

Improvement of productivity through improved design of workstation and fixture

– A case study of a manufacturing company

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Abstract - Industrial workbenches are designed to hold up to 750kg. They are made to withstand all the heavy duty tools and machines that are used on daily basis. With maximum load capacity we will be able to complete daily manufacturing tasks safely and with zero-safety risks. Plant layout is the most effective physical arrangement, either existing or in the plans of industrial facilities i.e. arrangement of machines, processing equipment and service departments to achieve greatest co-ordination and efficiency of 4 M's in a plant. In machining fixtures, minimizing work piece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. Fixtures are required in various industries according to their application. Fixtures reduce operation time and increases productivity and high quality of operation is possible.

Continuous improvement is the backbone of any company. In the present study, improvement work was carried on to standardize the rotation base workbench, lateral guide fixture, and introducing pokayoke devices wherever necessary.

By observing the assembly operations, some changes in design were suggested for workbench, new designs for fixtures for which there were no fixtures, introduction of pokayoke devices to avoid mistakes and the outcome of those designs after implementation were also studied. It is observed that rate of production increased from 4 tables/quarter to 6 tables/quarter which improved the labour productivity as well as revenue for the organization. The fixture reduced the overall cycle time by 5 minutes to assemble one motor.

Index Terms—Workbench, fixtures, pokayoke, productivity, cycle time

I. INTRODUCTION

Ergonomics deals with the study of people and their working environment. It involves the design of work to fit the worker to make him comfortable at work. This will improve the productivity of employees. It also helps to reduce the body pain faced by employees during work as observed by Kelly DeRango [1]. Workbenches play a very vital role in making the job comfortable for operators. Workbenches help in making the assembly of a product. A workstation which comply by the principles of ergonomics will make the worker comfortable at work. Fixtures on workbenches reduce the burden of making the assembly of a product. Fixture is fixed to a workbench to hold the work as well as guiding the tool. Fixtures are used to reduce the nonproductive time in a mass production system. A fixture is designed by following the principle of 3-2-1 and using CAD tools for modelling and FEA tools for analysis of various loading conditions. Fixtures help in maintaining the alignment of work pieces to get the required operation done.

A poka-yoke is a unique mechanism used as integral part of the lean manufacturing process. It helps an operator avoid (yokeru) mistakes (poka). Its purpose is to eliminate possible product defects by drawing human attention to errors as they occur. The concept was normalized, and the term coined, by Shigeo Shingo as part of the Toyota Production System. In the earlier time it was used as baka -yoke, which means “idiot proofing”. The name was later changed to the poka –yoke which means mistake proofing.

Shailesh S.Pachbhai and Laukik P.Raut [2] observe that high quality of operation is possible.in with the help of fixtures and also reduce operation time and increase productivity. Using fixtures in workstations reduce the problem of production scheduling explain Bruno et.al. [3]. Introduction of pokayoke to a rotary cage fixture will help to make continuous changes in product design and also to arrest the defect as observed by L.B.Raut and V.S.Jakukore [4]. Single Minute Exchange Dies (SMED) a unique form of fixtures, is used extensively in lean manufacturing and enables to reduce the setup time by nearly 55%, Shashikant Shinde et.al [5].

Thus a proper fixture when used effectively can reduce the cycle time. A pokayoke device can help avoid mistakes which may peep in during assembly. These devices will certainly help in improving the utilization of workstations thereby reducing the human effort and improving their performance.

II. LITERATURE REVIEW

Many studies have been conducted to investigate the benefits of fixtures. Lots of research have been taken place and still are going on to study the importance of better workstations. Companies do lots of research and develop better work stations to enable smooth and easy work to employees. Few such studies have been highlighted below.

According to W.Wiyaratn, A.Watanapa and P.Kajondecha [6], the systematic plant layout was studied and the problem in terms of material flow of each operation section was identified. With the SLP method, alternative plant layout significantly decreased the distance of material flow.

Charles Chikwendu okpala, Ezeanyim Okechukwu C [7] identified numerous advantages that are associated with the use of jigs and fixtures in manufacturing that includes: Production increase, cost reduction, interchangeability, and high accuracy of parts, reduction of accident as safety is improved.

According to Shailesh S. Pachbhai, Laukik P.Raut [8], in machine Fixtures, Machine work piece deformation due to clamping and cutting forces is essential to maintain the machining accuracy.

Abraham Zhang [9] identified that Toyota production system has extensive use of poka-yoke devices. It is also an essential process component of Motorola six sigma strategy. This paper advances the poka-yoke theory by formalising information system design as a new way of design for poka-yoke through multiple case studies.

According to Mr Gurunath V. Shindhe, Prof. V.S.Jadhav [10], workstation layout and work design are two major factors of ergonomics of worker's efficiency. Manufacturers found that instead of investing lots of money on Man, Machine, Method, improving ergonomics of workplaces is more beneficial.

According to Harri Laihonen [11], measurement of knowledge, work productivity and identification of key pre-requisites and restrictions should be taken into account while measuring the impacts of organizational change.

Above studies have highlighted the following points:

- Ergonomics is the main factor that one needs to look upon in workstation design.
- Instead of investing lots of money on man, machine and method, improving ergonomics of workplace is cost saving. It is important to reduce musculoskeletal disorder and prevent injuries to operator.
- Layout designing using Systematic Layout Planning significantly decreases distance of material and work flow travel and also resulted in increasing productivity of unit.
- To reduce the machine work piece deformation due to clamping and cutting forces, fixtures are very much essential to safely hold the work piece and to maintain machining accuracy.

Hence, we can conclude that the implementation of simple techniques like Poka-yoke, better ergonomics, fixtures at a very low cost will yield long lasting benefits both for employees and organization.

III. PROFILE OF THE COMPANY AND OBJECTIVES OF THE STUDY

The study has been carried out in an American based company. It manufactures various products related to energy, oil and gas, healthcare, and automobile and has its manufacturing units spread across the world. The present study is carried out at Bengaluru unit which houses nearly 1500 employees.

The assembly line where the study was carried out was facing the problems associated problems faced by workers due to poor ergonomics designs of workbenches, non-existence of necessary fixtures. They had to engage in heavy tools without proper fixtures. Due to this workers got fatigued within few hours of the work and their productivity was questionable. Hence, it was decided to study the arrangement and make the necessary changes to improve the working conditions for workers.

The entire project was undertaken to improve the productivity and provide better ergonomics. Following prime objectives were set during the study:

1. Improving the Ergonomics of the Workbench.

Ergonomics is the main factor that one needs to look upon in workstation design. Instead of investing lots of money on man, machine and method, improving ergonomics of workplace is cost saving. It is important to reduce musculoskeletal disorder and prevent injuries to operator.

2. Designing of Fixtures

To reduce the machine work piece deformation due to clamping and cutting forces, fixtures are very much essential. They safely hold the work piece and maintain machining accuracy. Fixtures also reduce the cost of production, increase the production rate, ensure high accuracy of parts produced, provide for interchangeability, ensure heavy and complicated shaped parts be machined easily, reduce quality control expenses, partially automates the machine tool and provide safety at the work point. By using them, we can arrange work properly and increased versatility of the machine tool.

3. Introducing pokayoke

Pokayoke provided with fixtures will reduce the possibility of errors.

4. To study its implementation.

Implement above plans to ensure that objectives are met in providing comfort to employees and improving their productivity.

IV. DESIGN, IMPLEMENTATION AND OBSERVATION

a. Design of rotation base workbench

In order to meet the objectives and achieve expected results, each part has been designed suitably. As in figure 1, the workbench consisted of Base fixture, Rotation brake fixture, longitudinal and lateral drive fixtures. The tools were placed in the drawers below the table and there was no space to locate shims (part of an assembly). Assembly of longitudinal drive and longitudinal break were made in the same station, the base part, which was got from the stores in the kitting trolley weighed around 200kgs caused ergonomical issues to the operator as it required more than one operator to lift the base part. After the completion of assembly, jib crane was used to lift the assembled part to the next station, resulting in high cycle time.



Fig. 1 Earlier design of workbench

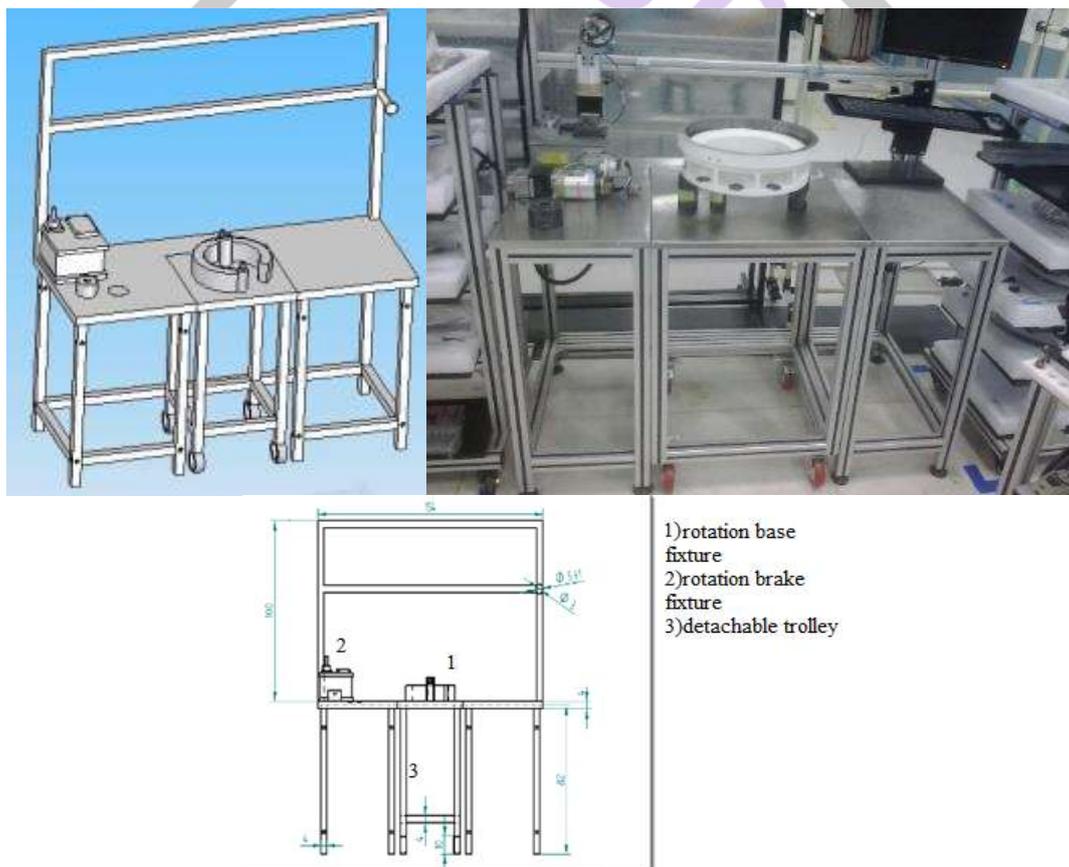


Fig. 2 Modified design of the workbench after implementation

The modified workbench is as shown in figure 2. It consists of workbench made from Cast steel consists of only Rotation base(1) and brake fixtures(2) which is the main workstation and it has a detachable trolley(3) on which the Rotation base fixture is fixed but the Rotation brake fixture is fixed on the table itself. A separate tool trolley is made for the ease of operators and the draws have been eliminated as they caused ergonomical problems for the operator. The trolley is sent to the stores where the base part is directly placed on trolley and the trolley is directly fitted in to the workbench. The calculations are as shown below;

Previously, time required to assemble one table = **103 hours**

Time required to assemble one table after implementation of modified workbench = 70 hours.

Time available for each operator per quarter = **455 hours**.

Hence, tables assembled per quarter = $455/103 = 4.41 \approx 4$ **tables**

Presently, after implementing modified workbench, cycle time reduces to 70 hours

Hence, number of tables assembled per quarter = $455/70 = 6.5 \approx 6$ **tables**

The modified workbench is observed produce the following benefits after implementation:

- Reduction in cycle time from 103 hours per table to 70 hours
- Ease of operation.
- Elimination of jib crane.
- Better material flow.
- Increase in annual production rate from 16 tables to 24 tables.

b. Lateral guide fixture

In a production line ergonomics is one major factor that has to be taken care of. Lateral guide fixtures are used to hold and guide parts used for assembling parts to a motor. Previously, during the assembly of motor using lateral guide fixture in the workstation lots of risk factors were observed for the operator. As indicated in figure 3, the top plate of lateral guide assembly was kept on a wooden block for the minor assembly, which was ergonomically not comfortable for the operator i.e. there was a chance of top plate falling in case the wooden block slipped. Since the wooden blocks were not fixed, it used to slip and cause accidental risks. This increased the cycle time as the operator assembled with lots of care and could not concentrate on assembly.

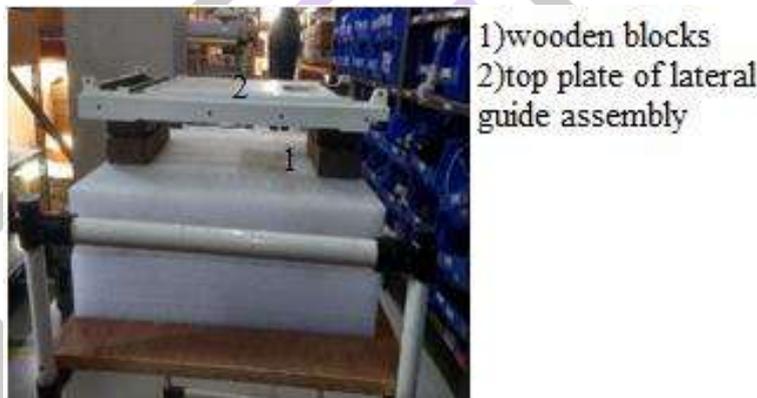


Fig.3 Earlier fixture using wooden blocks

This problem was overcome by changing the design of the fixture and making pokayoke a part of the fixture itself as shown in figure 4. A modified fixture was built, made up of delrin blocks which also acted as a poka-yoke. According to observations and operator’s suggestion, a movable trolley, holding fixture has been designed and it is movable because the part has to be placed on bottom table at the station.

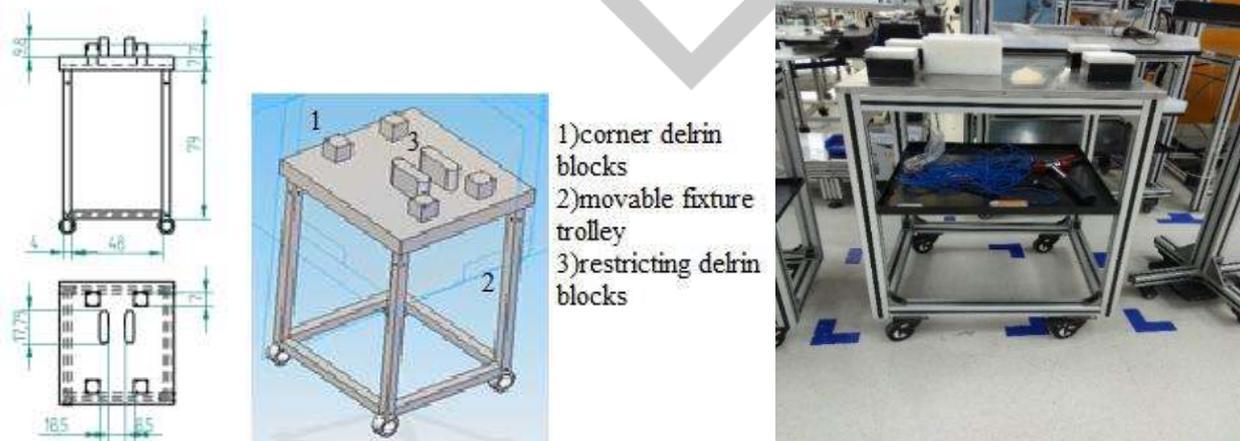


Fig. 4 Specification of proposed lateral guide fixture

In the new design a fixture has been designed where the delrin blocks are fixed on to the trolley. The plate has slots and it can be fitted in only one way on the delrin blocks on the table which will restrict the placement of plate in any other way due to the two

blocks in the center making it a poka-yoke. After implementing the new lateral guide fixture, the cycle time has been reduced from 15 minutes to 10 minutes per assembly of motor

The modified design helped to reduce ergonomic deficiencies. It even reduced the human risk and made it more easy to use for the operator. Further, quantitatively it reduced the cycle time from 15 mins to 12 mins per assembly of motor.

V. CONCLUSIONS

Ergonomics is based upon the concept of designing items to match the individuals who use them. Some of the key benefits obtained from introducing ergonomics in a working environment improved employee productivity and performance, quality of work, and also created a better culture of health and safety. In addition to these benefits, it has also prevented injuries due to sudden exertion. Proper office ergonomics can also help to prevent other types of common Musculoskeletal Disorders.

As per observations carried out for 3 months after implementation of workbench and fixtures, the productivity of the vascular tables was increased. Previously an operator used to manufacture **4 tables/quarter** and now after implementation of workbench and fixtures an operator is able to produce **6 tables/quarter** (one quarter=3 months). Approximate increase in the revenue is estimated as 240000 USD per year.

Rotation base station which used to consume more time to lift the base part was reduced by incorporating trolley which is detachable from the table. This produced the intangible benefit for the worker, who could work with lesser efforts than before.

Lateral guide fixture was helpful to the operator who used wooden blocks to place the part on it and assemble it. Using the fixture helped the operator to work more conveniently as well as reduce the cycle time by nearly 5 minutes. Since, these fixtures were attached with poka-yoke which makes it a mistake proof for the operators, chances of assembling in a wrong way also got eliminated. Now the operator can comfortably work on the station.

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