Production Process Design for Automotive Part with the Application of Lean Manufacturing and Computer Simulation

Thitiwat Varodhomwathana[1] and Srisawat Subsomboon[2]

***Abstract*—**A case study introduces a solution of Robotic Simulation and Plant Simulation for a new model. This research has applied Lean Manufacturing and Computer Simulation in the Design Production Process and Planning Stage of Thai Summit Leam chabang Auto-part Company. Our goals of this research is to design a process for new model (company never experience on produce this model before) to achieve customer's target. A new product is an assembly part by spot welding of 192 welding points and arc welding of 12 arc seams. The right part is assembly of 24 components with spot welding 96 welding points and arc welding 8 arc seams. The left part is assembly of 22 components with spot welding 96 welding point and arc welding 4 arc seams. On design a production process for a new model to achieve the capacity to produce over 6,250 sets per month (for 6,250 cars) and the product line can up capacity to 8,000 sets per month (for 8,000 cars) in the future. For this requirement pushes a production process to be flexible enough and allow improvement to meet of all requirements. This research providing a better inform supporting decision making. Design process and production planning for a new model, Lean Manufacturing and Simulation suitably applied for the purpose to reduce waste for example shorter robot path, avoid robot collision, shorter setup time and detect problem before run the system. The result of this research, design of the production process in 3 working stations: 1. Spot welding process by using 2 robots with a cycle time of 160 second for 64 welding points (the right part is 32 welding points and the left part is 32 welding points), 2. Arc welding process by 1 robot with a cycle time of 102 second for 12 arc seams (the right part is 8 arc seams and the left part is 4 arc seams) and 3. Spot welding process by using 4 robots with a cycle time of 210 second for 128 welding points (the right part is 64 welding points and the left part is 64 welding points). Normally, Company working with 2 shifts (shift1: working time 08.00 am – 05.30 pm and break time 10.00 – 10.10 am, 12.00 -01.00 pm, 03.00 – 03.10 pm., Shift2: working time 08.00 pm – 05.30 am and break time 10.00 – 10.10 pm, 00.00 – 01.00 am, 03.00 – 03.10 am) a day. We have created 3 scenarios for each of the target to produce 6,250 sets per month and 8,000 sets per month. For 6,250 sets with scenario1: working with company schedule time (no overtime) will take 23 days to produce (less than 1 month) result of 6,378 sets. Scenario 2: working with company schedule plus 2 hours overtime will take 21 days to produce result of 6,538 sets. Scenario 3: working with company schedule plus 4 hours overtime will take 19 days to produce result of 6,561 sets. For 8,000 sets per month with scenario1: working with company schedule (no overtime) will take 29 days to produce (less than 1 month) result of 8,041 sets. Scenario2: working with company schedule plus 2 hours overtime will take 26 days to produce result of 8,095 sets. Scenario3: working with company schedule plus 4 hours overtime will take 24 days to produce result of 8,288 sets.

***Keywords*—**Process Design, Lean Manufacturing, Digital Modelling, Plant Simulation

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I. Introduction

THAILAND'S Automotive Industry is recognized as one of the major automotive manufacturer of the world. Many of the world's major automakers, assemblers, and parts and components manufacturers have put their manufacturing line in Thailand. Thailand is currently the world's 2nd largest producer of one-ton pickup trucks and the 7th largest automotive exporter overall. It is the top manufacturer in all of Southeast Asia, the 9th world's largest automobile manufacturer in 2013[1]. In today's Automotive Manufacturing Industry there is an increased focus to produce the right product at right time and the pressure on demand higher quality, shorter delivery time, higher customer service level and lower prices [2]. This pushes automotive industry on setup higher flexibility system to meet all customer requirements. Traditional methods make difficult to determine cycle time, number of machines, capacities, layout, etc. Simulation much more suitable for flexible production process and simulation provides many tools utilized in planning phase [6], [14]. In this case study simulation has been introduced, a good simulation model can significantly improve our understanding of system's behavior [4] and with simulation we are able to answer all of questions about production [13]. The results of simulation providing a better inform supporting decision making and simulation is used for design process and optimizes the workstations to achieve customer demands throughput. A decision maker is able to test all possibility of achieving the customer demand before run the system [12].

II. Purpose of the Study

An optimization strategy and 'Lean manufacturing' is probably the first term that is mentioned. This generally

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accepted and applied strategy of 'waste' management should lead to a decrease of the costs which eventually contributes to an improvement of the results. a case study is focused on design a production process and production planning for a new model to achieve the capacity to produce over 6,250 sets per month (for 6,250 cars) and the production line can up the capacity to 8,000 sets per month (for 8,000 cars) in the future. The company working with 2 shifts a day. Shift1: 08.00 am – 05.30 pm break time 10.00 – 10.10 am, 12.00 – 01.00 pm and 03.00 – 03.10 pm. Shift2: 08.00pm – 05.30 am break time 10.00 – 10.10 pm, 00.00 – 01.00 am and 03.00 – 03.10 am.

III. Theory and Methodology

A case study will be applied of the Lean Manufacturing and Computer Simulation with Tecnomatix Simulation software, to analysis the design production process and create scenarios for production planning [5]. In the last several years, simulation has emerged as a complementary tool for the design and implement of Lean Manufacturing process. The key to Lean Manufacturing is to compress time by eliminating waste and let customers pull the product as needed.

A. Takt time Calculation

The production process design, start with calculate of Takt Time. The term of takt time comes from the German word Taktzeit, which loosely translates to "rhythmic time" or "keeping a beat", similar to the ticking of a metronome or the movement of a conductor's baton. Takt Time is a key concept in Lean Manufacturing. It is the heartbeat of a lean organization – matching actual production to customer demand. Takt time computed as:

Takt time = Available Operating time / Customer Demand.

1) For the demand of 6,250 sets per month:

Takt time = (30 days x (1,440 minute – 160 minute) x 60 second) / 6,250 sets

Takt time = 368.64 second / set

2) For the demand of 8,000 sets per month:

Takt time = (30 days x (1,440 minute – 160 minute) x 60 second) / 8,000 sets

Takt time = 288 second / set

B. Process Design and Robotic Simulate

To survive in today's highly competitive world, manufacturer need to find ways to reduce production time and costs in order to improve operating performance and product quality [2]. Robot simulation is one of the essential elements of modern manufacturing as it allows visualizing and testing a robotic system, even if it does not exist physically. Robot path simulation is a very useful process to predict and pre-evaluate performance of robot programs generated off-line. A three dimension computer aid design (3D CAD) is used as an interface to visualize and simulate pre-program robot paths [3],[7],[8]. The specific goals of using robot are to reduce setup time and increase flexibility to meet demands from customer. A cycle time is one of important data in design process. Cycle time is the time it takes to finish one product or the total of time takes before the product leave the workstation and move to the next station. In design production process cycle time of each workstation compare to takt time if producing faster than takt time results in delivery finish good to customer on time (overproduction). And if producing slower than takt time results in bottlenecks and customer orders that may not be filled on time [9].

C. Production Planning and Process Simulate

Simulation is a technique for modelling dynamics. Most of the automotive manufacturers worldwide currently require new and modified manufacturing system designs to be verified by simulation analysis before they are approved for final manufacturing design. A simulation model is a presentation of the working process or the system. The purposes of a simulation modelling are to analysis and predict the effect of changes to the system. Simulation is used before an existing system is altered or a new system is built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over utilization of resources and optimize system performance. The bottleneck is defining as the rate (parts per unit time) of the work station having the highest utilization. When a process has bottleneck mean blocking is occur in the process, the workstation before bottleneck station will block, blocking occur when the workstation must stop because there is no place to deposit the item just completed. Others workstations after bottleneck station have to wait for a product, waiting occur when the activities must stop because there is no work. The output of system or throughput is the volumes of production passing through the process over some time. For production planning of each requirement we create scenarios by using simulation model to fine the solution without disturbing the real process or before a process is built. This case study we follow these steps as shown in Fig.1.

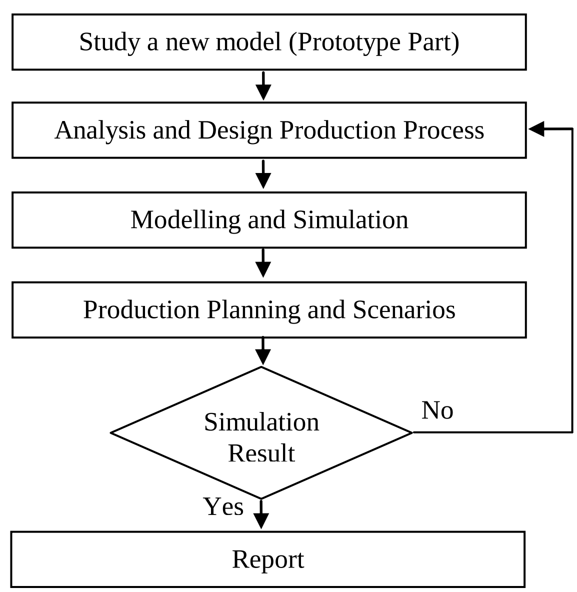

Fig. 1 Working steps of case study

1) *Study of a new model (Prototype part)*: A new model part is an assembly part, the prototype part assembly by Spot-welding 192 points and Arc-welding 12 Arc-seams. A new model is assembly of 7 subassembly parts. The right part is assembly of 24 components with Spot-welding 96 welding points and Arc-welding 8 Arc-seams. The left part is assembly of 22 components with Spot-welding 96 welding points and Arc-welding 4 Arc-seams. A new model is shown in Fig. 2.

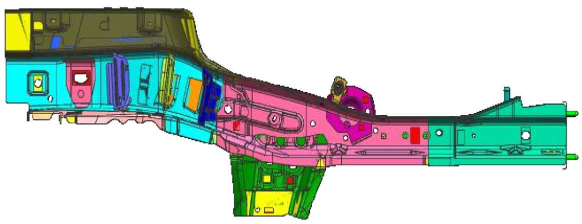

Fig. 2 A new model part

A new model part is an assembly part from 7 subassembly parts. An assembly part and subassembly is shown in Fig.3.

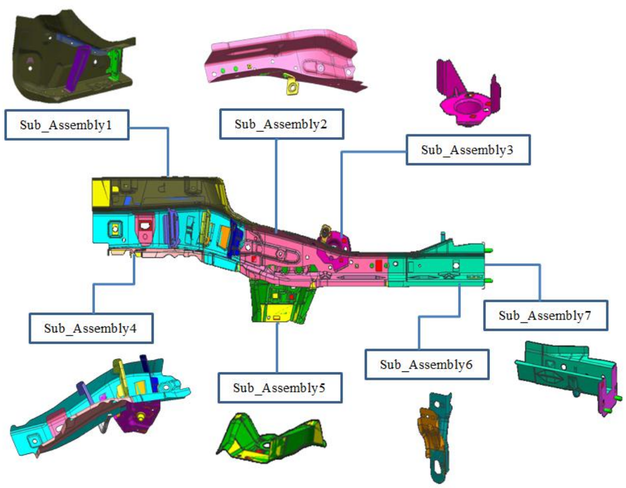

Fig. 3 An assembly of new model part

2) *Analysis and Design Production Process:* A Design production process in 3 working stations: station1. Spot welding process by using 2 robots with a cycle time of 160 second for 64 welding points (the first robot for right part with 32 welding points and the second robot for the left part with 32 welding points), station2. Arc welding process by 1 robot with a cycle time of 102 second for 12 arc seams (the right part is 8 arc seams and the left parts is 4 arc seams) and station3. Spot welding process by using 4 robots with a cycle time of 210 second for 128 welding points (the right part is 64 welding points and the left part is 64 welding points). The process design and equipments of each working station are shown as station1 is shown in Fig.4. station2 is shown in Fig.5. and station3 is shown in Fig.6.

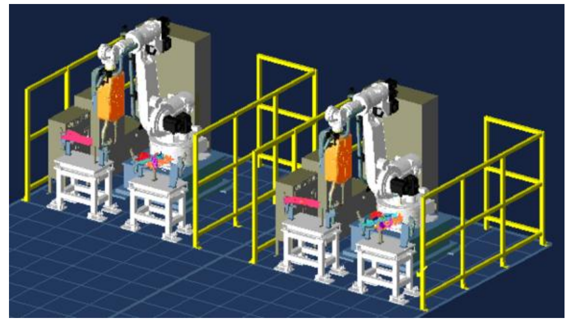

Fig. 4 Station1: Spot welding

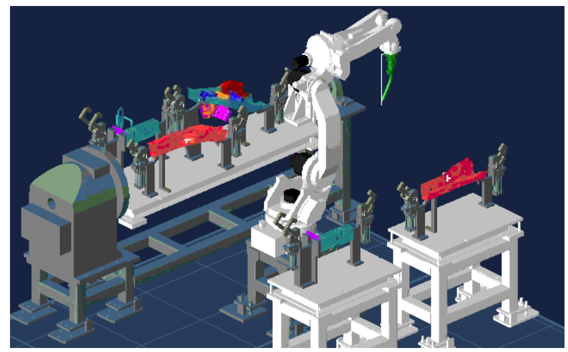

Fig. 5 Station2: Arc welding

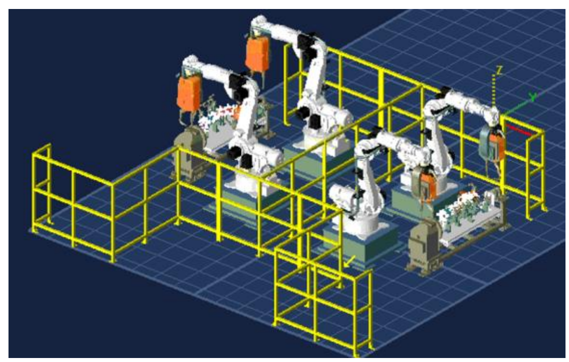

Fig. 6 Station3: Spot welding

3) *Modelling and Simulation:* A modelling of production process is created in Tecnomatix Plant Simulation software. A modelling is an assembly line, a cycle time set in a modelling assembly process is taken from simulation of Robotic Simulate from process designed (Station1: 160 second, Station2: 102 second and Station3: 210 second). And working time (simulation time) is taken from company working calendar. The company working with 2 shifts a day. Shift1: 08.00 am – 05.30 pm break time 80 minute. Shift2: 08.00pm – 05.30 am break time 80 minute. A new model process design is shown in Fig.7.

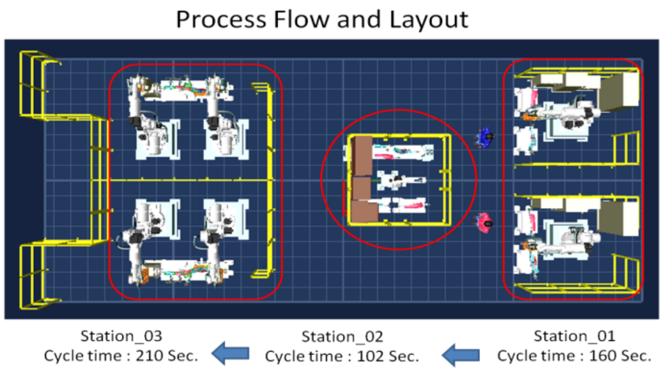

Fig. 7 A new model process

In the modelling we want to stop simulate if the output is reach the target. By this way we will know how many day it would take to reach the target. The coding is shown in Fig. 8.

```
is
do
    W_time := EventController.absSimTime;

    if @.Name = "P_53810" then
        P_53810 := P_53810 + 1;
    elseif @.Name = "P_54810" then
        P_54810 := P_54810 + 1;
    end;


    if ?.StatNumin >= 12500 then
        eventController.stop;
    end;
end;
```

Fig. 8 Coding to stop simulation

4) *Production Planning and Scenarios:* For production planning we create three scenarios for each requirement. The simulation model should be used for carry out specific what-if analysis and for supporting the manufacturing process management [11]. The Scenarios for 6,250 sets per month. Scenario1: working with company schedule (no overtime) result of 23 days (less than one month) and output of 6,378 sets (more than 6,250 sets). Scenario2: working with company schedule plus 2 hours overtime result of 21 days and output of 6,538 sets. Scenario3: working with company schedule plus 4 hours overtime result of 19 days and output of 6,561 sets. Scenarios for 8,000 sets per month. Scenario1: working with company schedule (no overtime) result of 29 days (less than one month) and output of 8,041 sets (more than 8,000 sets). Scenario2: working with company schedule plus 2 hours overtime result of 26 days and output of 8,095 sets. Scenario3: working with company schedule plus 4 hours overtime result of 24 days and output of 8,288 sets.

IV. Conclusion

The utilization chart shows result working percentage for planned time and unplanned time of each station.

Scenario1: Working time of 2 shifts a day total time 19 hours (included of break time 2 hours and 40 minute) per day is about 79.17 percent and unplanned time 5 hours a day is about 20.83 percent. Utilization chart shows station3 causes the bottleneck and station2 is most blocking. Result of 6,378 sets by 23 days and 8,041 sets by 29 days.

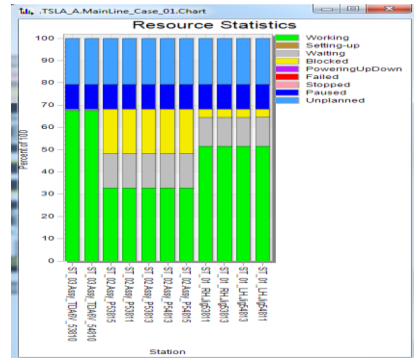

Fig. 2 A new model process

Scenario2: Working time of 2 shifts plus 2 hours overtime a day total time 21 hours per day is about 87.50 percent and unplanned time 3 hours a day is about 12.50 percent. Utilization chart shows station3 causes the bottleneck and station2 is most blocking. Result of 6,538 sets by 21 days and 8,095 sets by 26 days.

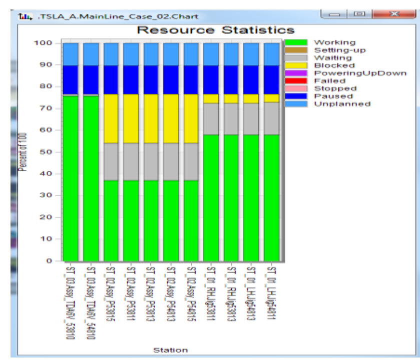

Fig. 2 A new model process

Scenario3: Working time of 2 shifts plus 4 hours overtime a day total time 24 hours planned. Utilization shows station3 causes the bottleneck and station2 is most blocking. Result of 6,561 sets by 19 days and 8,288 by 24 days.

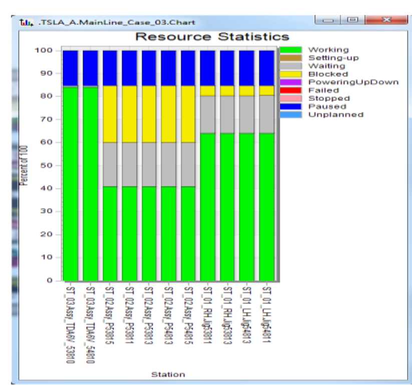

Fig. 2 A new model process

The result of process design in 3 working stations: 1. Spot welding process by using 2 robots with a cycle time of 160 second for 64 welding points (the right part is 32 welding points and the left part is 32 welding points), 2. Arc welding process by 1 robot with a cycle time of 102 second for 12 arc seams (the right part is 8 arc seams and the left part is 4 arc seams) and 3. Spot welding process by using 4 robots with a cycle time of 210 second for 128 welding points (the right part is 64 welding points and the left part is 64 welding points). Process design can achieve the capacity to produce over 6,250 sets per month and the production line can up the capacity to 8,000 sets per month.

There are a lot of benefits of applying simulation technology for productivity, improvement initiatives, some of these benefits include:

Avoiding Costly Mistakes – Simulation empowers the engineers and managers with a powerful technology to verify and improve the design and operational rules of material handling systems even before their installation. This clearly reduces the inherent risks and enormous costs involved in any automotive project.

Choosing the right system - Each automated system problem may have many solutions. The goal is to find the best solution for a given problem. "Best" may be defined in many ways, but it is usually a combination of the cost of the automation and the benefits of applying automation. A computer model gives you a "virtual factory" to determine which of the proposed automation technologies best fits your system.

Improving Design and Operational Rules and Implement New Systems - Simulation can serve as tools to try out new policies and decision rules for operating a system, before running the real system. With new systems which we may have little or no information, simulation can be used to answer "what if" questions in concepts and design phases of the project.

Effective Integration with other systems - A detailed computer model helps determine how well the system components integrate. A model also shows which of the components fall short of performance goals. Getting this information early in the design stage eliminates problems once your system is installed.

Visualization And Communication - The animation provided by 2D and 3D simulation packages make an excellent case for the motto "a picture is worth a thousand words." Visual aids go far in helping to comprehend solutions. Animation helps the engineer visualize and explain the working of a proposed or existing material handling system. The clients, in turn, find it an excellent tool to present their solutions to decision makers and upper management. Animation also helps the simulation model builders verify and validate a complex model visually. [10]

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