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Optimisation of R-1040 Engine Assembly 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 results of TPS techniques is done with the help of simulation modeling where Flexsim is used 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 and Flexsim Simulation software are used to optimisation of R-1040 Engine Assembly Line (fully Automated) where single operator operates multiple machines to assemble various parts as a single product. Standardised Work Combination Table (SWCT) is used as a tool to Study Operators movement from one point to another point during process and Time to cover specified distance. Simulation methodology has been conducted to verify and validate the existing situation as well as proposed results in the animated graphical form. The optimisation includes reduction in manpower, time to assemble per engine, movement of worker and total cost of production.

Keywords- *Flexsim Simulation Software, Time Study, Motion Study, Method Study,*

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I. INTRODUCTION

All R1040 Assembly line is consisting of various numbers of operations such as fitting of crank-shaft, cylinder head, connecting rod, cam-shaft onto crankcase. These operations are semi-automated i.e. requires combinations of man-machine to complete assembly operations. This line includes four main operations i.e. Assembly, Testing, Painting and Packaging. Hence line is known as ATTP line. ATPP stands for

A: ASSEMBLY
T: TESTING
P: PAINTING
P: PACKING

As the name suggests, ATPP involves ASSEMBLY of various components that come from machining lines and directly from the suppliers. This is followed by TESTING of these assembled products. These products are then forwarded for PAINTING or powder coating according to the design specifications. Finally these finished goods are packed in the PACKING section again as per the customer requirements [1].

There are different assembly lines for medium size engines, small engines, gen-set, and pump-set.

Medium engines contribute to almost 60% of volume of the sale. Kirloskar Oil Engines Ltd. is the world's largest producers of generator sets. Every assembly line has assembly stations. Every assembly station requires various components that need to be fitted to the product [2]. Some of these components themselves need to be assembled. This purpose is served by the subassembly lines. Every assembly line has subassembly lines that assembly required on the main line. Every station has a specific work performed on it. To serve this purpose there are pneumatic guns, torque wrench, etc. for carrying out the required job. Inspection and checks on the product is performed during assembly as well. This is to avoid rejection wastages [3]. If a problem occurs that is solvable by the maintenance associate then it is white tagged but if it is

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beyond his scope then it is red tagged and a maintenance engineer attends the problem. Every assembly line is followed by a series of testing. Testing involves various checks like for leakage in the fuel tank proper combustion inside the engine. Power delivered by the engine, emission control etc. It is then certified with a certificate depending on the norms that it meets. Associations like ARAI – Automotive Research Association of India certify the products. Painting or powder coating happens according to the standards of the company like engines that are used for power generation are colored blue and those that are to be used for industrial purpose are colored black. Before powder coating the product undergoes Pre-treatment. Packaging is done according to the needs of the customer. And the finished good is then dispatch for delivery. For this particular ATPP line, the focus is totally on Painting section. The existing layout of painting line is as shown in figure 1.

II. PROBLEM DEFINITION

With the existing layout, all the finished tested engines including R-series as well as HA-series engines are gathered near painting section. Then one by engines is loaded onto overhead conveyor. Overhead conveyor conveys engines from one machine to another machine for painting and related operation. Figure 5.1 shows distance travel by each engines through different machines for different operations. In existing layout the speed of conveyor is 0.6 meter/minute. With this speed, the amount of engines painted per shift is approximately 110 units. But the production of HA-series and R-series engines is approximately 170 engines per shift. Therefore it is difficult to paint all the engines of both types. Now one separate shift is arrange to solve this problem i.e. three shift per day. But for future, when demand is high and all the assembly line working in three shift per day, it is very difficult to solve this problem. So to solve this problem, Flexsim simulation model shown in figure 2 is used to analyse the process as well as find out the optimise results. Loading time required to load engines on to conveyor is approximately 210 seconds. During one shift it painted approximately 110 units with 0.6 meter/minute of conveyor speed. Present cycle time and present capacity is shown in table 1.

III. VERIFICATION AND VALIDATION

Verification and Validation is done with help of same Flexsim simulation model and it is found that the bottleneck operation is at final paint booth section i.e. it takes approximately 240 seconds. After simulation it gives same results as that of existing one.

IV. PROBLEM SOLUTION

For finding out the optimise results number of experiments are done on Simulated model [4]. By analysis using Flexsim software, it observed that the speed of overhead conveyor should be more as compared to existing one and bottleneck operation time should be minimize to get optimum flow of operation of whole line. For optimizing the painting line, number of experimentation work is done on simulated model with use of different conveyor speed within range of 0.6 meter/min to 1 meter/min. The results after experimentation are shown in table 2. And the models after getting optimise result of painting line shown in figure 3. In Proposed model, two painting booths are used instead of one booth and overhead conveyor speed is taken as 0.8 as optimum speed. The optimise results of simulation experiments are shown in table 2.

Following table shows that, the bottleneck time in proposed painting layout is 153 sec required to perform engine painting operation which is reduced from 241 sec in existing layout. Because of this reduction, the capacity per shift is increased from 111 engines to 175 engines per shift. For making the require arrangement as per proposed layout, it is necessary to invest some amount to install 1 extra painting booth as well as reorganize the path of conveyor by bi-furcated and merging it as shown in figure 3 [5]. To maintain the flow of engine during painting operation without scarifying the quality, other parameters is also need to be optimise as per proposed speed of conveyor such as heating oven, priming booth etc.

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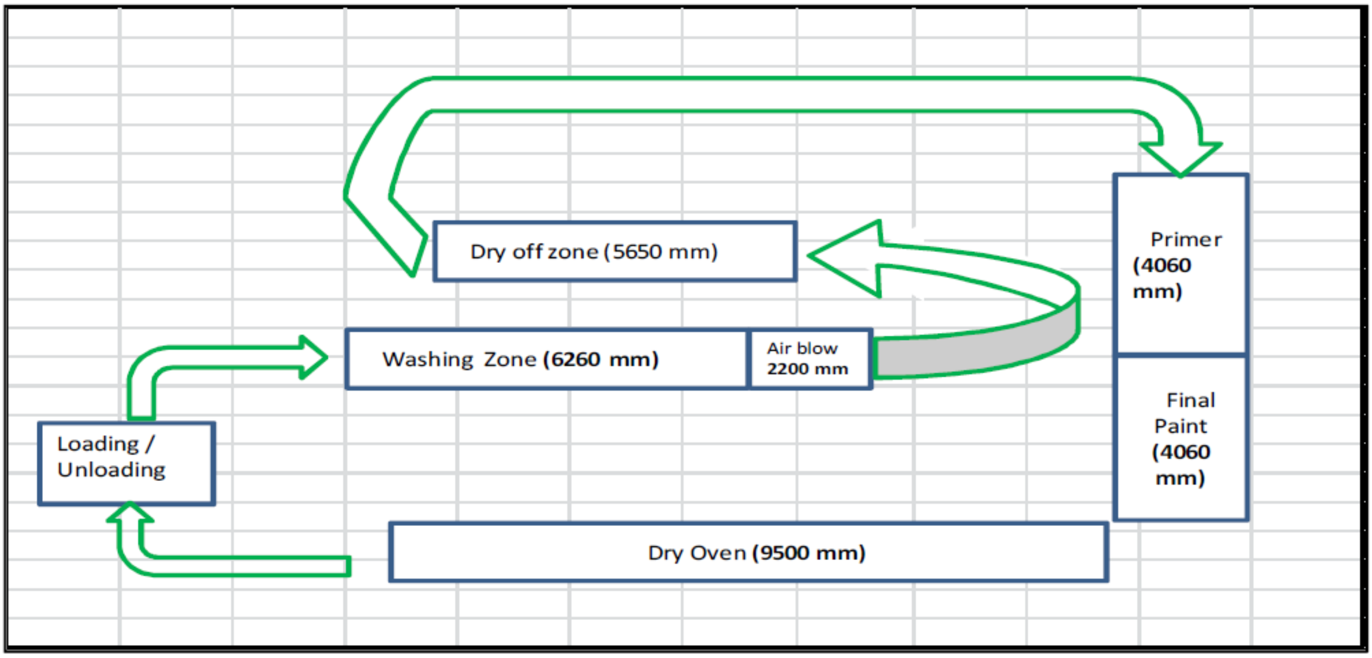

Figure 1. Existing Layout of Painting Line [1].Example of a TWO-COLUMN figure caption: (a) this is the format for referencing parts of a figure.

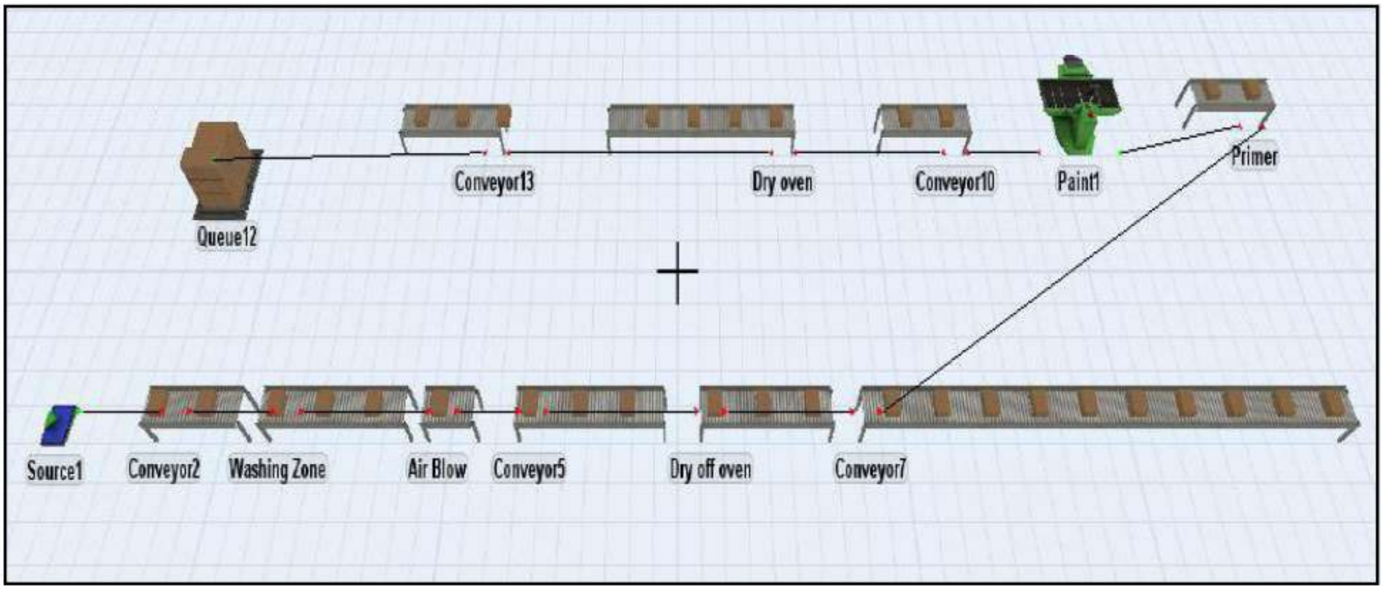

Figure 2. Flexsim Simulation model of existing painting line

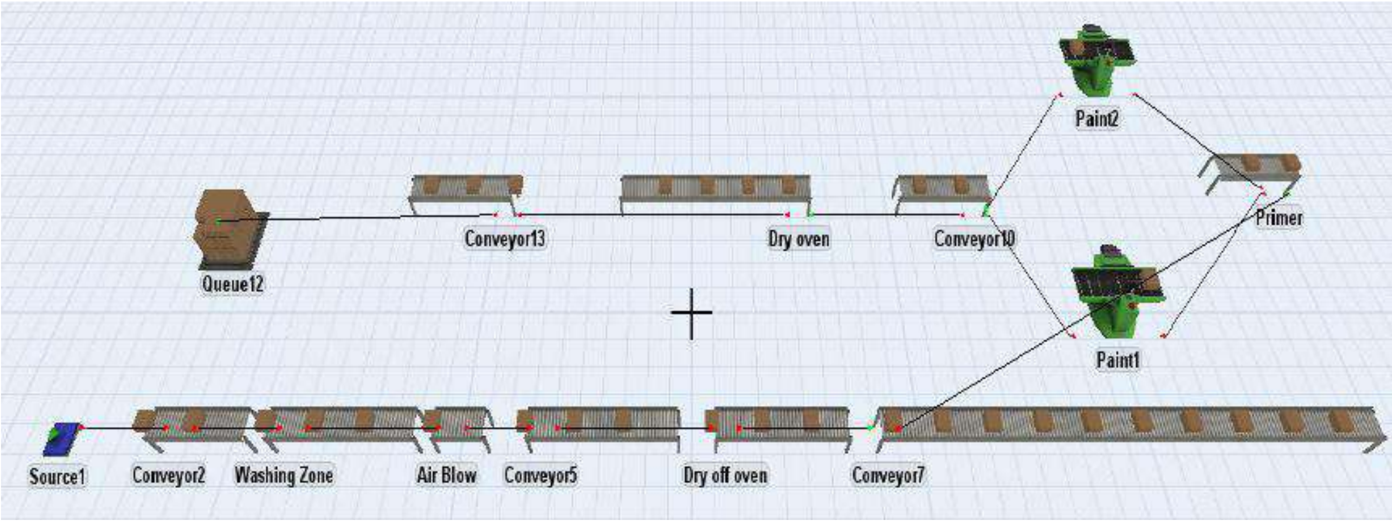

Figure 3. Proposed painting layout

Sr. no.	Activity	1	2	3	Max C.T
1	Cycle Time of Engine Painting(4R)	241 sec	238 sec	240 sec	241 sec
2	Cycle Time for primer	120 Sec	121 Sec	121 Sec	121 Sec
3	Engine air blow C.T	136 Sec	138sec	136 sec	138sec
4	Loading C.T	80 sec	81 sec	78 sec	81 sec
5	Unloading C.T	85 Sec	80 sec	82 sec	85 Sec

Available Time	Bottleneck C.T in Min	Capacity per shift
445	4.02	111

Table 1. Optimisation Of R-1040 Engine Assembly Line Using TPS Techniques And Simulation

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Sr no.	Activity	1	2	3	Max C.T
1	Cycle Time of Engine Painting(4R)	153 sec	152 sec	153 sec	153 sec
2	Cycle Time for primer	120 Sec	121 Sec	121 Sec	121 Sec
3	Engine air blow C.T	136 Sec	138sec	136 sec	138sec
4	Loading C.T	80 sec	81 sec	78 sec	81 sec
5	Unloading C.T	85 Sec	80 sec	82 sec	85 Sec

Available Time	Bottleneck C.T in Min	Capacity per shift
445	2.54	175

Table 2. Simulation Results of Proposed Painting Layout