Identification and Analysis of Various Delays Affecting Machine Utilization in a Tractor Part Industry using Work Sampling Technique

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Abstract

Objective: The aim of this paper is to study the operator activities in tractor part industry and the percentage distribution of various operations. The study also aims to analyze the personal and delay allowances by observing the operations and deriving the ratios within manufacturing period, so that utilization of machines can be enhanced by removing delays.

Methodology: A work sampling technique was used in the current study; relevant reports are studied to give the basis and methodology of the technique. In accordance with work sampling technique the machines to be observed, the number of observations and the procedure for making observations are determined and the percentage distributions of unproductive activities are calculated.

Findings: It is found that 74.43 percent of the available time for production of tractor components is utilized in productive activities and 25.57 percent of total available time is wasted due to avoidable and unavoidable delays. It is also observed that Setup time/Job changing activity has maximum percentage of occurrence among all the delays i.e. 6.06 percent of the total available time.

Applications: The paper deals with an actual production shop of a tractor part industry and gives general information about the distribution of activities in production shop. The study conducted in the industry helped to identify the low lying areas responsible for low machine utilization.

Keywords: CNC, Machine Utilization, Tractor part industry, Work Sampling

1. Introduction

In today’s competitive world, it became very difficult for any industry/organization to sustain and grow substantially in market because of various challenges faced by organizations. Rapid changes in demand of customers and market can be specified as one of the reasons. Growth of any industry is mainly influenced by the extent to which they are utilizing their resources. Any step or change which improves utilization of resources will directly affect the productivity as well as profitability of the organization. In tractor part industry, components are machined on various machines/stages before they are converted into a finished product. The machining processes are carried out in a specific defined order. Therefore, low productivity at any stage of production results in bottleneck formation affecting the productivity of whole plant. There can be many reasons which affect production rate as well as productivity of the machine or plant. It becomes necessary to obviate such obstacles so as to increase productivity and profitability of the organization.

Therefore, in this research work, reasons responsible for delays in production shop were identified, further they were broken into elements and can be readily measured as fixed or variable. Finally, these measurements can be combined into work standards.

Work sampling is a work measurement technique in which large numbers of instantaneous observations are taken at random intervals over a specified period of time of group of workers, machines or processes. Work sampling technique is used in measuring or forecasting, the rate of output of an existing or newly designed operation, also in determining how much time is consumed for various productive and nonproductive activities of a process or operation.
In [1] studied the operator activities using work sampling technique in garment industry and derived percentages of distribution of operations to analyze the personal and delay allowances by observing the operations within manufacturing period. [1] observed and analyzed the overall erection and framing process of a 5 story building. In the study, the steel framing workers appeared rather unproductive compared to other studies. They had calculated the labor utilization factor as 29.09% using work sampling study, also workers effectiveness was found to be 74.6% from 5-minute rating technique. [4] conducted a work sampling study on the construction site of pharmaceutical industry when they were upgrading their buildings & facilities. The aim was to measure productive/idle times and to identify areas for improvement. It was found that the site workers were productive 29% of the day, while they spent 18% of day handling construction materials and 17% of the day waiting around for materials, transportation and instructions.

2. Experimental Work

This study was carried out in production shop of tractor part manufacturing industry and work sampling technique was used to determine the amount to which extent machines are being utilized for productive activities or what percentage of time in the production shop is being spent on productive activities.

This technique is the act of observing an operator or machine at random time and then writing down whatever was going on that time the operator or machine were observed. For example, while walking through the production shop if machine is idle (Job changing/Setup time, for example) the observation sheet should record the activity of the operator or machine at that time, whether machine is working, or in any other state or activity.

The study is divided into following steps:
- Define the problem aim of the study.
- Determine the accuracy required.
- Define the machines, operations to be observed.
- Determine the number of observations required to define the exact state of system & observers required to conduct the study.
- Determine the procedure of recording observations.
- Explanations of the work sampling procedure to concerned ones.

The various delay causing elements resulting in stoppage of machines were identified. Figure 1 represents cause effect diagram.

![Cause effect diagram](image)

Figure 1. Cause effect diagram showing major reasons for delays.

The four major causes resulting in stoppage of machine are further broken into various elements. The groups of the elements are presented in Table 1.

- A, machine is idle because operator is either absent or on leave.
- B, machine is idle since operator is not on machine but is busy on some other task in industry.
- C, machine is idle because of material related problems.
- D, machine is not working due to maintenance related issues.
- E, machine is idle due to unavoidable delays.

The five major causes resulting in stoppage of machine are further broken into various elements. Suitable symbols are assigned to the various elements of delays. The groups of the elements are presented in Table 1.

Number of observations & tour periods were determined after conducting pilot study of production shop. We assumed that a confidence level of 95 percent and an accuracy of ± 3 percent are satisfactory for this study.

\[
s \times p = x \times \left[\frac{1-p}{p/N}\right]^{1/2}
\]

where, \(s\): desired accuracy, \(p\): percentage occurrence of activity, \(x\): a factor, whose value depends upon level of confidence, \(N\): number of observations required for the desired confidence level and margin of error.

After conducting pilot study, \(p\) was found to be 0.76136 which means 76.136 percent of the time machines were
utilized in productive activities, using the above given empirical relation \( N \) was calculated as 1390 where \( x \) is 1.96 for 95 percent confidence level.

The work sampling period is defined as 15 days. According to this, required daily number of observations was calculated using equation

\[
\text{Number of observations/day} = \frac{1338}{15} = 89.2
\]

Random tables are used to determine the time interval between two consecutive tours. Working hours, refreshment breaks and lunch hours are taken into consideration for determination of time period. Observations were recalculated at various stages of study, in accordance to which time period of study was extended.

### 3. Results

Observations (\( N \)) were recalculated at various stages of study, in accordance to which time period of study was extended. Observations were continued until the desired accuracy is achieved i.e. \( \pm 3 \) percent.

The percentage distribution of activities is shown in Table 2.

It is found that 74.47 percent of working time was spent for productive activities and 25.53 percent time is wasted or machines are remaining idle due to avoidable and unavoidable delays at the end of work sampling study. 11.78 percent of the total available time is wasted in nonproductive activities considered in group E i.e.

| Group | S. No | Cause of delay | Symbol |
|-------|-------|----------------|--------|
| Operator Absent (A) | 1 | Operator absent | \( A_1 \) |
| | 2 | Absent (Without prior information) | \( A_2 \) |
| Operator not on machine (B) | 3 | Personal need (Water) | \( B_1 \) |
| | 4 | Personal need (urinal) | \( B_2 \) |
| | 5 | Getting instructions from supervisor | \( B_3 \) |
| | 6 | For taking tooling in store | \( B_4 \) |
| | 7 | Moving here & there without any reason | \( B_5 \) |
| | 8 | Moved from his work place to another place for help/advice from co-worker | \( B_6 \) |
| | 9 | Moved to nearby machine as operator operating two machines | \( B_7 \) |
| Material related Delays (C) | 10 | Material shortage in store/ vendors | \( C_1 \) |
| | 11 | Waiting for material from store | \( C_2 \) |
| | 12 | Waiting for material from previous stage | \( C_3 \) |
| | 13 | Giving material to next stage | \( C_4 \) |
| | 14 | Tools/ materials available in tool room/store but not identified | \( C_5 \) |
| | 15 | Material segregation at machine | \( C_6 \) |
| Maintenance Issues (D) | 16 | Initial failure (Breakdown) | \( D_1 \) |
| | 17 | Machine operated by unskilled/untrained operator | \( D_2 \) |
| | 18 | Spare parts not up to mark | \( D_3 \) |
| | 19 | Scheduled maintenance | \( D_4 \) |
| Forced idleness (E) | 20 | Power failure | \( E_1 \) |
| | 21 | Inspection delay | \( E_2 \) |
| | 22 | Undue refreshment break (early stop/late starting) | \( E_3 \) |
| | 23 | Tool failure (unpredicted) | \( E_4 \) |
| | 24 | Machine cleaning for scrap | \( E_5 \) |
| | 25 | Setup time/Job changing | \( E_6 \) |
| | 26 | Cutting edge of tool to be changed | \( E_7 \) |
| | 27 | Tool Change and afterward inspection | \( E_8 \) |
| | 28 | Dressing of grinding wheel in Grinding machine | \( E_9 \) |
| | 29 | Changing of Grinding wheel in case of grinding machine | \( E_{10} \) |
forced idleness while 7.67 percent of the working time is unutilized because operator is not on machine, causes are considered in group B. Maintenance related delays i.e. Group D results in 3.77 percent wastage of working time, while Group A or Operator absent contribute 1.41 percent wastage of working time. Material related delays contribute only 0.8754 percent in wastage of time.

Table 2. Distribution of recorded observations

| S. No | Activity/ Cause of delay | Symbol | No. of observations | Percentage (%) |
|-------|--------------------------|--------|---------------------|----------------|
| 1     | Machine working          | W      | 1106                | 74.47          |
| 2     | Operator absent          | A      | 21                  | 1.41           |
| 3     | Operator not on machine  | B      | 114                 | 7.67           |
| 4     | Material related delays  | C      | 13                  | 0.8754         |
| 5     | Maintenance related delays| D    | 56                  | 3.77           |
| 6     | Forced idleness          | E      | 175                 | 11.78          |
|       | Total observations       |        | 1485                |                |

So it can be concluded that the machines are utilized for only 74.47 percent of total available time. Figure 2 shows contribution of causes in non-productive activities. It can be seen from Figure 2 that Group E, forced idleness due to unavoidable delays contribute 46.17 percent towards nonproductive activities while group B has second place with 30.08 percent and maintenance related delays i.e. Group D is on third place with 14.78 percent contribution towards nonproductive activities. Group A & Group C contribute 5.54 and 3.43 percent respectively in nonproductive activities.

From the findings of the work sampling study various areas in which improvement can be made were identified. As Group E i.e. forced idleness of machines has maximum share of 46.17 percent in nonproductive activities therefore the elements of this group should be analyzed, suitable countermeasures for various delays should be suggested. Group B consists of delays as Operator not on machine resulting in stoppage of machines shares 30.08 percent in nonproductive activities, appropriate measures should be taken to eliminate these avoidable delays. Group D which consists of maintenance related delays resulting in stoppage of machines contribute 14.78 percent in nonproductive activities therefore an appropriate maintenance policy should be adopted to reduce such delays. Similarly, countermeasures for other causes grouped in A and C should be suggested and implemented so that machine utilization capacity of plant can be improved.

In the present research work an effort has been made to identify the major delays resulting in idleness of machines and countermeasures are suggested. The percentages of occurrence of nonproductive activities are shown in Figure 3. Delay/Activity $E_6$ (Setup time/Job Changing) covers 6.06 percent of the total available time. A changeover as described in a consists of

- **Rundown** - running the last of the batch through the manufacturing system ready for the new product.
- **Setup** - involves removal of the old tooling and equipment and replacing it with new, followed by a rough-cut setting of the various adjustments required
- **Run up** - involves a series of fine adjustments and checks that are carried out during production until acceptable quality level and output production rate have been reached.

Single Minute Exchange of Die (SMED) is one of the lean tools which can be used to reduce the setup time and provide quick equipment change over. SMED is an approach developed in a Japanese industrial engineer to reduce setup time/changeover time. This technique will effectively reduce the changeover time resulting in enhanced machine utilization of the plant, thereby increasing productivity and profitability of the organization.

Also Delay $D_1$ (Initial failure/Breakdown of machine) covers 3.70 percent of the total available time. If all unplanned stoppages and bad production due to maintenance related causes is avoided than maintenance cannot be termed as cost centre rather it acts as profit generation function. Therefore, improvements or
changes are required in current maintenance policy of the organization; by working upon this aspect machine utilization as well as productivity of the organization can be enhanced. 9,10

Activity/ Delay B₆ (Operator moved from his workplace to another place for helping co-worker or for taking advice from co-worker) is on third place and covers 2.55 percent of the total available time. It is surely an avoidable delay which can be obviated by imparting skill training to the workforce and making them capable of handling responsibilities assigned to them.

Figure 3. The percentage distribution of nonproductive activities.

4. Conclusion

Using the work sampling technique (whose procedure is illustrated above) decision maker, is able to calculate the machine utilization in a production shop. It becomes possible to identify nonproductive activities and their effect on resource utilization and productivity of the plant. This study investigates the causes/delays affecting the machine utilization in production shop of tractor part manufacturing industry. We found that Setup time/job changing activity have the greatest contribution in nonproductive activities. Also delays due to maintenance related issues have remarkable percentages. Avoidable delays such as inspection delay, operator operating two machines resulting in stoppage of one machine and movement of operator from his place to another machine/operator for seeking help/advice results in considerable wastage of available time. To increase the machine utilization of the plant these activities should be eliminated from the manufacturing system.

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