Journal of Pharmacognosy and Phytochemistry 2016; 5(1): 198-202

Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2016; 5(1): 198-202
Received: 16-11-2015
Accepted: 18-12-2015

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Productivity enhancement in excavator manufacturing plant by eliminating non value added activities

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Abstract
The manufacturing sector has used time standards effectively for a variety of purposes such as for control and monitoring for capacity planning and setting up standard operating procedures.
Standardized work is defined as work in which the sequence has been efficiently and safely organized and is repeatedly followed by team members.
The time standards so set can be used by the firm for the following purposes:

- To measure the efficiency of the individual processes, departments and the firm as a whole.
- To evaluate existing processes and any new process that may be suggested as replacement for the existing processes.
- To carry out capacity planning.
- To link performances to salaries.
- To meet Takt time efficiently.

This time study analysis is implemented on the excavator assembly line and fabrication shop processes at Beta Construction Equipment, Peenya, Bangalore. Thereby, enabling to relate production sequence to Takt time, to ensure smooth and effective flow of a balanced production line by eliminating unnecessary non value added activities and production bottlenecks.
We have conducted time study of the entire production process of the Excavator at the Beta Plant at Peenya, Bangalore. After the time study analysis was complete the following results were obtained. These are the implemented cycle times after eliminating the non value added activities:
Cycle time of Upper Frame Fabrication = 382 minutes
Cycle time of Lower frame Fabrication = 518.41 minutes
Cycle time of Assembly feeders = 1276.7 minutes
Cycle time of Assembly stations = 544 minutes

Keywords: Productivity enhancement, excavator manufacturing plant

1. Introduction
The time taken by a worker or a machine to carry out an operation or to produce a given quantity of a certain product may be considered by the basic work content of the product or operation. Work content means the amount of work contained a product or process measure in “work-hours” or “machine-hours”. Work-hour is the labor of one person for one hour. Machine-hour is the running of the machine or piece of plant for one hour. The basic work content is the irreducible minimum time theoretically required to produce one unit of output [1]. This is the time taken to perform the operation if the design or specification of the product or service provided were perfect, if the process or method of operation were perfectly carried out, and if there no loss of working time from any cause what so ever during the period of operation [2].

2. About Excavator
Beta excavators are ready to help you dig and reach new levels of excavating equipment efficiency. It’s hydraulic excavator performance you can depend on for quarrying, mining, road building, civil engineering, general construction and more. Choose your bucket or a range of other Beta attachments and go to work. Each crawler excavator model is designed and built to deliver long-lasting performance, powerful strength and leading fuel efficiency. Dig further with Beta excavator. Top features for the range of Beta excavator include:

- Dependable Beta engine delivers high torque at low revs for class-leading fuel economy
- Beta Care Cab with ROPS, provides the safety and comfort to reduce operator fatigue and increase productivity

- Two-pump hydraulic system, for smooth control, response and high breakout force
- Reversible cooling fan and ease of service access for maximum availability
- 95% recyclable machine, helping to preserve our environment
- Care Track telematics as standard equipment*, helps you save fuel, reduce costs and maximize profitability

3. Literature Review

The manufacturing sector contributes to nearly 45% of India's Gross Domestic Product. This makes it by far one of the largest contributor to India's GDP. Traditionally Industrial engineering tools have found applications in the manufacturing sector. There have been very few instances of the same being used in the service sector [3].

Table 3.1: Difference between service sector and manufacturing sector.

Sl. No.	Characteristic	Manufacturing sector	Service Sector
1.	Nature of output	Tangible	Intangible
2.	Consumption of output	Consumption is done over time	Consumption is instantaneous
3.	Nature of jobs	Involve less labor & more equipment	Involve more labor and less equipment
4.	Degree of consumer contact	Low to Medium	Higher than that involved in a manufacturing setup
5.	Customer participation in conversion	No customer participation in the conversion process	Frequent customer participation in the conversion process
6.	Measurement of performance	Sophisticated measures of performance	Crude measures of performance

The manufacturing sector has used time standards effectively for a variety of purposes such as for control and monitoring for capacity planning and setting up standard operating procedures.

Standardized work is defined as work in which the sequence has been efficiently and safely organized and is repeatedly followed by team members [3].

As can be seen from the above table the manufacturing sector is characterized by tangible outputs which are consumed over a period of time. They generally require more machinery. The sector is also characterized with low degree of customer contact with very little participation of the consumer in the conversion process. Most importantly there are sophisticated measures of performance. Reasons for the use to work measurement techniques in manufacturing sector:

- The manufacturing setup is characterized by fixed processes. That is there is not too much of variability in the process. On the other hand the service sector is characterized by huge variability in the nature of the work involved. Thus standardization in service sector is a lot more difficult.
- The manufacturing sector has generally even demand or to be more precise it is earlier to ensure continuous production in a manufacturing setup. However in a service setup demand is ad hoc by nature. This implies that on a lot of occasions employees will be forced to remain idle.
- The manufacturing setup involves a greater use of machinery with labor taking a backstage. The greater amount of automation, the easier to determine standards. On the other hand the service sector has a greater dependence on labor. The employees have to contend with enormous variability in the job. Industrial engineers find it difficult to determine standards because of the variable nature and the ad-hoc occurrences of processes [4].

4.1 Problem Definition

Since Beta Construction Equipment, Bangalore is a new plant which is still in the process of setting an optimal Takt Time for the Excavator Manufacturing; our objective is to take time study of all the processes that go into manufacturing the excavator. With the help of the data obtained from this time study, they are looking to ramp up their production by performing Line Balancing and eliminating non value added activities to reduce the cycle time of all the operations in order to achieve an optimal Takt Time. As per their current Takt time they are able to produce 2.8 excavators per day. With the help of our study and analysis they aim to increase their output to 4 machines per day (510 minutes)

4.2 Objectives

- Analyze the process, identifying the value added and non- value added elemental activities.
- Conduct time study analysis of all the manufacturing operations of the excavator.
- Document the obtained data into standardized work sheets.
- Provide standardized work steps for training of new workers.
- Provide suggestions for improvement of the line operations.

4.3 Scope

There is immense scope for this project, as prior to this time study there had been no precise data regarding the time taken for the operations at the plant. Now with the help of our standardized work documents they have the power to:

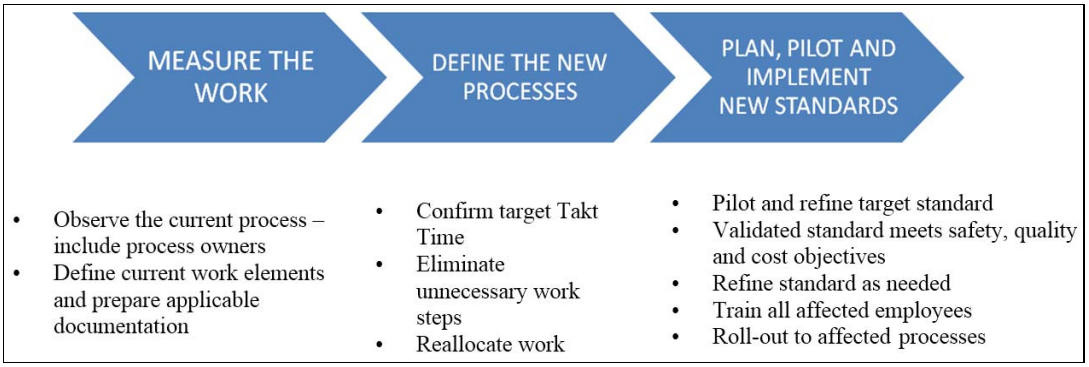
- Use these sheets on the line, at the individual stations, to maintain repeatability and quality of the operations.
- These sheets are going to be used for training of new employees to ensure set standard procedures are maintained.
- For line balancing operations.
- During need to increase output, the areas that need to be focused on can be referred using these documents.
- Main scope is for continuous improvement of the operations and increasing the productivity by eliminating/ reducing the non value added activities and the necessary non value added activities.

5. Methodology

"Time study is a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specific conditions, and for analyzing the data so as to obtain the time necessary for an operator to carry out as a defined rate of performance." The steps

involved in time study starts with selecting the job. If the purpose of study is the setting of performance standards, it should not normally be undertaken until method study has been used to establish and define the most satisfactory way of doing the job [5]. The next important point to be taken care of would be the "approach to the worker". It is to be noted that a distinction that has been made between representative worker and a qualified worker. "A qualified worker is one who has acquired the skill, knowledge and other attributes to carry out the work in hand to satisfactory standards of quantity, quality, and safety". The steps involving in carrying out a time study [6]:

1. Obtaining and recording all the information available about the job, the operative and working conditions, which is likely to affect the carrying out the work.
2. Recording a complete description of the method, breaking down the operation into elements.
3. Examining the detailed breakdown to ensure that the most effective method and motions are being used to determining the sample size.
4. Measuring with a timing device and recording the time taken by the operative to perform each "element" of the operation.
5. At the same time, assessing the effective speed of working of the operative relative to the observer's concept of the rate corresponding to the standard rating.
6. Extending the observed times to "basic times".
7. Determining the allowances to be made over and above the basic time for operation.
8. Determine standard time for operation.



6. Standardized Work Documents

6.1 Assembly Line Feeder Documents

Process	FEEDER 1 -BLOCK SUB ASSEMBLY	TIME MEASUREMENT SHEET						
No.	Job Element	Measuring Point	1	2	3	4	5	6
1	GET THE HEADLIGHTS AND PREPARE IT	NECESSARY NON VALUE ADDED ACTIVITY	1.5					
2	FIX HEADLIGHTS TO THE FRAME	VALUE ADDED ACTIVITY	2.5					
3	MOUNT THE HORN	VALUE ADDED ACTIVITY	2					
4	MOUNT THE PACKING AND MARK IT	VALUE ADDED ACTIVITY	1					
5	UNPACK AND MOUNT PIPE WA	VALUE ADDED ACTIVITY	3					
6	TORQUE PIPE WA	VALUE ADDED ACTIVITY	1					
7	PREPARE VALVES	NECESSARY NON VALUE ADDED ACTIVITY	26					
8	ASSEMBLE PIPE WA TO THE FRAME	VALUE ADDED ACTIVITY	1					
9	CLEAR THE HOLES AND MARKS THEM	NON VALUE ADDED ACTIVITY	5					
10	GET GROMMET FROM THE BIN	NECESSARY NON VALUE ADDED ACTIVITY	1					
11	PLACE THE GROMMETS	VALUE ADDED ACTIVITY	3					
12	ASSEMBLE THE HOSES TO THE VALVES AND MARK THEM	VALUE ADDED ACTIVITY	8					
13	UNPACK THE WIRING AND FIX TO THE FRAME	VALUE ADDED ACTIVITY	5					
14	WIRE THE FRAME WITH THE HELP OF STRIP CLAMP	NECESSARY NON VALUE ADDED ACTIVITY	30					
15	MOUNT THE ACCUMULATOR BLOCK AND VALVE ASSEMBLIES T	VALUE ADDED ACTIVITY	12					
16	FIX GROMMET	VALUE ADDED ACTIVITY	1					
17	FIX THE HOSES TO THE VALVE ASSEMBLY FIXTURE	VALUE ADDED ACTIVITY	15					
18	MARK THE HOSES AFTER TIGHTENING IT	NON VALUE ADDED ACTIVITY	0.5					
19	STRAP THE HOSES AND WIRES	NECESSARY NON VALUE ADDED ACTIVITY	3					
20	FIX THE DUMMY CAPS	NON VALUE ADDED ACTIVITY	4					
21	SERIAL NUMBER FOR THE CHASSIS	VALUE ADDED ACTIVITY	9					
Cycle Times			135	0	0	0	0	0

6.2 Assembly Line Stations Documents

Process	STATION 1 AND 2	TIME MEASUREMENT SHEET						
No.	Job Element	Measuring Point	1	2	3	4	5	6
1	BRING MCV FROM FEEDER ONTO FRAME	VALUE ADDED ACTIVITY	5					
2	GET TOOL AND TIGHTEN MCV TO FRAME	VALUE ADDED ACTIVITY	2					
3	ROUTING THE HOSES	VALUE ADDED ACTIVITY	7					
4	GET WIRE CLAMP N TORQUING TOOLS	NECESSARY NON VALUE ADDED ACTIVITY	3					
5	TORQUING AND CLAMPING ACTIVITY	VALUE ADDED ACTIVITY	21					
6	REMOVE EXCESS WIRE CLAMP AND KEEP TOOLS BACK	NON VALUE ADDED ACTIVITY	5					
7	BRING REQUIRED MATERIALS	NECESSARY NON VALUE ADDED ACTIVITY	5					
8	MOVE HYDRAULIC TANK ONTO FRAME FROM ITS POSITION	VALUE ADDED ACTIVITY	4.5					
9	CONNECT HOSES BETWEEN HYDRAULIC TANK AND ACC	VALUE ADDED ACTIVITY	1					
10	TIIGHTEN COUPLING BETWEEN HYDRAULIC TANK AND MCV	VALUE ADDED ACTIVITY	2					
11	ATTACH CLAMPS, SECTION PIPES AND EXTENTION PIPES	VALUE ADDED ACTIVITY	10					
12	COVER SECTION PIPES	NON VALUE ADDED ACTIVITY	1					
13	COMPLETE ALL TORQUING ACTIVITIES ON HYDRAULIC TANK	VALUE ADDED ACTIVITY	6					
14	BRING FUEL TANK INTO PLACE	VALUE ADDED ACTIVITY	6					
15	ACCURATE PLACEMENT AND TORQUING OF BOTH TANKS	VALUE ADDED ACTIVITY	20					
16	REMOVE AND RETIGHTEN THE BOTTOM BOLTS	VALUE ADDED ACTIVITY	8					
17	USE ATLAS COPCO TOOL FOR ACCURATE TIGHTENING	VALUE ADDED ACTIVITY	5					
18	WIRE CONNECTIONS TO FUEL TANK	VALUE ADDED ACTIVITY	7					
19	BRING BOTTOM PLATE ASSEMBY INTO POSITION	VALUE ADDED ACTIVITY	5					
20	ENGINE PREPARATION BEFORE LIFTING	NECESSARY NON VALUE ADDED ACTIVITY	5					
21	USE CRANE TO MOVE ENGINE ONTO FRAME	VALUE ADDED ACTIVITY	4.5					
22	COMPLETE ENGINE ASSEMBLY ONTO FRAME	VALUE ADDED ACTIVITY	66					
Cycle Times			199	0	0	0	0	0

7. Results and Calculations

7.1 Lower Frame Fabrication Stations with Cycle Time

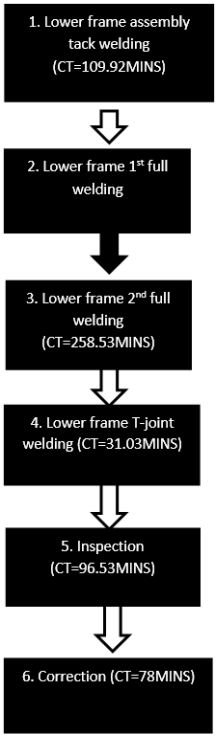


Fig 7.1: Lower Frame Fabrication Stations with Cycle Time

7.2 Assembly Line Stations and Feeders with Cycle Time

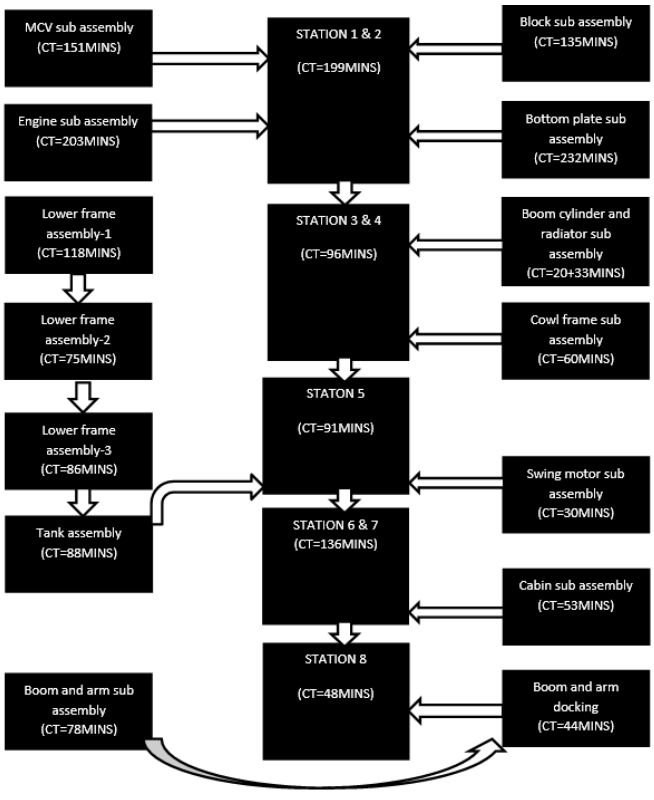


Fig 7.2: Assembly Line Stations and Feeders with Cycle Time

7.3 Calculations of Effective Working Time

The following table shows the effective working time**.**

Table 7.1

Particulars	Time (In Mins)
Total Time Available Per Shift	570
Less	
Morning Coffee Break	15
Lunch Break	30
Evening Tea Break	15
Total	60

Effective working time per shift = 570 – 60 = 510 minutes

7.4 Calculations of Allowances

Table 7.2

	Fatigue criteria	Points
A	Physical Strain	
1	Physical strain	0
2	Posture	1
3	Vibration	0
4	Short Cycle	3
5	Restrictive Clothing	0
B	Mental Strain	
1	Concentration	5
2	Monotony	6
3	Eye strain	4
4	Noise	0
C	Working Conditions	
1	Temperature and humidity	0
2	Ventilation	0
3	Fumes	0
4	Dust	0
5	Dirt	0
6	Wet	0
	Total Points	19
	Relaxation allowances percentage	12%

The allowances may be determined by means of table of comparative strains and the point conversion table provided in ‘Introduction to work study – Third Revised Edition. International Labour Organization’.

7.5 Result showing the present cycle times and the implemented cycle times

Table 7.3

Sl. No.	Department	Present Cycle Time (In Minutes)	Proposed Cycle Time = (Cycle Time - Non Value Added Time)	Percentage Reduction In Cycle Time
1	Upper Frame Fabrication	406	(406 – 24)=382	5.91
2	Lower Frame Fabrication	574	(574 – 55.59)=518.41	9.85
3	Assembly Line Feeders	1406	(1406 – 129.3)=1276.7	9.19
4	Stations	570	(570 – 26) = 544	4.56

8. Conclusion

- Identified and segregated the value added, non value added and necessary non value added activities.
- Executed time study analysis and documentation of standardized work sheets for all the operations of the excavator manufacturing.
- Set new targets for the employees based on the established time standards from our study.
- Established time standards and eliminating non value added activities the efficiency and hence the productivity can be improved.

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