Application of Maynard Operation Sequence Technique (MOST) - A Case Study

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Abstract - In today's fierce competition it is essential for companies to eliminate or reduce idle, down time of operations in addition to improved methods of working, to survive in the globally expanding scenario. The paper presents a case of a small-scale machining unit engaged in machining of Cylinder body part and Valve body part of tractor engine. The identified areas of improvement are - manpower utilization and establishment of capacity, based on scientific investigation. The study highlighted the need to establish a standard time for activities, planned aisles and streamlining the material flow. Workstations were a major focus and were rearranged as per the principles of method study and ergonomics. Time standards have been established for 7 CNC machine and 1 conventional drilling machine. Capacity of the valve body section is determined based on the improved working conditions. Present method improves the manpower utilization by up to 10% by reducing 25% of excess manpower.

Keywords –Maynard's Operation Sequence Technique (MOST), Bottlenecks, manpower utilization

I. Introduction

The advent of technology has seen businesses emphasize on diversification and competitiveness in establishing market share. Manufacturing companies are often unable to meet customer demands, which may happen due to various reasons such as improper resource allocation and utilization. Resource allocation and assessment of the manpower requirement can be gauged on two factors. The manpower employed is either in excess to the requirement, or in some cases in shortage. Another concern is the resource utilization level, which largely depends on the way of doing work, and tools used. In both cases, the resource allocation and utilization directly or indirectly affect the profitability of a business, as more wages for extra labor or high penalty for late deliveries need to be paid by the manufacturer. Thus necessary measures are to be initiated to sustain the competitiveness of a business in the market and to increase productivity.

As a part of strategy, productivity can be improved by applying the 'work and time measurement' techniques. Productivity can be enhanced by defining - proper working methods and standard time, maximizing the resource utilization and balancing of work among workstations, etc. One of the most common methods used in industries for determining the standard activity time is the Methods Time Measurement (MTM), developed in 1948 for dividing the operations into basic motions (Gennady et al., 1989). The detailed nature of MTM leads to a number of drawbacks such as the tediousness of work, the handling of a huge amount of detailed data during their application, and etc. Maynard proposed the concept of Maynard Operation Sequence Technique (MOST) in 1960, to overcome these drawbacks. The MOST is a technique used to analyze the operations or sub- operations in terms of time by performing several methods, steps and sequences. In other words, it is a predetermined motion time method that aims to define the standard time.

In this paper, investigation was carried out on a machining line of an automotive vendor company. The aim is to identify and minimize the Non Value added Activities (NVA), standardization of work method and time, maximizing the utilization of resources. The principles of method study and ergonomics along with MOST are applied for setting the time standards along with improved method of working.

II. BASIC MOST

MOST is a work measurement technique, introduced to compile the standard work time and maximize the resource utilization by improving the working method. Though Maynard first introduced the concept of MOST in 1960, its industrial application had begun from 1967 in the form of Basic MOST. In 1970, the Basic MOST was modified and named as Clerical MOST for performing administrative and clerical work in production and service industries There are three general versions of the MOST found in literature i.e. Basic MOST, Mini MOST, and Maxi MOST. To perform a manual work, the Basic most defines a sequence of three actions namely General Move, Control Move and Tool Use.

A. General Move –

The free movement of a studied object in air are explained and categorized under the General Move Sequence Model. In brief, the General Move model follows the Sequence of GET, PUT, and RETURN i.e. |A B G|, |A B P|, and |A|. An explanation of the parameters A, B, G, and P are given in Table 1.

Table 1: Parameters used in General Move

Representation	A	B	C	P
Description	Action Distance	Body Motion	Gain Control	Placement

B. Control Move –

The Control Move Sequence Model is used to study the movement of a studied element while it is in contact with surface or attached with other objects. The control move model has sequence of GET, MOVE or ACTUATE, and RETURN phases i.e. |A B G|, |M X I|, and |A|. An explanation of the parameters A, B, G, M, X and I are given in Table 2.

Table 2: Parameters used in Control Move

Representation	A	B	C	M	X	I
Description	Action Distance	Body Motion	Gain Control	Move Controlled	Process Time	Alignment

C. Tool Use –

The Tool Use Sequence is used to explain the application of tool during the assembly or production, The Tool Use model consists of a Sequence of GET TOOL, PLACE TOOL, TOOL ACTION, PLACE TOOL, and RETURN phases i.e. |A B G|, |A B P|, |U|, |A B P|, and |A|. An explanation of the parameters A, B, G, P and U are given in Table 3.The Tool phase includes F - Fasten, L- Loosen, C - Cut, S - Surface Treat, M - Measure, R- Record, and T - Think.

Table 3: Parameters used in Tool Use

Representation	A	B	C	P	U
Description	Action Distance	Body Motion	Gain Control	Placement	Tool Action

D. Time Unit used in MOST –

The time measurement unit (TMU) is used as a time unit for MOST analysis, which is converted to the minute by using the following Table 4.

Table 4: Unit conversion table

1 TMU	=	0.00001 HOUR	1 HOUR	=	100,000 TMU
1 TMU	=	0.0006 MINUTE	1 MINUTE	=	1667 TMU
1 TMU	=	0.036 SECOND	1 SECOND	=	27.8 TMU

III. CASE STUDY

This case study was conducted in an auto part vendor firm. This firm is responsible for the machining operation of cylinder head and valve body parts required for tractor engines. The firm is divided into major three departments, namely cylinder head part machining, valve body part machining, and Pre dispatch inspection area. Present study is focused on valve body part machining department. The Machining unit consists of 7 CNC machine referred to as VMC-(03,04,05,06,07,08,09) and one conventional Drilling M/C. The flow of material is as shown in figure 1.The flow of material starts from VMC-09 and flows subsequently to the other machining unit as shown. The input of one machine is dependent on the output of previous machine unit in the flow. The study is conducted for each machining unit breaking down activities into elements for MOST calculation.

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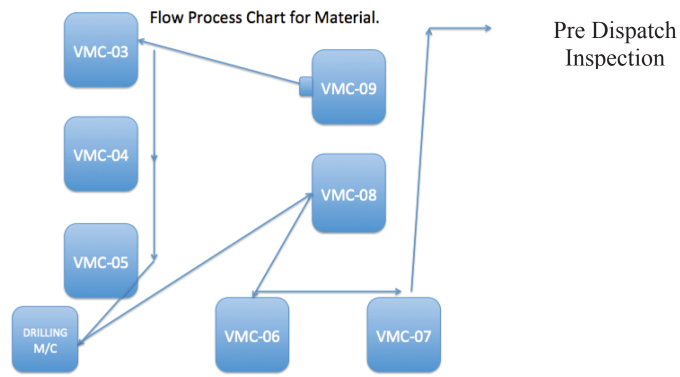

Fig (a). Process Flow of Material

To show the data extraction process in line with the MOST analysis, a brief explanation is given below by taking the example of an elemental activity performed to Pick and Place part on Machine at VMC -09. It performs rear part profiling of the valve body part.

Table 5.Sample of data extraction and MOST calculation

SN.	Method Description	Index Value	Frequency	Move
1	Move 1-2 Steps, bend, pick Valve Body and place with adjustment on the fixture	A3B6G3 A3B0P3 A0	1	General Move
2	Reach Grasp Fixture, Reach Place with Adjustment on Valve Body	A1B0G1 A1B0P3 A0	1	General Move
3	Reach Grasp Bolt, tighten with 5 finger spins	A1B0G1 A0B0P0 T10 A0B0P0 A0	2	Tool Use
4	Reach Grasp wrench, Reach put on bolt, Fasten 3 Arms Strokes, Reach put Aside	A1B0G1 A1B0P1 T16 A1B0P1 A0	2	Tool Use

Sample Calculation:

Formula: Time= (Sum of index value)X(Assigned Value for Basic Most, i.e 10)X Frequency. (Unit in TMU)

Element 1: (18TMU) x10 x1 =180 TMUs

Element 2: (6 TMU) x10 x1=60TMUs

Element 3: (12TMU) x10 x2 =240TMUs

Element 4: (22TMU) x10 x2 =440TMUs

TOTAL: 920TMU X0.036= 33.12 Seconds.

Similar procedure has been adopted in assigning the index values for estimating the elemental times involved in all other operations conducted. The relevant data represented in Table 6. The time unit is in minutes.

Table 6. Estimated values for all operation

Operation	TMU	Manual Work Content			Process Time	Cycle Time
		Online	Offline	Spraying Operation		
VMC09	2056	1.03	0.03	0.17	2.56	3.76
VMC03	2167	1.1	0.03	0.17	4.39	5.66
VMC04	2250	1.15	0.03	0.17	5.38	6.7
VMC05	2200	1.12	0.03	0.17	5.2	6.49
Conventional Drilling M/C	889	0.5	0.03	0	0.67	1.17
VMC08	2133	1.08	0.03	0.17	4.43	5.68
VMC06	1722	0.83	0.03	0.17	5.18	6.18
VMC07	1222	0.5	0.07	0.17	6.17	6.84

IV. METHODOLOGY

Analysis of the existing work method along with its time content has revealed the various areas of improvement such as establishment of work methods based on scientific techniques, setting of time standards. Due to the absence of pre-defined standard time, working methods and lack of practice of advanced techniques wastages such as unplanned walking distance, material wastages and imbalance in the material flow, the non-value added activities were noticed. Principles of method study and ergonomics were used for improvement of workstation design. The MOST technique is implemented for identifying the bottlenecks and Non Value Added Activity (NVA) of the production line as well as setting time standard. The whole methodology is arranged in two different sections namely (1) Bottleneck identifications and (2) Defining the scope of improvements.

A. Bottleneck Identification –

On the basis of the MOST analysis, some of the scope of improvement in the studied line for the rear valve body part has been identified and possible solutions of incorporating the advanced resources are proposed accordingly.

The MOST analysis is used in this study to determine the NVA activities, unnecessary movements and the bottlenecks of the whole line. The bottlenecks in this study are viewed from two different perspectives i.e. bottleneck workstations within the machining line and the bottleneck tasks within each workstations. The bottleneck workstation in the production line can be easily identified as the station having the maximum cycle time. Similarly, within the workstation, tasks having the maximum activity time can be identified as bottleneck tasks. The elemental times presented in Table 7 are used to identify the bottleneck task within the workstations. The Time unit is in minutes. From the table 7 it can be identified that VMC 07 is bottleneck station.

Table 7. Bottleneck Identification

Operation	Cycle Time	Capacity/Shift	Capacity/ Day
VMC09	3.76	180.3	360.6
VMC03	5.66	119.9	239.7
VMC04	6.7	101.2	202.5
VMC05	6.49	104.5	209
Conventional Drilling M/C	1.17	581.1	1162.3
VMC08	5.68	119.4	238.9
VMC06	6.18	109.7	219.4
VMC07	6.84	99.2	198.3

B. Scope of Improvement –

The present resource and manpower utilization of valve body machining department is as shown in table 8. The Manual content of work comprises of Online and Offline work content. The cycle time consist of online work content and process time. The time unit is in minutes.

Table 8. Present resource utilization

Operation	Manual Work Content	Process Time	Cycle Time	Idle Man Time	% Idle	Present Deployment
VMC09	1.23	2.56	3.76	2.53	67%	1
VMC03	1.3	4.39	5.66	4.36	77%	1
VMC04	1.35	5.38	6.7	5.35	80%	1
VMC05	1.32	5.2	6.49	5.17	80%	1
Conventional Drilling M/C	0.53	0.67	1.17	0.63	54%	1
VMC08	1.28	4.43	5.68	4.4	77%	1
VMC06	1.03	5.18	6.18	5.15	83%	1
VMC07	0.73	6.17	6.84	6.1	84%	1
Total Number of Man Deployed Online						8

The manpower allocation cab be rescheduled as 1 person each on machines VMC- 03/ VMC-0 and on VMC-06 / VMC-07. Thus manpower utilization is improved. The proposed manpower utilization is as shown in table 9.

Table 9. Proposed resource utilization

Operation	Manual Work Content	Process Time	Cycle Time	Idle Time	% Idle	Proposed Deployment
VMC09	1.23	2.56	3.76	2.53	67%	1
VMC03	1.3	4.39	5.66	4.36	60%	1
VMC04	1.35	5.38	6.7	5.35		
VMC05	1.32	5.2	6.49	5.17	80%	1
Conventional Drilling M/C	0.53	0.67	1.17	0.63	54%	1
VMC08	1.28	4.43	5.68	4.4	77%	1
VMC06	1.03	5.18	6.18	5.15	74%	1
VMC07	0.73	6.17	6.84	6.1		
Total Number of Man Deployed Online						6

V. RESULT

By applying the MOST technique, process flow, working procedure (also called standard operation procedure (SOP)) and layout of the plant, it can be easily identified that the work station cycle time can possibly be reduced by modifying method of working. As a result, fatigue experienced by the operator would be delayed and enabling them to work for longer hours consistently in terms of quality and rate of production. Thus by application of MOST and calculation standard time, the resources can be deployed in the most efficient way. Thus an anticipated increase in the manpower utilization of about 7% and reduction in manpower from previous deployment of 8 man on line to 6 man for the same work.

Operation	Present Deployment	Present% Utilization	Proposed Deployment	Proposed % Utilization
VMC09	1	33%	1	33%
VMC03	1	23%	1	40%
VMC04	1	20%		
VMC05	1	20%	1	20%
Conventional Drilling M/C	1	46%	1	46%
VMC08	1	23%	1	23%
VMC06	1	17%	1	26%
VMC07	1	11%		
	8	24%	6	31%

VI. CONCLUSION

Proposed method of valve body section improves the manpower utilization by up to 10% by reduction of 25% of excess manpower. This enhances the capacity of valve body department.

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