WORK MEASUREMENT APPROACH FOR PRODUCTIVITY IMPROVEMENT IN A HEAVY MACHINE SHOP

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Abstract

Productivity improvement is an everlasting continuous activity in manufacturing. Industries need to develop capability of coping up with customer demands to deliver quality products on time. Continuous improvement is the need of the hours which can be achieved by incorporating flexibility in layout, design and processes. This paper is aimed at improving productivity of mixed model production system of a medium scale manufacturing industry through work measurement approaches. The work measurement of various elements of the work cycle has been made on the basis of recommendations of ILO. The work cycles were divided into small measurable work elements. These elements were recorded on the observation sheet. Observations have been recorded for different trails to analyse the operation effectively for identification of value-added and non-value added element. Productivity improvement of 35% has been shown after elimination of non-value added elements.

Keywords: Productivity, work measurement, machine shop, mixed model production.

1. Introduction

Throughout the history of civilization, there has been a constant effort to improve the utilization of resources. A necessary requirement in this respect has been done to define appropriate measures of performance for systems. The concept of productivity provides us with one such measure. Operationalized as the ratio of output to input, the productivity measures aims at identifying how efficiently the resources in a system are used in producing the desired output. The objective of this section is to formalize the concept of ‘Motion study and work measurement / Work study’ [1]. Work Study is the systematic examination of the methods of carrying out activities such as to improve the effective use of resources and to set up standards of performance for the activities being carried out. Method study and work measurement are two principal activities of work study which originated in the work of F. W. Taylor. Work measurement involves assessing the time; a job should take to do [5].

In the 1950's and 1960's the work study officer or O&M Person (organization and methods) gathered the data and gave an advice. In the 1970's the titles evolved e.g. to that of management services officer. The most modern application of some of the techniques of work study is the early 1990's managerial recipe; "business process re-engineering" i.e. re-designing business processes which have developed to the extent that they mismatch the needs of the situation today [5]. The scope for work study definition and evaluation is useful for operations managers in a general sense. Such roles require data on operational capacities and effectiveness and the use of time and resources. Methods need regular re-evaluation.

The study area includes three production lines namely Differential housing line, Rear cover housing line and Gear box housing line of a tractor. These production lines includes 7 numbers of vertical machining centers, 11 horizontal machining centers, 6 special purpose machines, 11 radial machines, 4 lathe machines, 3 duplex machines, at the end of all three lines there is 1 washing machine and 1 CMM machine for inspection. In differential housing, line production is lagging behind the target due to line imbalance. So time study technique has been decided to measure the work. Cycle times of all machines measured with element and their breakpoints wise. This paper illustrates one such example of eliminating non value added time in an operation. It shows the flow of counterstriking the problem and suggests the productive way to be carried out for work measurement.
2. Differential Housing Line – The study area

Heavy machine shop under study is dedicated for a batch type of production of a differential housing component. Production line includes various CNC machines, lathe machines, boring machines and special purpose machines. For the study, the critical areas have been identified as Multiple Drilling Machine and Multiple Tapping Machine (make of BFW Bangalore).

Initially work measurement study has been carried out on Multiple Drilling Machine because work in process was held up on this machine, hence affecting the production of differential housing from Heavy Machine Shop. Figure 2 illustrates the Cycle time of individual machines. As shown in Figure 2 Multi Spindle drilling and Multi spindle tapping Machines are selected for elemental study as they were creating bottleneck condition on the production line. Both machines were made by same company and they have same methods of setup and maintenance criteria. Hence it was decided to conduct elemental study on Multi spindle Drilling Machine. Multi Spindle drilling Machine was dedicated for drilling operation of Dia. 10.25mm which are 19 in numbers and Dia. 6.8mm of 6 holes on both sides. Figure 3 showed the geometry of the differential housing.

3. Objectives of the study

3.1 To study the operation at elemental level through time study technique.
3.2 To eliminate the non-value added elements.
3.3 To optimize the cycle time to increase the production.
3.4 To evaluate the worker’s performance.
4. Methodology

The study illustrated in this paper does not only measure the work content and cycle times but also helps in analyzing the different elements consuming non value aided time in the whole operation. Initially the whole production line is studied for machine wise cycle times. Then the bottleneck stations were treated under elemental study using time study technique. Then the work cycles were broken into operations and operations were divided into measurable elements. For each elements cycle time has been noted down on observation sheets [2]. These times were analyzed and non-value added elements were eliminated to conclude for productivity improvement.

For the above explained operation, the elements and breakpoints were listed at the time of work measurement was undertaken, and were then noted on study sheet prepared for the time study. Figure 4 (a) illustrates the details of elements and breakpoints. Each elemental time has been noted down through stop-watch and recorded in a Time study sheet. Time study sheet includes all the information about the operation in the heading block at the top of the sheet and it should be filled before the start of actual time study. The same sheet can be continued for number of trails based on the set confidence and accuracy level. Figure 4 (b) illustrates the time study sheet. It includes rating which is the assessment of the worker’s rate of completing the job according to observer’s concept with corresponding to standard pace. Authors rated the operator based on British Standards which is the 0-100 scale. 0 for No activity, 50 for very slow activity, 75 for steady activity, 100 for standard activity, 125 for very fast and 150 for exceptionally fast. In-between ratings are also given based on the observer’s observation.

<table>
<thead>
<tr>
<th>Part: Differential Housing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material: Cast iron Gr 25</td>
</tr>
<tr>
<td>Operation: SIDE FACE DRILLING OPERATION</td>
</tr>
<tr>
<td>Machine: 475.01(BFW-1)</td>
</tr>
</tbody>
</table>

Elements and Break Points

a. Pickup casting from input conveyor, place it on Hydraulic lifter.
   Breakpoint: Improper tackling

b. Increase hydraulic pressure, Hydraulic Lifter lifts the component and places it on fixture.
   Breakpoint: Hydraulic Oil not available.

c. Dowell insert, Hydraulic Clamping of the casting and start the machine.
   Breakpoint: Difficulty in dowell insertion

d. Drilling operation of Dia. 10.2mm & Dia. 6.8mm under machine auto time.
   Breakpoint: Tool change/Machine breakdown

e. Stop the machine. Move gauges towards casting, check and ensure for quality specifications,
   Keep gauges in their respective place.
   Breakpoint: Gauges not available

f. Pickup component from machine conveyor and place it on output conveyor.
   Breakpoint: Improper tackling

Figure 4 (a) Elemental breakdown of operations
For constructing time study observation sheet, elemental time data has been collected by cumulative method of stop watch time study. Then observed time data has been converted to basic time by multiplying with the rating factor. Basic time is the time for carrying out an element of work at standard rating. Irrespective of workers speed or involvement basic time will give the timing according to standard rating [3]. Basic time can be calculated as the ratio of given rating to the standard rating and multiplied by subtracted time. Standard rating is taken as 100.

Table 1: Elements wise analysis of Basic times

<table>
<thead>
<tr>
<th>Elements/Trail Nos.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Actual Cycle time(Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.34</td>
<td>2.01</td>
<td>0.45</td>
<td>2.24</td>
<td>0.40</td>
<td>0.95</td>
<td>6.39</td>
</tr>
<tr>
<td>2</td>
<td>0.38</td>
<td>2.72</td>
<td>0.46</td>
<td>2.22</td>
<td>0.38</td>
<td>0.76</td>
<td>6.92</td>
</tr>
<tr>
<td>3</td>
<td>0.33</td>
<td>2.93</td>
<td>0.43</td>
<td>2.25</td>
<td>0.30</td>
<td>0.90</td>
<td>7.14</td>
</tr>
<tr>
<td>4</td>
<td>0.38</td>
<td>1.93</td>
<td>0.48</td>
<td>2.38</td>
<td>0.35</td>
<td>0.70</td>
<td>6.22</td>
</tr>
<tr>
<td>5</td>
<td>0.50</td>
<td>2.30</td>
<td>0.49</td>
<td>2.46</td>
<td>0.62</td>
<td>0.48</td>
<td>6.85</td>
</tr>
<tr>
<td>6</td>
<td>0.44</td>
<td>2.69</td>
<td>0.21</td>
<td>2.76</td>
<td>0.53</td>
<td>0.51</td>
<td>7.14</td>
</tr>
<tr>
<td>Avg. time (Min.)</td>
<td>0.40</td>
<td>2.43</td>
<td>0.42</td>
<td>2.39</td>
<td>0.43</td>
<td>0.72</td>
<td><strong>6.78</strong></td>
</tr>
</tbody>
</table>
The data taken from time study technique has been analyzed by calculating average and standard deviation of all the trails by making modification in the machine set up. This is because element ‘B’ consumes more time as compared to other elements. Although element D also taking more time but it is machine actual time i.e. this is fixed operational time. Hence it is decided to eliminate element B from the operation. As discussed in the Figure. 4(a) element B is describes the work to increase the hydraulic pressure. Hydraulic lifter lifts the component and places it in fixture. This activity consumes average of 2.43min and including this activity cycle time of this operation on multi spindle drilling machines was 6.78min. It is advised to the operator to place the component on fixture manually by eliminating hydraulic lifter setup. Input conveyor extended near the machine so that the operator movement to pick up the component should be reduced. After this setup change element ‘B’ is totally eliminated from the list of elements.

5. Results and Implementations

Operator starts the cycle with lifting the component from input conveyor and places it on hydraulic bed using tackle. When he increases the hydraulic pressure, the hydraulic bed starts moving from its ground level to machine fixture level. This hydraulic lifter designed by machine maker is used to lift the component and place it on fixture. After clamping the component he starts the machine for drilling operation of Dia. 10.25mm and Dia. 6.8mm. Hydraulic lifting set was consuming about 2.43min of time on every cycle time increasing. There authors found the chances of reducing the cycle time of this operation. It was an external setup attached by manufacturers of that machine. The unit was easily removable according to maintenance team.

After this time study analysis, authors decided to remove hydraulic setup to reduce the cycle time. Maintenance team in presence of machine makers removed the set up and also reduced the distance between input conveyor and the fixture. Initially input conveyor was at 2.3m distance from the hydraulic bed. After removing the hydraulic lifter setup, the distance got reduced by 1.6m. Operators are advised to lift the component and instead of hydraulic bed, place the component directly on the machine fixture. This practice is initially monitored for process disturbances, manual fatigue conditions and quality parameters. No changes are observed after change in machine setup.

Again time elemental study has been carried out in 6 trails to ensure the smooth movement of operation. Figure.5 illustrates the new set of elements and breakpoints. The only difference is Element B activity was eliminated and is replaced by next activity. Hence number of activities also reduced for operator in completing the whole operation. Table 2 illustrates the changes in basic times and reduced cycle time after eliminating hydraulic setup.

| Part: Differential Housing  
| Material: Cast iron Gr 25  
| Operation: SIDE FACE DRILLING OPERATION  
| Machine: 475.01(BFW-1)  

| Elements and Break Points  
| a. Pickup casting from input conveyor, place it on Hydraulic Lifter.  
| Breakpoint: Improper tackling  
| b. Dowell insert, Hydraulic Clamping of the casting and start the machine.  
| Breakpoint: Difficulty in dowell insertion  
| c. Drilling operation of Dia. 10.2mm & Dia. 6.8mm under machine auto time.  
| Breakpoint: Tool change/Machine breakdown  
| d. Stop the machine. Move gauges towards casting, check and ensure for quality specifications. Keep gauges in their respective place.  
| Breakpoint: Gauges not available  
| e. Pickup component from machine conveyor and place it on output conveyor.  
| Breakpoint: Improper tackling  

Figure5 Elemental breakdowns of operations after removing hydraulic setup
Table 2: Element wise analysis after eliminating Hydraulic setup

<table>
<thead>
<tr>
<th>Elements/Trail Nos.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Actual Cycle time (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.31</td>
<td>0.42</td>
<td>2.25</td>
<td>0.39</td>
<td>0.87</td>
<td>4.24</td>
</tr>
<tr>
<td>2</td>
<td>0.39</td>
<td>0.41</td>
<td>2.26</td>
<td>0.41</td>
<td>0.72</td>
<td>4.19</td>
</tr>
<tr>
<td>3</td>
<td>0.34</td>
<td>0.44</td>
<td>2.25</td>
<td>0.32</td>
<td>0.93</td>
<td>4.28</td>
</tr>
<tr>
<td>4</td>
<td>0.32</td>
<td>0.47</td>
<td>2.27</td>
<td>0.36</td>
<td>0.84</td>
<td>4.26</td>
</tr>
<tr>
<td>5</td>
<td>0.41</td>
<td>0.46</td>
<td>2.26</td>
<td>0.31</td>
<td>0.47</td>
<td>3.91</td>
</tr>
<tr>
<td>6</td>
<td>0.39</td>
<td>0.41</td>
<td>2.26</td>
<td>0.61</td>
<td>0.38</td>
<td>4.05</td>
</tr>
<tr>
<td>Avg. time (Min.)</td>
<td>0.36</td>
<td>0.44</td>
<td>2.26</td>
<td>0.40</td>
<td>0.70</td>
<td>4.16</td>
</tr>
</tbody>
</table>

Comparing Table 1 and Table 2, it can be concluded that the cycle time of the multi spindle drilling operation has been reduced from 6.78 min to 4.16 min. In the same way Hydraulic setup is eliminated from the next machine Multi spindle tapping machine. Horizontal deployment of the same idea benefitted in reducing the cycle time on tapping machine also. Hence production line counterstruck the bottleneck condition on these two machines.

6. Conclusion

Work measurement includes time study and motion study as well. Work measurement should be carried out by conducting both time and motion study in order to achieve reasonable results. Before conducting time study, it is very much necessary to consider the motion study also. Hence motion study can be considered as a basis for time study. As discussed earlier, time study measures the required time to perform the operation as per the specified process flow. Authors studied the time study on bottleneck stations to eliminate the unnecessary time to improve the production quantity on machine. Basic time has been calculated for each element and then analyzed the obtained data for changes to be implemented on machine. Then the new work method is developed by eliminating hydraulic setup and the change is horizontally deployed on the work station to get the tangible benefit of time study. To eliminate the observer’s errors in collection of time data, one can implement the automation using handheld computers or video recorders. By this work measurement method productivity got improved 35% without investing extra resources. This approach explains the best way of increasing productivity by eliminating the ineffective efforts by the operators and the machine shop as well.

References


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