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Research Paper

CYCLE TIME REDUCTION THROUGH TOYOTA PRODUCTION SYSTEM

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Toyota's renowned Toyota Production System (TPS) has confirmed the competitive advantage of continuous process improvement in manufacturing. The wide range of industries such as aerospace, metals processing, consumer products etc. have tried to copy TPS system. This system draws a clear distinction between operators own work and work done by his machine in auto cycle modes. Also the operator work is accurately quantified. This makes a very significant departure of Toyota production system from conventional engineering practice prevalent in many old establishments. It follows general rules such as all work is highly specified in its content, sequence, timing, and outcome. Each worker knows who provides what to him, and when. Every product and service flows along a simple, specified path. The man power requirement calculated by TPS concept, results in most optimum utilization of manpower, which is one of the keys to high lobour productivity. In this paper, an attempt is being made to optimize the manpower requirement of one of the section of manufacturing unit by application of TPS concept.

Keywords: Optimization, Toyota Production System, Productivity Improvement, TACT time, MOST

INTRODUCTION

For productivity improvement, Toyota Production System (TPS) is the most power- ful model which takes concern of efficient design and management of large-scale operations. TPS is an integrated socio-technical system, developed by Toyota that comprises its management philosophy and practices. TPS organizes manufacturing and logistics for the automobile manufacturer, including interaction with suppliers and customers. This system helped boost Toyota Motor Corporation from a small truck maker struggling in the wake of World War II, to the world's third largest automaker by the end of the 1980's (M Cusumano, 1985), For improving productivity, most of the modern production systems rely on the principle of assembly line work. (N Boysen *et al*., (2008). The components of the products to be processed, moves down line which is composed of successive stations. At each workstation, one or more workplaces are installed. Generally, each workplace is equipped with one operator who performs a set of tasks on each of the successive product units in a defined

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manner considering cycle time. Usually the total work content is divided into smaller tasks. The standard time is estimated for each of the identified tasks. Maynard Operation Sequence Technique (MOST) is work measurement techniques that deliberate on the movement of objects. It is used to analyze work and to determine the normal time that it would take to perform a particular task/operation. MOST was originally developed by H. B. Maynard & Company Inc. The earlier research reveals that MOST concept was widely used for many of the manufacturing application (H Maynard *et al*.,1948; D Karger, and F Bayha, 1987; G Kanawaty, 1992; F Longo, and G Mirabelli, 2009; K Zandin, 1990). MOST is a work measurement technique that concentrates on the movement of objects. It is used to analyze work and to determine the normal time that it would take to perform a particular process / operation. MOST is a powerful analytical tool to measure every minute spent on a task. It makes the analysis of work a practical, manageable and cost effective task. Even though the production line is established, it presents numerous problems. One of the problems is, balancing operations or workstation in terms of equal times and of the times to meet the desired rate of production. The purpose of this paper is to optimize the manpower requirement of manufacturing unit for improving productivity.

METHODOLOGY

It was observed in paint shop of this toy manufacturing unit that even after knowing all parameter like details of activities, their dependency, required production quantity and time estimates for various activities, the required production target was not achieved. In spite of sufficient manpower deployment in the paint shop, there were bottleneck at some stations. It was also observed that some stations on line were overburdened while some were underutilized creating imbalance on paint line. All these problems ultimately results in lowering productivity and inefficient manpower utilization. The operation related to paint shop were selected for study and line balancing. The reasons for having selected these operations are as follows:

1) Required production target was not achieved.
2) Bottleneck at some workstations on the line.
3) Some workstations were over-burdened while some underutilized.
4) Possibility of methods improvements in some operations.
5) Possibility of manpower reduction in paint shop.
6) Minimizes losses during production

Table 1 depict the existing work distribution pattern in the paint shop.

Table 1: Existing Work Distribution

Sl. No.	Activity	No. of Worker
1	Phosphating of H/W bodies	1
2	Drying and handling H/W bodies to oven	-
3	Cleaning of bodies by cloth	2
4	Jigging of bodies	4
5	Cleaning of bodies by compressed air flow	1
6	Base coat painting	1
7	Top coat painting	1
8	Dejigging of painted bodies	2
9	Final inspection of painted bodies and self arranging in crate	3
10	Removing jig from paint booth hook, hanging on trolley bar and load/un-load trolley in oven	1
	Total man power deployment	16

Time Available to Complete Task (TACT) of a factory is like the pulse rate of the human body. TACT time is the rate, at which production actually need to be done for achieving a given output target. TACT time is directly proportional to net available time for production, and inversely proportional to the quantity required to be produced. TACT time thus focuses the attention of everyone on the shop floor on what has to be done this movement. The Basic MOST System is used for evaluating the standard time for various operations.

A. The Basic MOST System

The Basic MOST System satisfies the work measurement situations in manufacturing industries. The units used in MOST system are labeled as Time measurement Unit (TMU). And one TMU is equivalent to 0.00001 hour. Every company very likely has some operations for which the Basic MOST is the logical and most practical work measurement tool. The sequence models of Basic MOST represent only two basic activities necessary to measure manual work i.e. General Move and Controlled Move. The remaining sequence models included in Basic MOST was added to simplify the measurement of hand used tool. The Basic MOST work measurement technique (M Cusumano, 1985), comprises the following sequence models:

(i) General Move Sequence: for the spatial movement of an object freely through the air

A B G	A	B P A
Get	Put	Return
Where	A =	Action distance
	B =	Body motion
	G =	Gain control
	P=Placement	

(ii) Controlled Move Sequence: for the movement of an object when it remains in contact with a surface or is attached to another object during the movement.

The move sequence model is

A B G	M X I	A
Get	Move	Return
Where	M =	Move Controlled
	X=	Process Time
	I =	Alignment

(iii) Tool Use: for the use of common hand tools. However, the Tool Use sequence model does not define a third basic activity normally it is a combination of General Move and Controlled Move activities.

The tool use sequence model is

ABG ABP (F/L/C/S/M/R/T)* ABP A, where

ABG: Get Tool, ABP: Put Tool, *: Use Tool, ABP :Aside Tool, A : Return

Subsequent to listing all the standard operations & dividing these activities into smallest practical indivisible task, the normal time for various operations was estimated by using Basic MOST. After having found the normal time for operations, these times are extended to standard time by adding the requisite allowance. Table 2 shows, summary of Normal and standard time for various operations on paint line for processing one batch of H/w car bodies.

CALCULATION OF TACT TIME

The next requirement in TPS, is finding net available production time and production quantity in the shift to estimate TACT time.

The company has working shift of 8 hours and 30 minutes, but all this time is not available for production. Thus, after deducting total non productive time in shift from total shift time, the net available production time in shift was evaluated.

Table 2: Basic and Standar Time for Various Operations for Processing One Batch

Sl. No.	Activity	Basic Time in Sec	Standard Time in Sec
1	Phosphating of H/W bodies	97	107
2	Drying and handling H/W bodies to drying oven	2.7	3
3	Cleaning of phospheted bodies by cloth	233	257
4	Jigging of H/W bodies	273	300
5	Cleaning of bodies by compressed air flow and hanging the jig on paint booth hook.	99	109
6	Base coat painting	105	121
7	Removing jig from booth hook, hanging it on trolley bar & load/unloading trolley in oven	29	32
8	Rehanging of jig on paint booth hook,for top coat, handling of trolley from and to dejigging area	32	35
9	Top coat painting	130	149
10	Removing the jig from paint booth hook, hanging on trolley bar, load/unload in oven	29	32
11	Dejigging of painted bodies and placing empty jig on hanger in jigging area	200	220
12	Final inspection of painted bodies and self arranging bodies in plastic crate	246	271

After considering anticipated rejection & losses from past data and present findings, the total bodies to be painted per shift are calculated. It was estimated that the company has to process 189 batches, where each batch contains 72 H/w bodies. This batch size indicates number of bodies that can be mounted fixture which is its limiting capacity for painting. This data was used for calculation of TACT time.

WORK DISTRIBUTION

The work assigned to each operator must be such that each operator can complete his work within TACT Time. Machine and operator Time analysis chart reveal idea of bottleneck stations and also some operations which can be combined together.

For operation sequence number 3, 4, 11 and 12 the time required to perform task is greater than TACT time. That is, if only one operator is provided for each of the above operation, they will create Bottleneck at respective station. Therefore for operation sequence 3, 4, 11 and 12 we have to provide 2 operators each.

From Machine and Operator Time analysis chart, it is clear that we can combine operation sequence no. 2, 7, 8 and 10 for which total operator is 102 seconds. These operations can be combined because all are handling operations from one station to another. One operator will be assigned this task. For remaining operations the cycle time per batch is less TACT time, moreover these operations cannot be combined. Thus each operation is provided one operator.

Thus, after considering operators work content per batch for each operation and TACT Time, the final work distribution is as shown in the Table 3.

Therefore, total number of operators required to carry out complete task related to paint line was found to be 13. After assigning work to each operator on line operator utilization for various station was calculated.

Table 3: Work Distribution Table

<table>
<tr><th>Oprn No.</th><th>Activity</th><th>No. of Worker</th></tr>
<tr><td>1</td><td>Phosphating of H/W bodies</td><td>1</td></tr>
<tr><td>3</td><td>Cleaning of bodies by cloth</td><td>2</td></tr>
<tr><td>4</td><td>Jigging of bodies</td><td>2</td></tr>
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<tr><td>9</td><td>Top coat painting</td><td>1</td></tr>
<tr><td>11</td><td>Dejigging of painted bodies</td><td>2</td></tr>
<tr><td>12</td><td>Final inspection of painted bodies</td><td>2</td></tr>
<tr><td>2</td><td>Drying and handling H/W bodies to oven</td><td rowspan="4">1</td></tr>
<tr><td>7</td><td>Removing jig from hook, hanging on trolley bar, load/unload trolley in oven</td></tr>
<tr><td>8</td><td>Rehanging of jig on paint booth hook, handling of trolley from and to dejigging area</td></tr>
<tr><td>10</td><td>Removing the jig from booth hook, hang on trolley bar, load/unload in the oven</td></tr>
</table>

CONCLUSION

This analysis provides utilization of operators for various work station considering TACT Time and work content for respective station. It is seen that there is considerable variation in the work content from operator to operator from a minimum of 102 seconds to maximum of 150 seconds, even after combining some operations since it is not possible to split the activities further. Therefore, while one has to work almost continuously, the other operator have some idle time equal to difference between TACT time and work content. For jigging of bodies, the work content of the operator is slightly more than Tact time. In such cases the operator must work little faster. If this is not possible then management should try the possibility of shifting some load to other operator during idle time.

The proper application of TPS results in improving productivity through labour effectiveness and utilization resulting in reduction of extra manpower. The bottleneck workstations were identified and number of operators to be deployed in paint shop were estimated which comes out to be 13. Thus resulting in reduction of manpower from 16 to 13 i.e. 18.75% reduction in manpower maintaining the production target, ultimately improving productivity. Thus by applying Toyota Production System, cycle time can be reduced to considerable extent, hence enhancing productivity.

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