A case study on the applications of productivity indices with resources frugality

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Abstract. The basic attributes of any industry or a firm are productivity, quality of products, as well as the cost and flexibility of manufacturing systems. Productivity out of all is the most imperative attribute and hence becomes centre of study in the field of Industrial engineering, for the researchers all around the world. This paper presented a study in this same regard through a case study carried out in XYZ Industry. Considered industry comprises many shops like Machine shop, Maintenance shop, Assembly shop and Fabrication shop. Out of these, Maintenance shop and Assembly shop are taken into account for the productivity improvement exercise. Fragile productivity points were identified by analysing the processes that were going on floor area of shops under consideration and hence those processes were exchanged with new ones, exchanged processes implemented practically on floor area and results were obtained. Obtained results are shown in this paper as savings, from which it can be concluded that desired objective of productivity improvements have been achieved. So study presented in this paper gives encouraging consequences by improving the productivity of concerned manufacturing industry.

1. Introduction

Production and Productivity concept go hand in hand. One can comment on the production simply by knowing the numerable figures but this is not the case with productivity. One cannot comment on productivity unless one goes through its in depth analysis. Thus we can say that productivity is the study of qualitative analysis of doing a work, that work may or may not be engineered but when this work is associated with Engineering field, productivity importance increases exponentially. It also explains a lot about a firm’s technical efficiency, scale efficiency, and allocative efficiency. Japanese companies have introduced a lot of terms like SIX SIGMA, JIT, KANBAN; with the sole purpose of productivity improvement. Japan thrives continuously for its improvements in manufacturing abilities and today it is known as the most standardized nation for its manufacturing capabilities. Many other nations follow Japanese way of production say for an instance 5S’ concept which meticulously contribute in reducing time required to carry out an activity.

Hence productivity concept is an indispensible one for an industry as its assessment reveals a lot about a firm’s ability and qualitative analysis of all the resources possessed by it. Therefore, a study is presented in this paper in the same context taking XYZ company into consideration. The prime concern is to identify the defects associated with the processes at different shops and implement alternate solutions/process without effecting the production line. Productivity has been improved as
validated by analytical calculation after implementing the alternate processes. The present work can be a base to better understand productivity in different manufacturing sectors and implement alternate solutions to improve the same.

2. Literature survey

The study on increase in productivity has carried out by many authors. Piotr Tomaszews et al. [1] carried out their study on productivity improvement by taking a case study carried out at Ericson. The objective of the study was to acknowledge how maturity and experience affect productivity in software development on a particular specialised platform. Productivity of two projects are quantified by comparing i.e. in initial development stage and then in more matured development stage. Their study revealed a factor of four differences in productivity. Influence of both the factors on productivity are accessed and explained its nature. A number of improvement are thus suggested and issues various guidelines for introduction of a new technology. Henri Juslen et al. [2] examined that under real working conditions productivity can be enhanced by a lighting system which allowed people to adopt high lighting levels. Study as mentioned was conducted in Finland’s luminaries factory for a period of 16 months in which overhead of ten individual’s workstations a task-lighting system was installed. Productivity was monitored by recording the Illuminances selected by the users.

Hannu Rantanen [3] aimed to carry out his study in small industrial firms in which he focused the chief source of internal hindrance in productivity improvement. He found that the internal obstacles which are under the control of the firm and can easily be handled and sorted out. He concluded that the price competitiveness of Finnish products can be increased by improving the productivity. He summarized that although all the companies want to increase productivity but they overlook the factors which restrain them in achieving their targets in this regards. Carrino et al. [4] focused their study on productivity improvement in gas metal arc welding (GMAW) processes with the objective of optimizing the deposition rate of the filler metal. To achieve this objective they focused their study on the welding current intensity and by applying a fuzzy-logic-based system whose elements were determined by an artificial neural network (ANN), the possible solution is obtained. Results of their study confirmed that in order to develop an integrated welding system, this approach was indeed effective for the productivity improvement. Elimam et al. [5] presented a study in which productivity is improved by financial incentives and by improving quality in manufacturing technology and service facilities. To determine the optimum financial incentives and price discount levels, they developed a Non Linear Programming (NLP) model for each rate class. Objective of his model was to maximize net revenues and to observe the impact of incentives on productivity and thus on quality improvements. Steve Berquist [6] founded the ways by which a firm can achieve from its maintenance workforce by designs and implementing the maintenance management processes, which directly impacts the productivity. Activity sampling method was used to identify the causes of delay, it also measures the direct utilization achieved in the field by the craft labour. This information is then used to target particular changes, to remove hindrance thus improved both overall maintenance workforce productivity and wrench time. Theodore Papadogonas et al. [7] paper investigated the labor productivity at the firm level and the exercise of productivity improvement is done in the Greek manufacturing sector. In this paper samples of 3035 firms were taken and then the analysis was carried out which was based on regression models and descriptive statistics. The results showed that labor productivity growth is dependent on the growth of R&D activity and net fixed assets per employee. It was concluded that firm size, industry age and employment growth affect labor productivity growth negatively.

Woodruff Imberman et al. [8] described a theory that companies in the past have dwelled toward this job elimination method for productivity improvement, it stated that the fewer employees would cut payroll costs and the remaining workers will work harder and hence profits will increase. However, as concluded in a study on downsizing by the American Management Association that by
eliminating jobs only one-third of the companies out of the 1,441 firms surveyed, achieved both immediate and long-term cost reductions and profits and the rest (66%) showed no gain while some companies even showed losses. Incentive plans was an alternative approach to job elimination for productivity improvement. Mudit Kulshreshtha et al. [9] with the objective of achieving overall productivity growth, studied the Indian coal sector which used a non-parametric index number method. Study was carried out for Coal India Ltd. (CIL) and its major subsidiary companies in which Total factor productivity (TFP) indices are calculated from the output and input indices. Results of this analysis indicate that the labour productivity increased significantly but material productivity increased marginally, however, capital productivity did not improve as expected.

3. Productivity Analysis

Material Productivity: It is nothing but ratio between output and material input. Material Productivity becomes a key factor in economic production as given by:

\[
\text{Material Productivity} = \frac{\text{Output}}{\text{Material Input}}
\]

Labour Productivity: It is the ratio of output to human input or it may also be defined as ratio of total revenue from production to expenditure on labour.

\[
\text{Labour Productivity} = \frac{\text{Total revenue from production}}{\text{Expenditure on Labour}}
\]

Capital Productivity: It is the ratio of Turnover i.e business done by an organisation in amount of rupees in a particular time period to Capital input.

\[
\text{Capital Productivity} = \frac{\text{Turnover}}{\text{Capital Input}}
\]

Machine Productivity: It is the ratio of output and Actual machine hours used.

\[
\text{Machine Productivity} = \frac{\text{Output}}{\text{Actual machine hours}}
\]

Overall Productivity: It is the ratio of total output to the total input i.e labour input, material input, capital input and machine input.

\[
\text{Overall Productivity} = \frac{\text{Total output}}{\text{Labour input+Material Input+Capital Input+Machine input}}
\]

4. Analysis of various process in maintenance shop

4.1. Provision of alternate display unit for cnc system against defective display system

Old Method Description: Provided monitor on table near Electrical panel. Due to misjudgment of parameter, chances of taking wrong reading is possible, resulting in rejection of job. Operator feels uncomfortable while doing machining work.
Cost Analysis: Cost of procuring new Display unit is Rs. 4.5/- Lac. Cost of procuring second hand Display unit is Rs. 1.4/- Lac.

New Method Description: Fitted new LCD monitor in old cabinet of CRT after removing defective picture tube. In this method, it works same as old display system.

New Cost Analysis: Cost of procuring new LCD is Rs. 5000/-

Methods Comparison:

| Old Method Description                                                                 | New Method Description                                                                 |
|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Provided monitor on table near Electrical panel. Due to misjudgment of parameter, chances of taking wrong reading is possible, resulting in rejection of job. Operator feels uncomfortable while doing machining work | Fitted new LCD monitor in old cabinet of CRT after removing defective picture tube. In this method, it works same as old display system |

Cost Comparison:

| Cost Analysis                                                                 | New Cost Analysis:                                                                 |
|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Cost of procuring new Display unit is Rs. 4.5/- Lac.                          | Cost of procuring new LCD is Rs. 5000/-                                          |

Savings: Rs 4.45 Lac by considering new Display and Rs. 1.35 Lac by considering second hand display unit.

4.2 To replace the imported geared motor by in house developed lifting arrangement for lifting of charging trolley

Old Method Description: Lifting of charging trolley by geared motor. Gear box imported and too much old model. Same model of gear box not available in the market.

Cost Analysis: Cost of new gearbox arrangement is RS. 11, 50,000/-

New Method Description: The charging trolley lifting arrangement made in house. Used worm reduction gear box. Used old motor from in house stock. Increase charging trolley speed by approx. 10%. Length of wire rope was reduced from 30 meters to 21 meters.

New Cost Analysis: Gear box 50,000/- + Old motor Rs 12,000/- Cost of erection and commissioning Rs. 15,000/- + others Rs 10,000/- Total Approx = Rs 87000

Methods Comparison:
### Old Method Description
Lifting of charging trolley by geared motor. Gear box imported and too much old model. Same model of gear box not available in the market.

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| Old Method Description | New Method Description |
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| Cost of new gearbox arrangement is RS. 11,50,000 | Gear box 50,000/- + Old motor Rs 12,000/- + Cost of erection and commissioning Rs. 15,000/- + others Rs 10,000/- Total Approx = Rs 87000 |

Savings: Approx. = Rs 10,63,000/- Wire rope saving cost = Rs 9,000/- year.

## 5 Analysis of various process in assembly shop

### 5.1 To reduce the cycle time in machining of the eccentric gear & process simplification for assembly

**Old Method Description:** First set the gear on the boring m/c. Take the centre and drilling. Reset the gear. Again drilling done.

**Cost Analysis:** Hours waste per Press due to above as per old method $4 \times 4 = 16$ hrs. per press In terms of rupees per Press with avg. of $16 \times 1850 = Rs 29600$

**New Method Description:** Take the match marking from the flange. Drilling and tapping done. Reset the gear. Take match marking. Drilling and tapping done.

**New Cost Analysis:** Expected time with this process is 20 hrs. In terms of rupees per press $20 \times 350 = Rs 7000$

**Methods Comparison:**

| Old Method Description | New Method Description |
|------------------------|------------------------|
| First set the gear on the boring m/c. Take the centre and drilling. Reset the gear. Again drilling done. | Take the match marking from the flange. Drilling and tapping done. Reset the gear. Take match marking. Drilling and tapping done. |

**Cost Comparison:**

| Old Method Description | New Method Description |
|------------------------|------------------------|
| Hours waste per Press due to above as per old method $4 \times 4 = 16$ hrs. per press | Expected time with this process is 20 hrs. In terms of rupees per press $20 \times 350 = Rs 7000$ |
16x1850 = Rs 29600

Savings: Total saving in rupees 22600 per press per year saving : 5x 22600=113000

5.2 Cycle time reduction in stud & nut fitting on crown in intermediate shaft assembly.

Old method description:
Earlier we used to first check the stud thread by fitting on crown. Then to suit machining of thread was required to be done on stud. After that stud fitting was done. In some cases this to suit machining required to be done even twice.

Cost Analysis: Assembly hrs = 6 , Machining hrs = 4

New method description: A ring gauge of suitable thread in sizes m30, m32, m36, m42 is made & sent to vendor. It worked positively. Now there is no need to check or correct the threads by machining. Hence saving of assembly man hrs and machining hrs as well.

New Cost Analysis: Assembly hours= 3, Machining hrs. = nil

Methods Comparison:

| Old Method Description                                                                 | New Method Description                                                                 |
|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Earlier we used to first check the stud thread by fitting on crown. Then to suit machining of thread was required to be done on stud. After that stud fitting was done. In some cases this to suit machining required to be done even twice. | A ring gauge of suitable thread in sizes m30, m32, m36, m42 is made & sent to vendor. It worked positively. Now there is no need to check or correct the threads by machining. Hence saving of assembly man hrs and machining hrs as well. |

Cost Comparison:

| Cost Analysis | New Cost Analysis |
|---------------|-------------------|
| Assembly hrs = 6 | Assembly hours= 3 |
| Machining hrs = 4 | Machining hrs. = nil |

Savings: Saving in labour cost = 3x400x40= Rs 48000, Saving in machining cost = 4x450x40= Rs 72000

6. Conclusion: The productivity improvement exercise has been carried out at Maintenance shop and Assembly shop only. In order to avoid hampering in concerned company’s manufacturing activities, study was restricted to these shops only. Case study carried out in this paper in XYZ industry has shown that there is a huge prospective of floor productivity improvement in the shops under consideration. Savings explain number of hours saved and which in turned saved expenses
associated with it. Savings also accentuate reduction in labour cost and machining cost. Assembly shop has got comparatively weak prospective of productivity improvements than machine shop. Besides savings acquired in various processes in maintenance shop, replacing the skilled manpower with highly skilled ones, is strongly recommended, as it saves substantial amount of time in accomplishment of an industrial activity. Based on the study that carried out in XYZ Company, productivity improvement exercise to be carried out is strongly recommended by targeting individual shops that too in segments. It was analysed during study that increasing the labour productivity is a tedious task as company had already worked extensively over its manpower. Thus it is concluded that productivity improvement is an ongoing activity, no organisation in the world can flourish without being focused on it. Profit yielding directly depends on effective utilization of available resources which is linked with how effectively an organization is using its man, material, money, machine in other words productivity indices. Hence it becomes inevitable to study productivity improvement in industries all over the world.

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