Applications of work study techniques for improving productivity at assembly workstation of valve manufacturing industry

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Abstract. The work is carried to determine total cycle time to manufacture one gate valve assembly in valve manufacturing industry. Improvement in productivity can be achieved through more efficient use of capital investments, human resource, technological innovation and developments. The goal was to improve the productivity through more efficient use of capital and human resource. Plant layout is the arrangement of machines on shop floor. This arrangement of machines will have impact on total cycle time to produce finished product. The present study explains about the productivity improvement in the plant layout of Micon valve manufacturing industries which is one of the reputed industries in Dharwad, India. Data was collected about existing plant layout and about chain of flow of product, man or machine with help of flow process chart. This flow process chart was used to establish layout from the point of improving layout and to identify/decide the locations of different workstations. The results obtained from this research work indicated that in proposed method there was reduction in total cycle time of 73 minutes and the total distance travelled by 130 meters, which lead to increase in productivity at the assembly line of valve manufacturing industry.

Keywords: Productivity; work-study; cycle time; plant layout; flow process chart

1. Introduction
Productivity improvement can be attained through different ways: that is, through more effective use of human resources, through technological innovations and developments, and finally through capital investments. Productivity of human resources mainly deals with motivation theory. Motivation theory defines the desire to satisfy certain needs which motivate people to work in a dedicated manner. Greater the need greater will be dedication. Productivity of resources deals with all types of resources must be used in effective manner and avoidance of waste at every level of production. Productivity through technological innovation and developments basically deals with work study techniques. Work study is defined as a complete set of techniques through which work can be simplified, standardized and measured. Work study may require almost no or least capital investment. Productivity can be raised to a reasonable extend with use of work study. Productivity improvement through capital investment is basically a change in technology. Change in technology will happen when it is unable to satisfy the requirements of market in terms of quality, quantity and that technology is not economically viable, this change requires lot of capital expenditure and time expenditure. Raghunath G. Kulkarni et al. aimed at the study was to maximize production rate through detailed analysis of existing plant layout to meet the increasing customer demand. Simulation study is carried out during several orientation visits to the plant and getting familiar with the system components. Among existing simulation software’s such as Arena 10.0, Promodel, Process model etc, Arena 10.0 was used to run real time simulation and construct the system model [1]. RavikumarKamble and VinayakKulkarnipaper explains the study about productivity improvement at assembly work station using work study[2]. Hadiusing the concept of shortest route, they built model for the established single model assembly line balancing problem[3]. M Duran T. etal, in many situations the worker or machine will develop quickly because of continuous repetition of like activities. As a result, manufacturing lead time of the product shortens [4]. Khalid, S. and Saleh have studied the manufacturing process of the automobile industry, during the study the bottleneck process was
identified with operation process chart and analysis was done with help of simulation software called Arena and they have obtained the solution to increase manufacturing capacity [5].

Savsar, et al. paper describes the result of a simulation model developed to examine just-in-time production systems [6]. Shuang, L., Wang, X. and Lixin have researched about optimization of Assembly Line with help of Work Study techniques and improved the bottleneck process in a lamp assembly line. [7]. Malashree P, et al. have discussed on experimental Study on Productivity Improvement using the concept of Ergonomics and work study. The study was carried out in metal section industry to achieve cycle time minimization, changing the sequence of operations and reducing the workers fatigue. Using Work pro software analysis of data was performed and developed the proposed method [8].

In order to improve the productivity in Micon valve manufacturing industries, initially plant visit was made, and discussions made with proprietor and observations made during the visit, the ineffective time related with the manufacturing and assembly plant layout was found to be more. The existing methods involved in gate valve body manufacturing and assembly workstation were studied and finding improved methods using work study techniques to decrease lead time and get better productivity. The aim of study was to maximize productivity through minimizing bottlenecks identified at various stages of the existing layout. Flow process chart was drawn through several orientation visits to the plant and getting familiar with the different work elements. Flow process chart was drawn for both existing and proposed system. With the work study, results of both existing as well as proposed method were compared which results in reduction in total cycle time to manufacture and assemble one gate assembly.

2. Methodology

To accomplish the objective of the research, method study concept was utilized and is basically concerned with scaling down of the work content of job or operation. Selection of work to be studied and document the relevant facts about existing method, next study the documented facts critically and in ordered sequence and the next step is to develop the most cost-effective, realistic and efficient method. Finally state new method and set in place as standard and sustain the standard practice by typical checks.

![Steps in work study](image)

**Figure 1. Steps in work study**

2.2 Plant layout

Plant layout study is defined as engineering study, which basically aims to analyze various physical configurations of the manufacturing unit. The manufacturing process of gate valve manufacturing at Micon industry Dharwad has 7 sections in the plant. It is the process layout where in similar machines are placed at a place with similar operations. The flow of materials is concurrent. Using the concept of method study the flow process chart was drawn for existing layout and proposed layout. The plant under the study consists of 7 workstations and is as follows: lathe, drilling, boring, welding, storage,
assembly, and quality check. The part to be manufactured will move from lathe workstation to drilling section then to the boring workstation followed by welding workstation and finally to storage. Each part at the plant is sent through quality check.

3. Work study experimentation

   Analysis of plant layout

Existing plant layout

In existing study of plant layout the sequence of operations followed are: lathe-drilling-boring-welding-storage-assembly-quality check. Data collection includes the distance travelled and time required for each operation. The flow process charts collect and classify the complete information necessary for the analysis and improvement of plant operations as a whole or phase wise. This sequence of operations were followed to manufacture and assemble one gate valve assembly, the total cycle time taken was 7.5 hours. The distance travelled by component in existing plant layout was 400 meters. The fig 2 explains about existing layout of valve manufacturing.

Proposed plant layout

In proposed study of plant layout the sequence of operations followed are: lathe-boring-welding-drilling-storage-assembly-quality check. Data collection includes the distance travelled and time required for each operation. The flow process charts collect and classify the complete information necessary for the analysis and improvement of plant operations as a whole or phase wise. As outcome of analysis, operations may be eliminated, combined or rearranged. Workstations, storage space area, and inspections may be relocated to decrease the travel distance and thereby save the labour time. This sequence of operations were followed to manufacture and assemble one gate valve assembly, the total cycle time taken was 6.28 hours. The movement of component in existing plant layout was 270 meters.

![Figure 2. Existing plant layout](image-url)
**Figure 3.** Flow process chart of Present method

| Step # | Activity description | Time [min.] | Distance [meters] | Value Category |
|--------|---------------------|-------------|-------------------|----------------|
| 1      | Turning operation   | 120         |                   | VA             |
| 2      | Inspection          | 3           |                   | NVA            |
| 3      | Movement            | 20          | 100               | NVA            |
| 4      | Jigs and fixtures   | 10          |                   | VA             |
| 5      | Drilling operation  | 100         |                   | VA             |
| 6      | Movement            | 10          | 30                | NVA            |
| 7      | Boring operation    | 10          |                   | VA             |
| 8      | Movement            | 5           | 20                | NVA            |
| 9      | Welding operation   | 10          |                   | VA             |
| 10     | Movement            | 10          | 30                | NVA            |
| 11     | Storage             | 10          |                   | NVA            |
| 12     | Movement            | 25          | 160               | NVA            |
| 13     | Bonet assembly      | 10          |                   | VA             |
| 14     | Hand wheel attachment| 10         |                   | VA             |
| 15     | Gasket attachment   | 10          |                   | VA             |
| 16     | Gate valve assembly | 10          |                   | VA             |
| 17     | Testing             | 20          |                   | VA             |
| 18     | Movement            | 10          | 40                | NVA            |
| 19     | Storage             | 3           |                   | VA             |

**Table:**

| Count | Time per process step |
|-------|-----------------------|
|       | 10                    |
|       | 6                     |
|       | 1                     |
|       | 2                     |

**Results:**

- Total Ute: 11
- Total Wait Time: 325 mins
- Distance traveled: 400m
- Lead Time: 11.5 mins
- Overall Time: 11.5 mins

**Diagram:**

- Lathe machines
- Boring machines
- Drilling machines
- Assembly
- Storage
- Quality check

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Figure 4 Flow process chart of Proposed method

Table 1. Summary of flow process chart (Present and proposed)

| Work elements       | Present method | Proposed method |
|---------------------|----------------|-----------------|
| Operations          | 10             | 10              |
| Inspections         | 3              | 0               |
| Transportation      | 6              | 5               |
| Delays              | -              | -               |
| Storage             | 2              | 1               |
| Value added time    | 325            | 333             |
| Non Value added time| 125            | 44              |
| Distance travelled  | 400            | 270             |

3.1.1 Comparison of existing method and proposed method

The main goal of study was to minimize the total cycle time and total distance travelled. In the present method the total cycle time taken was 7.5 hours and total distance travelled was 400 meters. In the proposed method, the total cycle time taken was reduced to 6.28 hours and total distance travelled was reduced to 270 meters. The main reason for this improvement in reduction in total cycle time and total distance travelled was the number reductions in inspections, transportations and storages. The value and non-value added activities were recognized and respective times were also noted down. The reduction non-value added activities and non-value added times will reduce total cycle and finally, improve productivity of valve manufacturing industry. The total cycle time taken in existing plant layout to manufacture one gate valve assembly is 450 minutes and the total cycle time taken in proposed plant layout to manufacture one gate valve assembly is 377 minutes. The savings in total cycle time was 73 minutes.
4. Results and discussion
Productivity in existing method, working hours of one operator is 480 minutes/day. The total cycle taken to manufacture one gate valve assembly is 450 minutes. To manufacture one gate valve assembly it requires 6 operators. In a day per shift, 6 operators can manufacture 2 gate valve assemblies. Productivity in proposed method, working hours of one operator is 480 minutes/day. The total cycle taken to manufacture one gate valve assembly is 377 minutes. To manufacture one gate valve assembly it requires 6 operators. In a day per shift, 6 operators can manufacture 3 gate valve assemblies. Cost of one labor (operator)/shift is 450 Rs. In existing method, to manufacture two gate valve assemblies the number of operators requires are 6, the cost of labor in existing method, (6*450)= 2700 Rs. In proposed method, to manufacture three gate valve assemblies the number of operators requires are 6, the cost of labor in proposed method is (6*450) = 2700 Rs. The percentage cost savings was 1350 Rs, savings in cost of labor was nearly 33 percent.

5. Conclusions
The productivity improvement was achieved using the principles of work study and concepts of method study in Micon valve manufacturing industries. The productivity was improved in valve manufacturing industries; during the existing layout analysis existing sequence of operations followed, the total time taken to manufacture one gate valve assembly is 450 minutes. The available labor hour is 8 hours/day and requirement of labor was 6 to manufacture gate valve assembly. The daily output of 6 labors is 2 gate valve assemblies. During the proposed layout analysis existing sequence of operations followed, the total time taken to manufacture one gate valve assembly is 377 minutes. The available labor hour is 8 hours/day and requirement of labor was 6 to manufacture gate valve assembly. The daily output of 6 labors is 3 gate valve assemblies. The improvement of productivity was in terms of one gate assembly with same amount of resources as well as human labors. The cost analysis was performed cost of one labor (operator)/shift is 450 Rs. In existing method study, to manufacture two gate valve assemblies the number of operators requires are 6, the cost of labor in existing method, (6*450)= 2700 Rs. In proposed method study, to manufacture three gate valve assemblies the number of operators requires are 6, the cost of labor in proposed method is (6*450) = 2700 Rs. The percentage cost savings was 1350 Rs, savings obtained in cost of labor was nearly 33 percent.

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