Improvement of Productivity for an Engine Assembly Line with the help of Maynard Operating Sequence Technique (MOST)

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Abstract
This paper represents the Work Measurement using Basic MOST which is conducted at KIRLOSKAR OIL ENGINE LIMITED, Kagal plant, Kolhapur for DV engine assembly line. This paper highlights a methodology developed for standardization in the process activities by using Maynard‟s Operation Sequence Technique and minimization of fatigue among the workers in manufacturing line by using Ergonomics. Productivity is the primary goal which is to be achieved for any profitable Manufacturing System. All this initiated by performing study on the manual operator‟s activities. For an engine assembly processes the tools description, process description and existing MOST sheets were studied which provided detailed information about all the movements of assembly activities.
Keywords: MOST, Basic MOST, Non-Value Added activities, most sheets, DV engine assembly line.

Introduction

In this world of advanced technology, every industrial organization has become more competitive in securing its own market share. In this competitive manufacturing arena, inside most of the mass production industries, the lean manufacturing philosophy is widely accepted as it helps to satisfy the customer demand on time by maximizing their utilization. As a part of the way of implementing lean manufacturing philosophy, the work and time measurement techniques helps the manufacturer to increase the productivity by defining the proper working method and standard time, the way of maximizing the resource utilizations and helping to distribute the work load among the workstations etc.

In this paper, a diesel engine assembly line is taken under consideration with the aim of changing the conventional tools, minimizing the bottlenecks, and improving the productivity by standardizing the work method and time. To do so, the MOST technique is implemented for increasing the productivity by identifying the bottlenecks, standard times and Non-Value added activities of the production line.

The project work is carried out in „Kirloskar Oil Engine Limited‟, Kagal plant, a part of kirloskar group. It offers wide range of products includes diesel engines, agricultural pump sets & generating sets. Productivity has been the key factor in the industry and it can be enhanced by minimizing the time.

So the case study is carried out in DV engine assembly line, In this assembly line per shift 5 to 6 engines are manufactured, manual work is very important due to the increase of customized products. A time estimation method based on MOST is reviewed and employed in the assembly line. In order to reduce these factors and to achieve higher productivity at the assembly line the current project work is aimed towards analysis of the existing process, by applying highly practical efficient and cost effective time estimation technique such as MOST-method.

Literature review

The first comprehensive work on MOST was published by Kjell B. Zandin [1] with his appropriate study methods any method can be improved, many efforts have been made to simplify the work measurement task. It was originally developed by H. B. Maynard & Company Inc. this Work measurement technique is largely concerned with human work output and includes a certain amount of allowance to provide for a worker"s personal needs, fatigue and unavoidable delays during the assembly operation they opine. The development of manufacturing data is the first step in the work measurement and forms the basis for applying the time standards.

Patil S showed that it"s possible to achieve major times reduction in the manufacturing of the products. MOST nearly gives non-machining time reduction up to 60 to 65%. Lean manufacturing is an operational strategy oriented toward achieving the shortest possible cycle time by eliminating waste.

They pointed out that estimating methods cannot determine accurate times; hence MOST is a standard method to determine the potential error which helps in minimizing the time taken to perform a task or operation.

Francesco Longoand others pointed out that one of the most important approaches for studying line balancing is work measurement technique using MOST. They suggested that for designing an assembly line, both the line balancing as well as the work measurement technique has to be considered, which plays an important role for measuring the time standards in the assembly process.

Ashish Thakre etal proposed that the MOST work measurement technique is used for minimization of non-productive activities in an assembly line. The study conducted using MOST revealed the excessive movements of the operators that significantly added to the basic work content.

Objectives

1) To study current manufacturing process & practices the given setup for a selected division in the case study organization.
2) Studying the existing performance levels at workplaces selected.
3) To perform work study using BASICMOST at selected manufacturing processes
4) To identify non value added activity occurring at the identified production area
5) Calculation of standard time at workplaces.
6) Implementation of modified process derived from Lean Manufacturing and BASIC MOST application & evaluates the improvement.

Most methodology

MOST is a predetermined motion time system that is used primarily in industrial settings to set the standard time in which a worker should perform a task. The time units used in MOST are based on hours & parts of hours called TMU. The following conversion is provided for calculating standard times:

1 TMU = 0.00001 hour
1 TMU = 0.0006 minute
1 TMU = 0.036 second
1 hour = 100, 000 TMU
1 minute = 1, 667 TMU
1 second = 27.8 TMU
To convert calculated index value into final TMU, we have to multiply total index number by 10.
Ten is called as multiplying factor which is standard number to get TMU of an activity.

Some of important characteristics of MOST are;

1) Gives High accuracy.
2) Reduces the cost and paperwork thus improves productivity.
3) Reduces analysis time with establishing on accuracy.
4) Reduces the time required for data development thus establishing standards.
5) Easy to learn and implement even non-industrial engineers can also easily learn.
6) Generates consistent results.

MOST System Family***:***
Depending upon the level of accuracy MOST is divided into three systems as described below.
The repetitiveness of the operations and cycle time of the operation being performed, type of operation etc., these includes

i. .Mini MOST
ii. Basic MOST
iii. Maxi MOST

(i)Mini MOST: At the lowest level. In general, this level of detail and precision is required to analyze any operation likely to be repeated more than 1500 times per week. An operation in this category may range from 2 to 10 seconds.
(ii)Basic MOST: At the intermediate level, operations that are likely to be performed more than 150 but less than 1500 times per week. An operation in this category may range from a few seconds to 10 minutes in length.
(iii)Maxi MOST: At the highest level, operations that are likely to be performed fewer than 150 times per week. An operation in this category may be just less than 2 minutes to more than several hours in length.

Present work is carried using the basic MOST which are explained in the following section.

Basic MOST System:

In basic MOST the objects can be moved in only two ways, either they are picked up and moved freely through space or they are moved and contact with other surface. The use of tools is analyzed through a separate activity sequence model that allows the analyst the opportunity to follow the movement of a hand tool through a standard sequence of events which is a combination of the two basic sequence models.

i.General Move Sequence: The general move sequence relates to the object which follows an unrestricted path from one location to another through the air.

The Sequence Model

Get	Put	Return
A B G	**A B P**	**A**

The first phase, referred to as „Get", describes the actions to reach the object, with body motions (if necessary) and gain control of the object.

Where

A = Action distance of a hand or body must travel to reach an object

B = Body motion required to during this action

G = Gain control of an object considering the degree of difficulty encountered.

The second phase, referred as „Put", the put-phase of the sequence model describes the action to move the object to another location. As before in first phase, A and B-parameters indicate the distance of the hand or body travels with the object and the need for anybody motions during the move before the object is placed. The manner in which the object is placed is described by the P-parameter.

The third phase simply indicates the distance travelled by the operator to return to the workstation.

ii.Controlled Move Sequence: The controlled move sequence describes the manual displacement of an object over a „Controlled" path. Controlled move follows a fixed sequence of sub-activities identified by the following steps; reach with one or two hands to the object with a distance either directly or in conjunction with body motion, gain manual control over the object, move the object over a controlled path, Allow time for a process to occur, Align the object following the controlled move, return to workplace.

The Sequence Model

Get	Move	Actuate Return
A B G	**M X I**	**A**

The fundamental changes occur in the activity after following G-parameter. This phase describes actions either to simply move an object over a controlled path or to actuate a control device.

Where M – Move Controlled (all manually guided movements along controlled path)

X – Process Time (indicates the time required for work controlled by mechanical or electronic devices, machines)

I – Alignment of objects.

iii.Tool Use Sequence: normally it is a combination of General Move and Controlled Move activities, along with specially designed parameters describing the actions performed with hand tools or, in some cases mental processes required when using the senses as a tool.

The tool use sequence model is ABG ABP *ABPA

In which

ABG – Get Tool, ABP – Put Tool, * - Use Tool, ABP –Aside Tool, A – Return

„Use Tool „phase is provided for the insertion of one of the following tool use parameters. F, L, C, S, M, R and T-parameter to fasten, loosen, cut, surface treat, measure, record and think respectively.

Case study

MOST application at Production Line:

The present study makes use of Basic MOST for the estimation of NVA activities and worker"s fatigue problem and tries to reduce them.

The study was carried out in three phases: (i) Time Study (ii) Basic MOST analysis to identify NVA activities and (iii) Finding & Elimination of the NVA activities by suggested the necessary changes in work methods.

I. Time Study:

The total activity time consists of operator of traveling due to placement of material and other operating devices far from line were note down by timing device i.e. stop watch. Time study is a technique to estimate the time to be allowed to a qualified and well-trained worker working at a normal pace to complete a specified task by using specified method. This technique is based on measuring the work content of the task when performed by the prescribed method, with the allowance for fatigue and for personal and unavoidable delays. This technique is based on measuring the work content of the task when performed by the prescribed method, with the allowance for fatigue and for personal and unavoidable delays. Divide the operation into reasonably small elements, and record these on the Time Study observation sheet multiply it by the rating factor to get normal time.

(a) Normal time = Observed time * rating factor

Determine allowances for fatigue and various delays.

Determine standard time of operation by adding allowances

In normal time i.e.

(b) Standard time = Normal time + Allowances

Table-1
Measured time of station no. 1 using stopwatch-

	ACTIVITIES	TIME (seconds)
1	Liner Fitment	360
2	Crankcase Dummy Plate Fitment	160
3	Fitment of oil drain pipe adaptor of FIP on crankcase	100
4	Fitment Of Core Plugs	50
5	Fitment of turbo oil supply adaptors	45
6	Bell Housing Dowel Fitment	55
7	Camshaft dowel fitment (On camshaft trolley)	45
8	Oiling of cambores	55
9	Camshaft insertion	90
10	Fitment of thrust plate for camshaft	100
11	Fitment of camshaft gear	70
12	Camshaft endplay checking	70
	TOTAL TIME (in seconds)	**1200**
	TOTAL TIME(in minutes)	**20**

II. MOST time study of diesel engine assembly line:
The present project work is focused on the detailed analysis of operations associated with DV diesel engine assembly involving nine main assembly stations & four sub-assembly stations, which covers the subassembly of Piston connecting rod, cylinder head, and Header cooler, CAC pipe & alternator. Further each activities of subassembly is broken down into subsequent elemental operations using Basic MOST. Critical elemental operations which directly affect the productivity are first identified and attempts are made to reduce these index parameters by knee observation of worker‟s movement.
Each activity is broken down into elements and these elements are then sequence modeled using the index parameters and index parameter values using MOST Data Card.

TMU= (Sum of all elements)
Where,
TMU= Time measuring unit.
The operational time for each element is evaluated based on the parameters and index values the time value for a sequence model in the basic MOST is obtained using the relation as given below.

(c) Standard Time = (TMU) × (0.36 × frequency) in seconds

The common scale of index numbers for all MOST sequence models is 0, 1, 3, 6, 10, 16, 24, 32, 42 and 54. Higher index values of the parameters lead to higher work contents. The time value for a sequence model in basic MOST is obtained by simply adding the index numbers for individual sub-activity and multiplying the sum by 10.

For example, suppose an operator walks 5 steps towards rack & bend slightly to pick up a bolt from the bin & then place it near the table within reach.
A 10+B3+G1+A1+B0+P1+A0
So the TMU is,
(10+3+1+1+1)*10 =160 TMU

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Table 2:

MOST Estimation Sheet of existing activities of station No.1:

Sr No.	STATION 1 A	Estimated Time in sec
1	walk 5-7 steps from towards engine pallet & connect the hooks of crane to engine	42.84
2	clean the crank case using banyan cloth	10.08
3	pick up dummy plate according to crankcase length & mount it on crank case	10.08
4	pick up allen bolts & assemble them on dummy plates	29.88
5	pick up battery operated gun & tighten allen bolts	21.6
6	apply oil in crankcase liner bore	27
7	apply oil to O-rings	12.6
8	pick up three liner O-ring & locate one by one liner O-ring on liner grooves	53.28
9	pull liner trolley near assembly fixture	16.2
10	clean the liner from inside & outside with banyan cloth	10.44
11	clean liner seating face in crank case	7.2
12	pick up zealac from the rack, uniformly apply zealac sealant on liner resting face of liner	10.8
13	pick up liner subassembly & carefully insert it in crankcase	41.04
14	pick up liner pressing mandrill & hand hammer from rack	4.68
15	press liners by hand pick up liner pressing mandrill & hand hammer	51.12
16	clean the top surface of liner for excess zealac sealant	23.4
17	pick up camshaft from rack & guide it in cambore	11.88
18	apply oil on camshaft then insert camshaft in cam bore	68.76
19	pick up the cam gear from the trolley & mount it on cam shaft	33.12
20	insert the 4 bolts in cam gear	37.44
21	fit the lock pin & fittment of cam gear	92.16
22	pick up the torque wrench & apply torque to all bolts	40.32
23	check the clearance	12.6
24	bring dial gauge, mount it on crank case	25.92
25	check the reading	54.72
26	fill up check sheet	38.52
	TOTAL TIME in seconds	**787.68**
	TOTAL TIME in minutes	**13.02 min**

III Finding & Elimination of NVA Activities:

From MOST analysis it"s found that some excessive activities are occurring during operator"s manual operations Index parameters represent the element involving Considerable walking, bending, grasping, placement, process time etc. Such elements obviously indicate the higher probability of NVA activities. Primary observations revealed the scope for reducing the NVA activities.

Table 3:

DETAILS OF OPERATION TIME REDUCTION				
Sr No.	**Operation Name**	**Existing Time (Seconds)**	**Modified Time (Seconds)**	**Reduction in Time (Seconds)**
1	moving crane towards engine pallet & connecting hooks to the engine	60	42	18
2	fitment of liners	360	285	75
3	camshaft insertion	90	80	10
TOTAL				**103**

Table 4:

DETAILS OF OPERATION TIME ELIMINATION		
Sl No.	**Eliminated Operation Name**	**Operation Time in (Seconds)**
1	move empty liner trolley	27
2	bring sealant (zelac) from another station	10
TOTAL		**37**

Due to space limitations, details of modified standard time for all assembly stations & sub-assemblies of components are not presented in the paper

Table 5:

DETAILS OF MODIFIED STANDARD TIME FOR DV engine assembly line.

STATION NO	Current standard time (minutes)	Modified standard time (minutes)
1	20	13.58
2	32	16.52
3	6	2.68
4	54	36.49
5	46	38.87
6	41	33.23
7	52	45.52
8	6	3.05
9	94	73.85
TOTAL	**351**	**263.73**

Conclusion

After implementation of new time standards for elemental operations the following improvements are achieved

1) There is a significant reduction in the overall time consumption of DV engine assembly process from 351minutes to263.73minutes.
2) Because of utilization of MOST one extra engine can be manufactured per shift.
3) The study revealed that the MOST can be successfully utilized to determine the NVA activities associated with various work elements.
4) The study carried out to eliminate waste by Value stream mapping and implementing BASIC MOST to improve effectiveness of process. Also BASIC MOST helps to improve effective working time.
5) Further Lean manufacturing was employed for identification of wastes in a process along with Method time measurement to improve effectiveness of process.

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