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Determination Of Value Added, Semi-Value Added And Non-Value Added Activities Of An Assembly Line By Basic Maynard Operations Sequence Technique Using Protime Estimation Software –A Case Study

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Abstract: In today's circumstances all the manufacturing companies are determined to eliminate the non-value added activities from its production system to improve its productivity. The challenge is the determination and distinguishing the value added and non-value added activities of the processes. The value added, semi-value added and non-value added activities of a production system can be determined by different ways. One of the ways is by time study. Time study can be done by stopwatch study and predetermined motion time systems. This paper represents a case of an assembly line in an industry, engaged in the production of control panel's, where basic Maynard operation sequence technique was adopted to determine the value added, semi-value added and non-value added activities during assembly operations. Determining and distinguishing between the activities is the major focus of this paper. This paper highlights the systematic procedure required to determine the percentage of value added, semi value added and non-value activities in the overall cycle time for the assembly operations of a product by using the protime estimation software.

Keywords: Predetermined motion time system (PMTS), Maynard operation sequence technique (MOST), Value added activities (VA), Semi-value added activities (SVA), Non-value added activities (NVA), Time measurement units (TMU), Protime estimation software

I. Introduction

The need of easy manufacturing an automobile in turn made the assembly line possible [4]. Assembly line represents the heart of manufacturing industries. There are different methods to measure the efficiency and productivity of an assembly line, but all those methods will be dependent on the time study data. Time study of an assembly line can be conducted in many ways. Most commonly used techniques are stopwatch study and predetermined motion time system (PMTS) study [1].

PMTS is a calculating method of time study, which consists of predefined time data and a systematic procedure to analyze and divide the manual works into motions, body movements and other human activities and gives prescribed time values to all the works [1]. The PMTS methods are helpful to define both time and work standards. The limitation of inconsistency of the stopwatch study can be eliminated in the PMTS methods. Most commonly used PMTS method is methods of time measurement (MTM) developed in the year 1948 [3]. MTM-1 is most detailed system in which human motions are described amongst 10 categories of body movements. The handling of a huge amount of data during its practical application can be tiresome. To overcome these drawbacks, the M.O.S.T. method was developed by K. B. Zandin in the year 1980 [3]. Productivity can be improved by applying the M.O.S.T. technique [1].

The cost of a product is determined by the cost of all resources used in the production of that product. Thus every operation is evaluated for the value it adds to the final product. In this sense, the value of each operation customer

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is willing to pay are called value addition (VA) activities. And for which customer is unwilling to pay is called non-value added (NVA) activities. Few of the activities are supportive for the value addition activities; such operations are called semi-value added (SVA) activities. NVA and SVA activities can be minimized by proper production planning.

In this paper, investigation was carried out at an assembly line of a manufacturing industry. The aim is to determine the percentage of VA, SVA and NVA activities in the overall cycle time required for the assembly operations of a product by using the protime estimation software.

II. Basic M.O.S.T.

Work is defined as the displacement of mass or object. In the assembly point of view, the displacement of mass or an object takes place when there is a certain motion of an operator, who is moving the mass or an object.

For example, consider a part within a reach of two steps placed on the ground from an operator needs to be inserted inside a product. In this task an operator walks two steps from his initial position bend and rises to pick up the part and again moves two steps to reach the initial position and applies small pressure to insert a part inside the product. So there is a motion of four steps, bend and rise motion and applying pressure to complete the task. This is the work according to M.O.S.T. method. M.O.S.T. is a system to measure work; therefore, M.O.S.T. concentrates on the movements of the objects by an operator [3].

According to Maynard the movement of an object follows certain constantly repeating patterns such as reach, grasp, move and position the object [3]. Basic M.O.S.T. focuses on work involving the movements of objects (parts or tools) from one location to another in the workplace. Basic M.O.S.T. has three activity sequence models [3].

1. General move – Object moved freely in space. It follows sequence of GET, PUT and RETURN.
2. Control move – Object remains in contact with surface. It follows sequence of GET, MOVE and RETURN.
3. Tool use – Use of tools. It follows sequence of GET TOOL, PLACE TOOL, TOOL ACTION, PLACE TOOL and RETURN.

TABLE 1
SEQUENCE MODEL OF BASIC M.O.S.T. [1]

Activity	Sequence Model	Sub activities
General Move	[ABG] [ABP] [A]	A – Action distance
		B – Body motion
		G – Gain Control
		P – Place
Controlled Move	[ABG] [MXI] [A]	M – Move controlled
		X – Process time
		I – Align
Tool Use	[ABG] [ABP] [*] [ABP] [A]	*F – Fasten
		*L – Loosen
		*C – Cut
		*S – Surface treat
		*R – Record
		*M - Measure

The time for each basic element in M.O.S.T. is given in units of time measurement units (TMU). Where 1TMU = 0.00001hour = 0.0006minutes = 0.036Seconds.

Formula to calculate the timings of tasks in basic M.O.S.T. is given by:

Time = Sum of index values x 10 x Frequency [1]

III. Methodology

The methodology for calculating the cycle time of the activities by B.M.O.S.T. and distinguish them has the value added activity, semi-value added activity or non-value added activity is shown below. For this purpose an activity is considered from internal assembly station.

In this activity an operator walks 1-2 steps from his initial position to reach for part. Then bend and rise's partially to pick up the part placed on the table. Then operator returns to his initial position along with the part to place the part inside the product. Then the operator picks up the tool within reach by bending and rising partially to fasten the part to the product. Here tool used is power tool. All the activities have frequency of one.

For easy understanding and to get higher frequency of results, this activity is divided into three sub activities. First sub activity is reach and pick up the part. Second sub activity is to move the part and insert it inside the product. Third sub activity is to pick up the tool and fasten the screw and place back the tool. In the protime estimation software a

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main activity can be divided into sub-activities. Table 2 gives data of the activity and the B.M.O.S.T. calculations.

TABLE 2
DATA OF THE ACTIVITY AND B.M.O.S.T. CALCULATIONS

Sl. No.	Title	BMOST Code/ Index Value	Total time in TMU	Move
1	Walk 1-2 steps, bend and rise 50%, pick up light object.	A3B3G1 A0B0P0 A0	70	General move
2	Walk 1-2 steps, hold light object, resistance offered insert the object by applying light pressure, and time required is 1-2 seconds aligning to one point.	A3B0G1 M3X3I1 A0	110	General move
3	Pick up the tool within reach, bend and rise 50%, pick up object which is heavy, within reach position the tool precisely and fasten the screw of 2 quantity, bend and rise 50%, put tool aside.	A1B3G3 A1BO ((P6 A1 F3)*2) A0B3P1 A1	350	Tool use

Sample calculations:
Formula

TIME = Index Value x 10 x Frequency [1]

1. Time = [A3B3G1 A0B0P0 A0]*10*1
   Time = [3+3+1] x 10 x 1
   Time = 70 TMU
   Time = 70 x 0.036 Sec
   Time = 2.52 Sec

Walking and bending to pick up the material is considered as NVA activity. So A3 and B3 are considered has non-value added activity. The picking up of materials is considered has semi-value added activity, thus G1 is SVA activity. So out of 70 TMU, 60 TMU is NVA activity and 10 TMU is SVA activity. Table 3 shows the list of few of the main activities of an assembly line considered has VA, SVA and NVA.

TABLE 3
LIST OF MUDA CLASSIFICATION [6]

Category	Activities
VALUE ADDED (VA)	Bending the material
	Cutting the material
	Making whole
	Screwing / Fastening
	Welding
	Inserting
	Painting
	Quality necessary
SEMI-VALUE ADDED (SVA)	Picking / Supply
NON-VALUE ADDED (NVA)	Packing / Unpacking
	Walking for materials
	Walking for tools
	Waiting
	Hoisting
	Unnecessary Quality check
	others

So depending on the activities listed above, an operation is classified has VA, SVA or NVA. Similar procedure has been adopted in assigning the index values for calculating the task times for all the sub activities. Table 4 shows the data of VA, SVA and NVA of the above mentioned activity.

TABLE 4
DATA OF VA, SVA AND NVA OF THE ACTIVITY

Sl. No.	BMOST Code/ Index Value	VA (%)	SVA (%)	NVA (%)	Total time in TMU
1	A3B3G1 A0B0P0 A0	0 (0)	10 (14.2)	60 (85.7)	70
2	A3B0G1 M3X3I1 A0	30 (27.2)	40 (36.3)	40 (36.3)	110
3	A1B3G3 A1BO ((P6 A1 F3)*2) A0B3P1 A1	80 (22.8)	130 (37.2)	140 (40)	350

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IV. Case Study

This case study was conducted at an assembly line of industry. This industry is responsible for the production of control panels for telecommunication industries.

Present study is focused on the activities of the assembly line for a product. The assembly line for a product consists of 30 activities to get the finished artifact. These 30 activities are divided among 4 stations. The assembly operation takes place on the conveyer system. The flow is in-line flow.

The product goes to all stations one after the other when the activities are completed within the given takt time. So the input of the product to one station depends on the output of its previous station.

The procedure mentioned in the methodology was adopted to calculate the cycle time of all the 30 activities of the assembly line using protime estimation software. Table 5 gives the list of operations, total TMU of the operations and cycle time.

TABLE 5
LIST OF OPERATION AND THEIR CYCLE TIME

SL. NO.	Operations	Screw Size	Total TMU	Cycle Time (MIN)
1	Frame loading to the station		310	0.19
2	Moving wheel removing		560	0.34
3	Tube holder fixing	M6*15	590	0.35
4	Tube light fixing		130	0.08
5	Top cover fixing	M12*25	970	0.58
6	Top mounting angle fixing	M6*20	970	0.58
7	Door hinge fixing	M6*20	920	0.55
8	Bottom mounting angle fixing	M6*20	970	0.58
9	Bottom cover fixing	M12*20	970	0.58
10	Plinth fixing	M12*25	1030	0.62
11	Place wooden pallet on the conveyer		230	0.14
12	Unload the frame		180	0.11
13	Move frame to next station		370	0.22
14	OFC plate fixing	M6*20	650	0.39
15	Pallet screw fixing	M6*30	750	0.45
16	Single door retainer fixing	M6*20	550	0.33
17	Smoke detector fixing	M6*20	580	0.35
18	19” angle fixing	M6*20	2210	1.33
19	Fan support bracket fixing	M6*20	750	0.45
20	Move frame to next station		260	0.16
21	Shelf fixing	M6*20	780	0.47
22	Battery support fixing	M6*20	2060	1.24
23	Electrical bus bar fixing	M6*20	820	0.49
24	C – rails fixing	M6*20	1310	0.79
25	Cable manager fixing	M6*20	1460	0.88
26	Move frame to next station		260	0.16
27	Left cover fixing	M8*20	1530	0.92
28	Right cover fixing	M8*20	1530	0.92
29	Rear cover fixing	M8*20	1530	0.92
30	Front door fixing		1310	0.79
TOTAL TIME			**26540**	**15.96**

The table 5 is the typical details of the time study results obtained from the protime estimation software. The overall cycle time required to assemble the product in an assembly line is 15.96 mins.

The VA activities are considered as actually productivity of an assembly line because these activities add a value to the product. Whereas the SVA and NVA activities doesn’t add any value to the product and they are considered as MUDA (waste) according to lean fundamentals.

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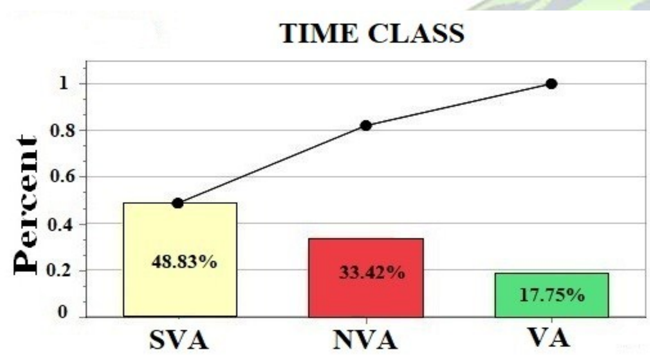
V. RESULTS

By applying BMOST method for all the 30 activities of the assembly line for a product it was found that;

1. 7.79 mins (48.83%) of the overall cycle time (15.96 mins) is SVA activities.
2. 5.33 mins (33.42%) of the overall cycle time (15.96 mins) is NVA activities.
3. 2.84 mins (17.75%) of the overall cycle time (15.96 mins) is VA activities.

Graph 1 shows the time class category of the activities.



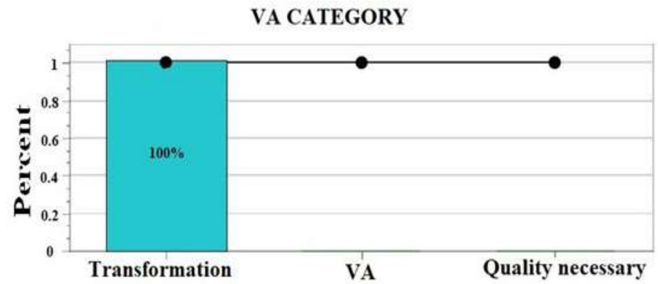
Graph 1.Time class category

TABLE 5
VA, SVA, NVA ACTIVITIES TIMINGS

Activities	Cycle Time
VA activities	2.84 mins
SVA activities	7.79 mins
NVA activities	5.33 mins
Overall cycle time	**15.96** mins

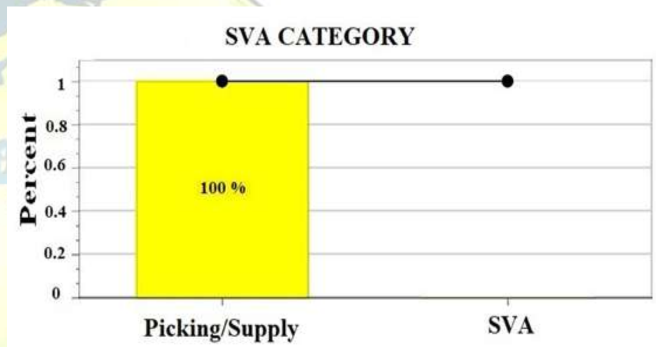
Further, result obtained from the software also consists of the graphs of individual activities of VA, SVA and NVA activities categories as shown in the graph 2, 3 and 4.

Graph 2 shows that out of all the activities under VA category, transformation alone has 100% i.e. 2.83minutes.



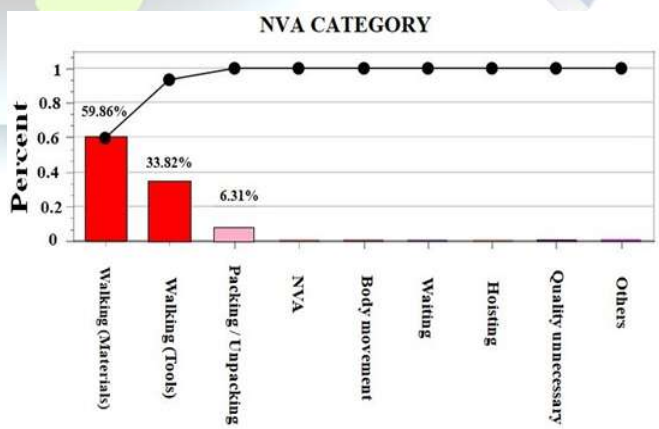
Graph 2.VA activities category

Graph 3 shows that out of all the mentioned activities under SVA category, picking/supply activity consumes 100% timings i.e. 7.79 minutes.



Graph 3.SVA activities category

Graph 4 shows that the activities under NVA category such as walking for material, walking for tools and packing/unpacking activities has 58.86%, 33.82% and 6.38% share respectively out of 5.33 minutes of NVA activities.



Graph 4: NVA activities category

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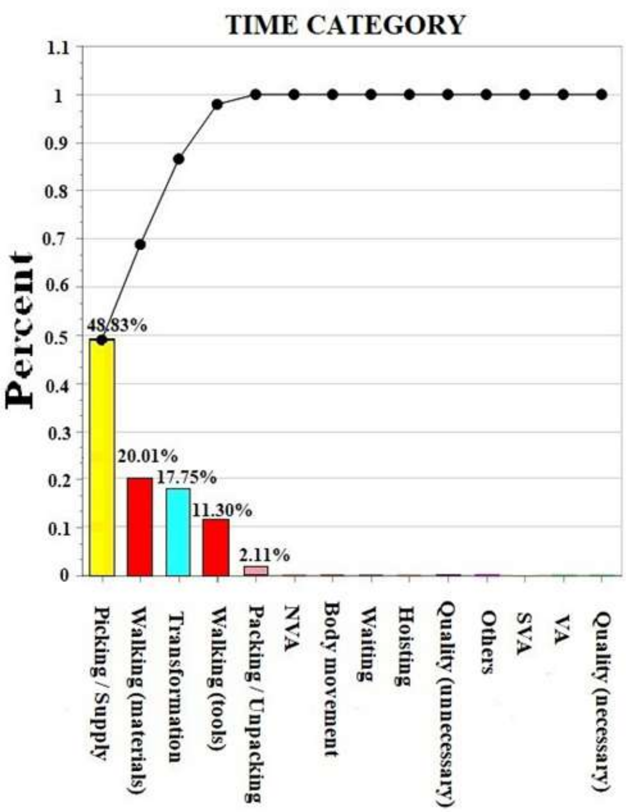
Software also gives overall activities graph as shown in the graph 5.



Graph 5: Overall activities graph

VI. Conclusion

From the time study results it was found that maximum portion of work was SVA activities. The sum of SVA and NVA activities are almost 82% of the overall cycle time. VA activities are only 18% of the overall cycle time. This shows that the actual productivity (VA activities) is only 18% of the overall cycle time required to assemble a product in an assembly line.

The results obtained from the software will be helpful to analyze the activities of the assembly line. Thus Basic M.O.S.T. time study proved to be an effective tool for the work and time measurement studies.

Further these results can be considered to do continuous improvement programmes (CIP) to reduce the NVA activities of the assembly line. If the NVA activities are reduced, overall cycle time required to assemble a product will also be reduced. This will increase the efficiency of the assembly line.

This software also includes stopwatch study which further increases the quality of the study being conducted. This software is like a complete package for all the work and time measurements studies for industry.

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