface of (7 $\times$ 2.1 ft). The shoulder stress and back pain are caused when the worker is working under such conditions for a prolonged period of time [21, 22].

The bins (B25) containing fasteners were located at the farther right end corner and superimposed by (2 $\times$ 3 ft) in straight line on the assembly table. A pneumatic press of 21 kg is located at the front right end of the assembly table and the screw driver is hinged at a distance of 1.7 ft from the front of the assembly table with locating the fixture straight to it on the table. Thus, the workers will have to move

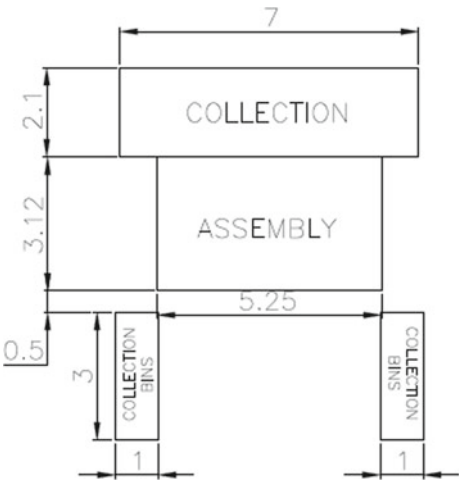


**Fig. 1** Layout of the existing workstation

their arm by providing some force to pick the fasteners during the time of assembly and some operators took certain volume of fasteners and kept it within their easy reach, which are to be used in next operation. So, it stands as a little disturbance to the worker during their arm motions.

Here, the limit to hold the screw driver by the worker was exceeded. Figure 1 shows the layout of the existing workstation, the collection of fasteners was done on the bins (B15) located at the left and right of the assembly table, and it was transferred to the collection table for the next stage of inspection. All the dimensions mentioned in this article are given in ft. Since, it has been measured from the workstations and recorded.

## 5 Design and Development of Multiple New Workstation

The redesigned workstation was proposed by taking into account of the ergonomic factors while designing. It is proposed to develop the new workstation that could be used by an individual irrespective of their height and working in the desired posture. For designing the new workstation, anthropometric data of five workers were taken to identify the range of movements which is essential to have worker comfort. Table 1 gives the anthropometric data of the workers. Anthropometric data of workers such as standing height (SH), vertical grip reach (VGR), forward grip reach (FGR), foot length (FL) and sitting height (SH) are collected. In order to do the work without any kind of unnecessary movements and fatigue, the fully adjustable ergonomically designed chair and working table were suggested.

By taking into account of the ergonomic principles and the anthropometric data of the workers, new advanced tables were designed with adjustable vertical movement

**Table 1** Anthropometry data of workers

| | Worker 1 | Worker 2 | Worker 3 | Worker 4 | Worker 5 |
|---|---|---|---|---|---|
| SH | 5.53 | 5.39 | 5.27 | 5.59 | 5.25 |
| VGR | 6.73 | 6.57 | 6.28 | 6.84 | 6.19 |
| FGR | 2.42 | 2.38 | 2.34 | 2.45 | 2.31 |
| FL | 0.77 | 0.75 | 0.73 | 0.8 | 0.72 |
| SH | 2.87 | 2.66 | 2.59 | 2.92 | 2.56 |

**Table 2** Dimensions of storage bins

| Storage bins | Length (ft) | Breadth (ft) | Height (ft) |
|---|---|---|---|
| B15 | 0.66 | 0.46 | 0.33 |
| B25 | 0.75 | 0.5 | 0.416 |
| B45 | 1.1 | 0.68 | 0.65 |

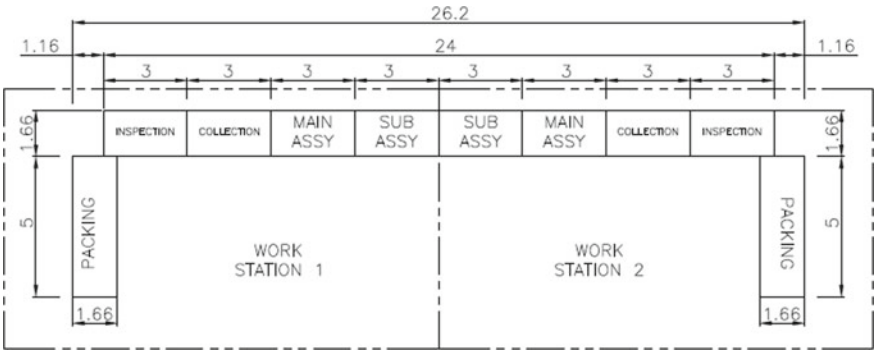


**Fig. 2** Layout of the new workstation

[23–25]. The total gap between the vertical heights of each bins was maintained at 0.15ft. Table 2 gives the dimensions of the individual storage bins.

Finally two packing tables were designed with breadth and height of the previous table with varying length of 5-ft. A lamp with 750 lx was used in the individual worktable at distance of 4.10-ft from workplace [26, 27]. Figure 2 shows the layout of new workstation designed with considering ergonomic principles.

## 6 Results and Discussions

A test was conducted on both the workstations to estimate the new workstations in terms of productivity. The assembly of mounting kit consists of four assembly work and three non-assembly work (collection, inspection and packing) and the assembly

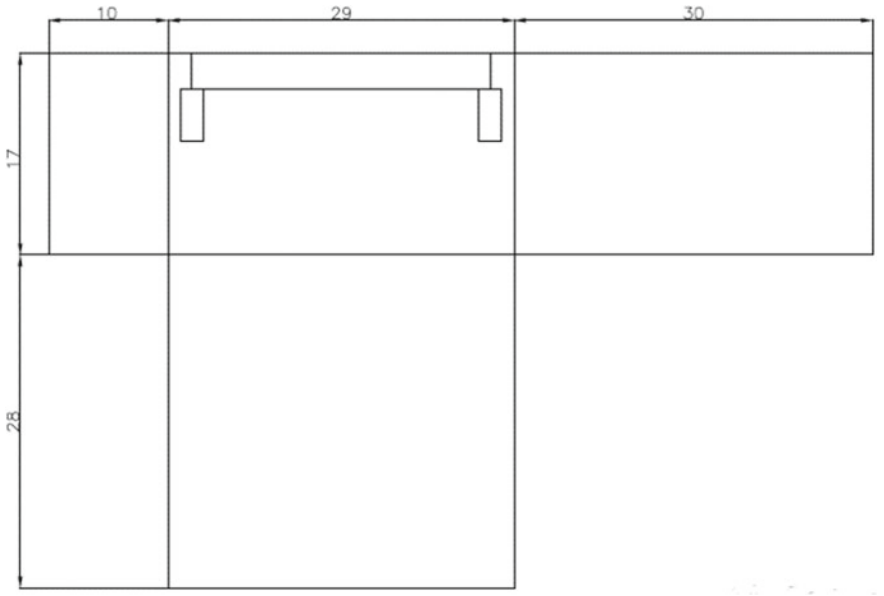


**Fig. 3** Layout of assembly unit after implementing the ergonomic principles

performed on the workstations that are not designed by taking into consideration of ergonomic principles. Also, the workflow in the existing workstation was not followed properly. Workers completed the assembly work in certain periodic time, and the remaining non assembly work in an individual time. The experiment was conducted in two ways: (1) assembling mounting kits on the existing workstation method and (2) assembling the mounting kits on the new workstation that incorporated ergonomic principles. The output of these two scenarios are compared and suggested to the organization. The layout of assembly unit after implementing the new workstation with extended area is shown in Fig. 3.

The time study for each and every work classified by the elements is noted for both the existing and new workstation. The comparison of time study shows that the new workstation was higher in comparison to the mean time of the existing workstation. The number of products produced per day by single new workstation increases to 117, compared with the existing workstation with output quantity around 99. This increase is achieved through the reduction of time in collection of fasteners of about 75 to 50 s by modifying the workstation Thus, by incorporating the flexibility and ergonomic principles with proper work flow provides higher worker performance [9–11]. The workplace has been designed in such a way that it suits the workmanship which increases the number of products that is evident from the results. Major changes incorporated in the new workstation were: (1) appropriate table surface area with the height adjustments, (2) fully ergonomically designed chair with suitable back rest and height adjustment, (3) locating the bins in the assembly and collection table using bin rails. Since the workstation was fully adjustable, a flexible posture in the

task performance is possible by the workers. Hence, the workers can easily adjust the new workstation depending upon their level of use. The ergonomics and the proper work flow incorporated to the workstation made the worker comfortable, less fatiguing and more efficient [21–23]. The results obtained in this research work are in consistent with the earlier research which improves the productivity by incorporating the ergonomic principles [25].

## 7 Conclusion

A new workstation was developed, and it is fully adjustable by the workers for comfort and could be used in sitting and standing posture. Hence, the job rotation is also easily achieved by adjusting the worktable height depending on the workers' comfort. So, the new workstation designed ergonomically had a positive effect on increasing the worker efficiency. The collection of fasteners of about 75 s was reduced to 50 s by modifying the workstation. The output product of the multiple new workstation is around 234, while the existing workstation had output of 99 products per day. Thus, the efficiency result proposes that the new workstation was comfortable to the workers. In other words, justification was done on a good workstation with consideration of ergonomic principles could ensure workers' health and safety and also improves the productivity. Future scope of this research work includes implementation of indication light system to each bins, and bar code is used in place of bill of materials during collection. By the scanning of bar code, the corresponding bins will illuminate which enables the operator to pick the fasteners from bins quickly.

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