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Improving Productivity for Engine Crank Case Machining Line Using TPS Techniques and Simulation

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Abstract

Process optimisation is a major decision problem when drawing a balance between work distribution of workers during processing and maintaining requirement as per demand of customer. Toyota Production System (TPS) techniques are useful tool to optimise the process parameters in process type of industry. The validation of optimum process result from TPS techniques is done with the help of simulation modelling using ARENA as simulation software. Simulation methods of analysis, supported by increasingly powerful and user-friendly software tools, are gaining greater acceptance as an indispensible aid to business managers, engineers and analyst seeking productivity improvement. Within this paper TPS techniques are used to optimisation of Engine Crank-case machining line (fully Automated) where single operator operates multiple machines to load and unload the work-piece to and from machines. Simulation methodology has been conducted to verify and validate the existing situation as well as proposed results.

Keywords: *ARENA Simulation Software, Time Study, Motion Study, Method Study, Standardised work combination table.*

1. Introduction

Present business conditions are forced production companies which want to achieve and to detain its concurrent abilities on the global market to continuously optimise internal organisation of theirs production systems with the aim to increase capacity, decrease costs of production simultaneously and keep products quality at least on the same level. To global business trends are expose production companies in India too. To fulfill above mentioned requirements companies must improve their mostly inefficient production processes.

1.1. Toyota Production System (TPS)

The practical expression of Toyota's people and customer-oriented philosophy is known as the TPS. This is not a rigid company-imposed procedure but a set of principles that have been proven in day-to-day practice over many years [1]. There are two primary pillars of the system. The JIT concept aims to produce and deliver the right parts, in the right amount, at the right time using the minimum necessary resources. This system reduces inventory, and strives to prevent both early and over production. There are several important components to TPS: takt time, flow production, pull via kanban, and leveling (heijunka) [1]. Jidoka (Build in quality) is the second pillar of the system. There are two parts to Jidoka a) Building in quality at the process and b) Enabling separation of man from machine in work environments. The driving force of the Toyota Production system is the elimination of waste aimed at ever improving quality, cost, productivity, safety and morale. The result is greater satisfaction for our major constituents: our customers, our employees and our investors [1]. Many other tools and techniques that were developed in Toyota such as 7 Waste, Standardized Work, 5S, Single Minute Exchange of Die (SMED), Visual Control, Error Proofing, as well as many others [2]. The production system philosophy of Toyota embodies a manufacturing culture of continuous improvement based on setting standards aimed at eliminating waste through participation of all employees. The goal of the system is to reduce the timeline from the time an order is received until the time it is delivered to the actual customer. Ideally the system strives to produce the

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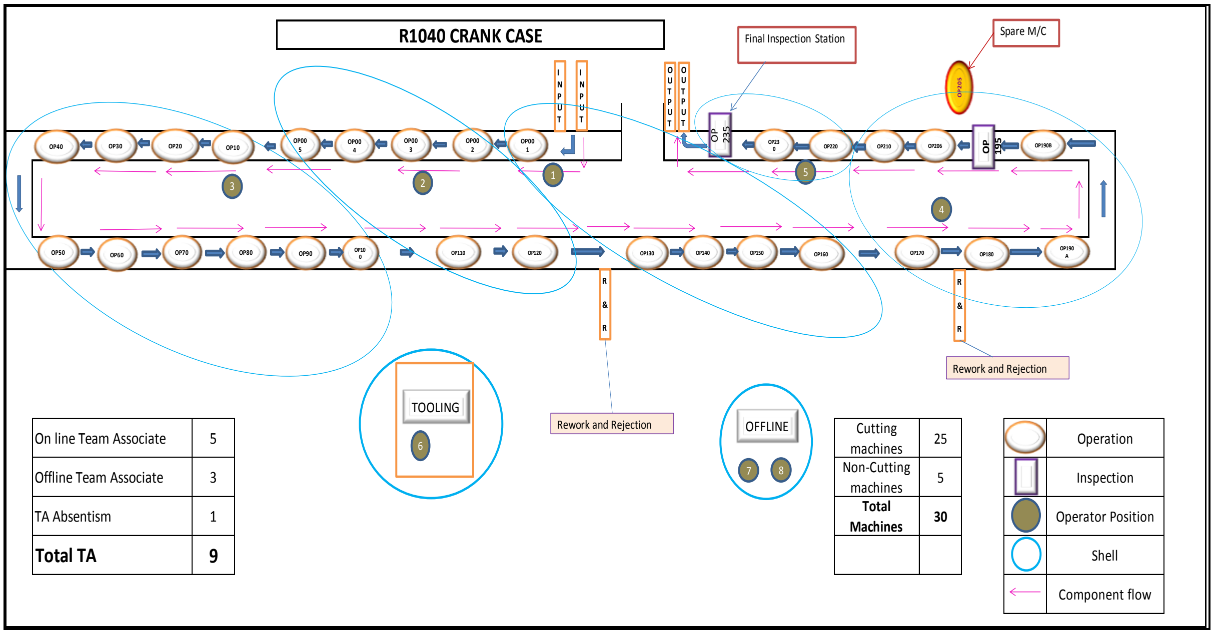

Figure 1. Existing man-power deployment of Engine Crank-case Machining Line

highest possible quality, at the lowest possible cost, with the shortest lead-time possible. The goal of the TPS is to provide products at world class quality levels to meet the expectations of customers, and to be a model of corporate responsibility within industry and the surrounding community [3, 4].

1.2 Simulation Software (ARENA)

The ARENA modelling system from Systems modelling Corporation is a flexible and powerful tool that allows analysts to create animated simulation models that accurately represent virtually any system. Simulation analysts place graphical objects called *modules* on a layout in order to define system components such as machines, operators, and material handling devices. ARENA is built on the SIMAN simulation language. After creating a simulation model graphically, ARENA automatically generates the underlying SIMAN model used to perform simulation runs [5]. The ARENA template is the core collection of more than 60 modules provided as part of the general ARENA system. It was designed to provide a general-purpose collection of modelling features for all types of applications. In addition to providing core features for resources, queuing, inspection, system logic, and external file interface, the ARENA template provides modules specifically focused on specific aspects of manufacturing and material handling. For manufacturing, it contains modules that incorporate such features as machine downtime and maintenance schedules. For material handling applications, modules exist for representing conveyors (synchronous and asynchronous) and various types of transportation devices [6].

1.3. Engine Crank-case Machining Line

A product taken for case study from Oil Engine company, which is one of the leading company in the area of off-Road vehicles engines production. In company, 5'C (Crank-case, Cylinder-head, Crank-shaft, Cam-shaft, and Connecting-rod) engine components are to be machined. Out of, this paper concerned with optimisation of engine Crank-case machining line. The existing man-power i.e. Team Associate (TA) deployment of this line is shown in figure 1.

2. Problem Formulation and Analysis

During Planning of capacity of worker and their operation, management predicts the sequence of operation as well as worker capacity in Crack-case machining line. But after implementation the plan, the capacity of worker increased and sequence of operation is not optimum. The distribution of work as well as time during processing is imbalance in existing layout and it results as increasing idle time as well as waiting time during operation. So it affects the productivity and efficiency of machining line. TPS techniques and Simulation Software need to be study as well as implemented in order to optimise process parameters.

3. Data Collection

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For existing work element, data are to be collected and their analysis has been done by following tools:

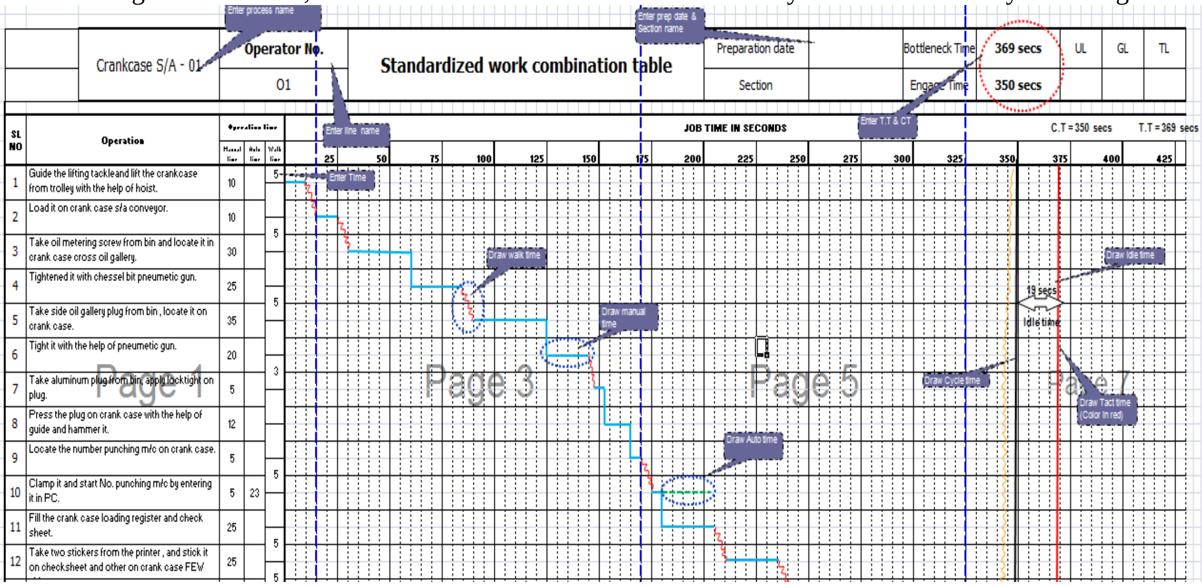

Figure 2. Standardised Work combination table

3.1. Time Study and Method study

Time study and Method study are important tools to analyse the process parameters. By using this, idle time as well as waiting time can be easily calculated. To collect required data, the particular process should be captured and capturing done with the help of video camera & stop watch.

After data collection, the whole activities are split into small activities like pick Crank-case, put Crank-case, etc. with activities time and machining time also. This data help to analyse the process which includes activities (value added, non value added and non value added but necessity activities). Time study and method study gives total time required to perform each activity during process.

3.2. Standardised Work Combination table

Standardised Work Combination table is an important tool used in TPS, which help to analyze the existing operational activities during actual process [4]. After data collection through time study each big activities split up into small activities including value added activities and non value added activities (Loading & unloading of Crank-case, TA walk with Crank-case and TA walk without Crank-case) are noted with their corresponding time into standard format given by TPS. Then draw chart as per standardised table format shown in figure2 for each TA working on crank-case machining line. Standardised work combination table shows waste activities, waste movement, TA walking distance and their corresponding time also. From that engage time, idle time and waiting time calculated.

3.3. ARENA Simulation Model

ARENA 10.0, which is one of the most powerful software for simulation, is used to build the model. Fig.3 shows the simulation model of existing Engine crank-case machining line.

This model consist of 30 *Process module* (number of process on line) with their machining time, *Station & Route module* to transfer Crank –case from one machine to another station with respective transfer time, *Create module* to enter Crank- case on to line and *Dispose module* to exit Crank-case from machining line. Data on arrival rates, inter-arrival times and activity times are collected from time study database. The data were fed to the Input Analyzer application of ARENA for analysis to obtain the statistical parameters of raw data as shown in figure 3.

3.3.1. Verification and Validation

In the Crank-case machining line, model verification and validation steps are implemented. For verification, the animation method is used to show the Crank-case movement inside the model and to ensure that the movement is similar to existing process.

Validation of the ARENA model is done by comparing the model output with real system output. For sake of validation, the number of Crank-case produced per shift is 58, while the real produced rate per shift is 60 Crank-case which is approximately same. After analysis of existing process through

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simulation as well as TPS techniques, the results for each TA are as shown in figure 4.

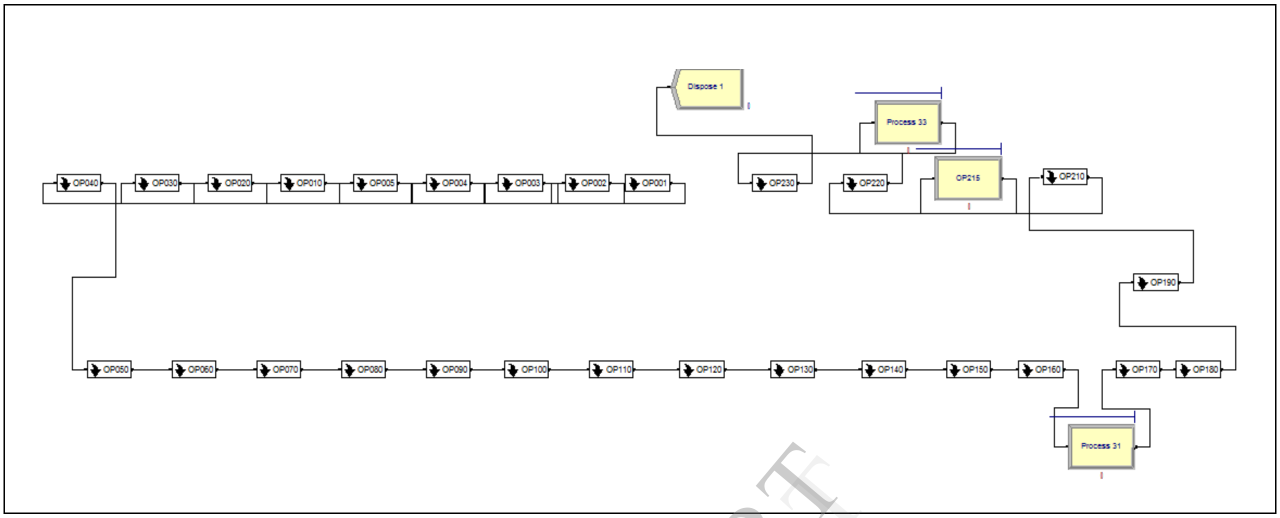

Figure 3. Simulation model for existing engine Crank-case machining line

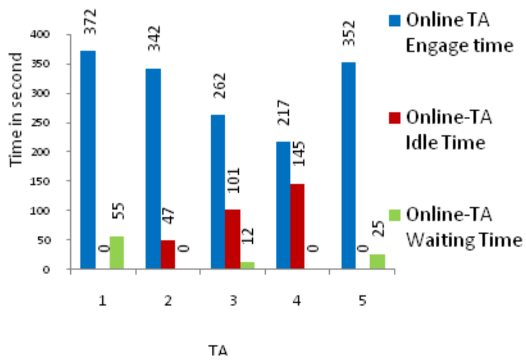

Figure 4. Analysed results of existing man-power deployment for engine Crank-case machining line

4. Problem Solutions

Depending on the analysed results of man-power deployment on machining line, we came to conclusion that:

i. The line is more imbalances.
ii. Online TA idle time is more = Avg. 58 minute per shift.
iii. Online TA waiting time is more = Avg. 19 minute per Shift.
iv. The final inspection is not necessary because after each workstation there is online inspection.
v. The activities like de-burring and chamfering need to be done by machine itself, it not required separate TA. Therefore final inspection, de-burring and chamfering need to be removed in proposed man-power deployment calculations.

On the above calculations of idle time and waiting time, we reconstruct man-power deployment (Proposed loop) as shown in figure 5.for same line with 4 number of TA. For proposed man-power deployment, time study and motion study has been done (Because loading time, unloading time and movement time for TA is same, and the change only in sequence of operation). Standardised work combination table for each TA (4 numbers) drawn to perform the analysis of proposed man-power deployment and then simulate the proposed man-power deployment to predict the output. After simulation it gave same output (58 numbers per shift). The analysed results of proposed man-power deployment for Crank-case machining line are shown in figure 6.

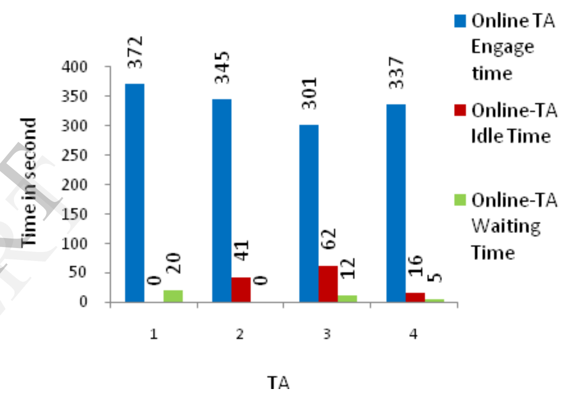

Figure 6. Analysed results of proposed man-power deployment for Engine Crank-case machining line

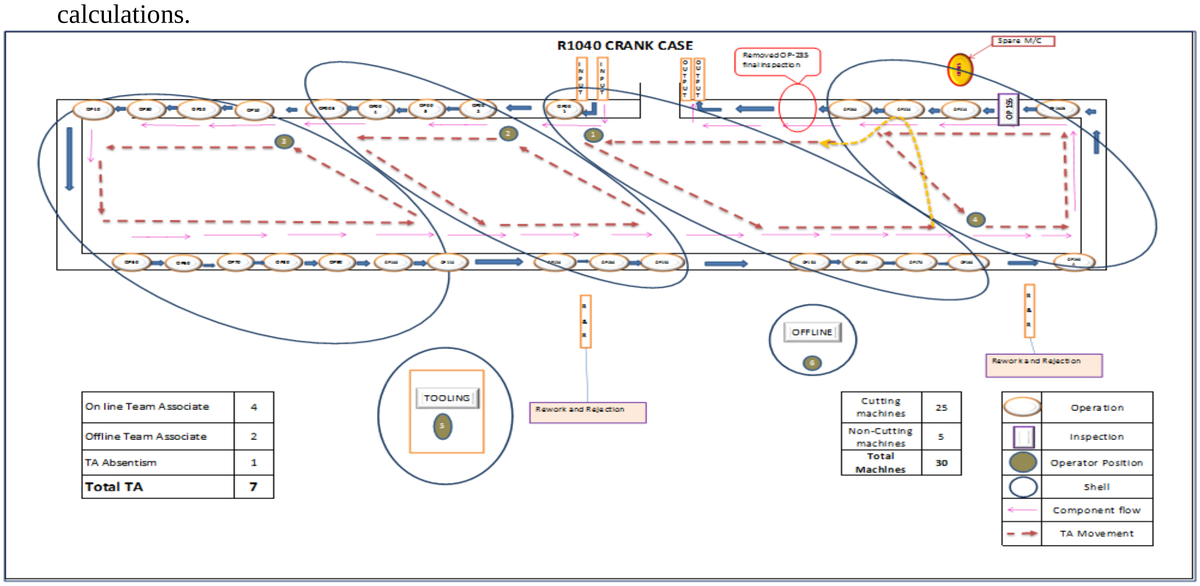

Figure 5. Proposed man-power deployment for Engine Crank-case machining line

5. Conclusions

The achievements in productivity improvements can be noticed as follows:

i. Online TA reduced by 1 i.e. from 5 to 4 no's without changing output per shift.
ii. Man-power deployment is approximately balanced.
iii. Online TA idle time reduced by 37 minute per shift, i.e., from 58 to 23 minute per shift.
iv. Online TA waiting time reduced by 12 minute per shift, i.e., from 19 to 7 minute per shift.
v. The productivity improvement calculation shown in table 1.

Table 1. Productivity and cost comparison

Loop	Output/ shift	Online TA	Man-hours/shift	Productivity
Existing	60	5	33	1.8/hour
Proposed	60	4	26	2.3/hour
Decrease man-hour by	**20 %**			
Productivity increase by	**25 %**			
Annual cost saving (Rs.)	**156000**			

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