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# THE AUTOMOBILE ASSEMBLY PRODUCTIVITY ENHANCEMENT BY JOB TASKS AND SEQUENCING

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**Abstract.** Manufacturing factories are facing the operation challenges in processes, systems and work sequences in order to get high production efficiency. The automobile assembly lines are facing similarly the same challenges. This operational research in the automobile factory aimed to find the cause of the production problems and to solve the problems by managing both the human and material resources in order to enhance the production efficiency. The data analysis (standard time, production demand and production efficiency) were performed in order to re-arrange the job tasks and sequencing. After the line balancing implementation showed that the productivity was enhanced and reached the demand target without extra payment.

## INTRODUCTION

In the present, automobile becomes an essential for everybody for their convenient. There are various methods of the automobile production depend on their types and prices.

According from a case study factory, 2 automobiles are produced per day which sometime need over time working hours and one working day is 480.00 minutes. The automobile assembly per day is 2, therefore takt time per day is 8 hours (480 minutes) divided by the production capacity which is 2 per day equal to 240 minutes. This means time consume at each station cannot be more than 240 minutes. The station no. 2 takes longest time which is 140.32 minutes, so the time used of station no. 2 would be the cycle time and causes the imbalance and time lagging in the production because station no. 1 cannot transfer the job to station no. 2 due to its unreadiness. Therefore the station which used maximum time is considered as the cycle time. The time taken by station no. 2 also affects the cycle time and takt time of the other stations. Moreover, when the production increases, there is an overtime working which eventually caused and increase in the capital cost. Therefore, the objectives of this study were to find the cause of the production problems and to solve the problems by managing both the human and material resources.

## LITERATURE REVIEWS

Bautista, Alfaro-Pozp and Batalla-Garcia (2015) stated that the Assembly lines in the automotive industry are a clear example of this type of mixed-product lines, which are known as Mixed-Model Assembly Line (MMAL). In this type of lines, different components (seats, steering wheels, pedals, etc.) are incorporated into the vehicle body depending on the type of vehicle that is assembled at each moment. Therefore, these lines must be flexible and able to adapt to each type of product assembled in them without incurring excessive costs. An issue that can be classified owing to the variability of processing times in the operations required to assemble the products. If the units have heterogeneous processing times, in the stages of the production process in a workshop, we are facing permutation problems such as Flow-Shop Problems mentioned in Bautista, Cano, Companys, and RIbas (2012) and Pan & Ruiz (2013) Wenqi (2007) stated that based on this theorem, an improved shifting bottleneck procedure (ISB) for the job shop scheduling problem has been proposed. Besides ISB is implemented straightly, a re1ned version that combines ISB with the strategy of back tracking is presented. These two procedures have been tested on many benchmarks with various sizes and hardness levels. The

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computational experiment shows that ISB is more efficient and effective than shifting bottleneck procedure. The target equation is to minimize holding cost with indicate constraint as number of waiting job equal zero and it shows positive answer. Caumond (2008) using memetic algorithm to solve job sequencing problem in consider of time lag which is defined as a job-shop problem with minimal and maximal delays between starting times of operations. Caumond converted job sequencing problem into disjunctive graph and solve with memetic algorithm. Jensen et. al. studied the job shop scheduling problem under the assumption that the jobs have controllable processing times. The research presented 2 models of controllable processing times: which are continuous and discrete and found that both models present polynomial time approximation schemes when the number of machines and the number of operations per job are fixed. Guinet (2000) reduced the complexity of job shop scheduling problem to flow-shop problem with job precedence constraints in order to minimise the maximum completion time of the jobs. An extension of Johnson's rule was exercised to solve it. The optimality of the extended Johnson's rule is proved for two machine job-shop problems and the rule efficiency for some three and four machine job-shop problems is shown. Birgin (2015) stated that Each job is composed by several operations with a linear precedence structure and has a predetermined route through the machines. The flexible job shop scheduling (FJS) problem is a generalization of the JS problem in which there may be several machines, not necessarily identical, capable of processing each operation.

## METHOD

The automobile production line can be divided into 6 stations as shown in figure 1.

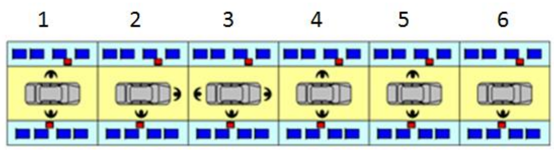



**Figure 1: Interior Assembly Production Layout**

The selected model is, a large-sized luxury automobile, assembled the interior part and exterior as follow: under bonnet, under the vehicle, front and back wheel, inside the cabin and under the rear bonnet as shown in figure 3. The assembly line can be divided into 6 stations and each station has its own work procedure as follow:

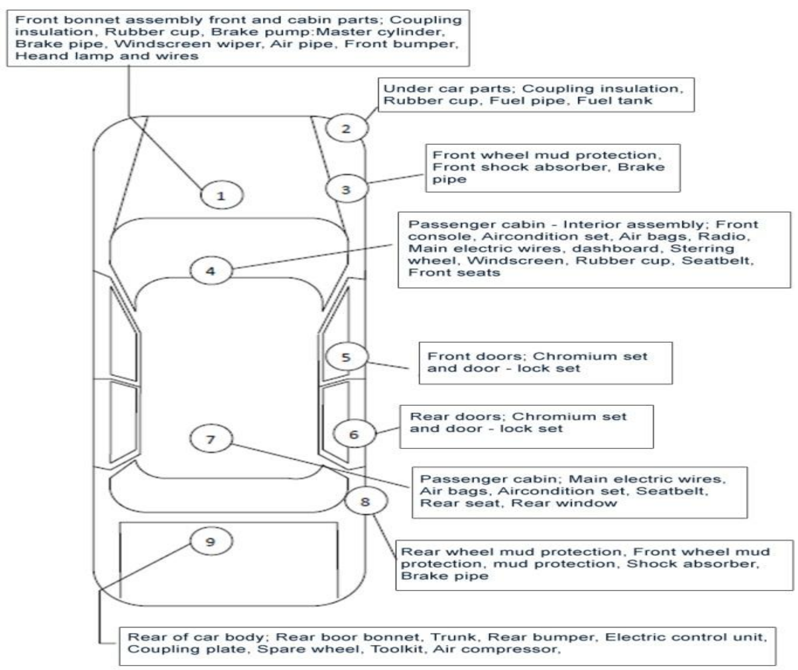



**Figure 2: Assembly Production**

**DATA ANALYSIS**

According to the production data of the case study factory, production rate was 54 units per month, 2 units per day and the maximum capacity was 42 units per month including overtime working for 12 units per month. The production time are shown as follow:

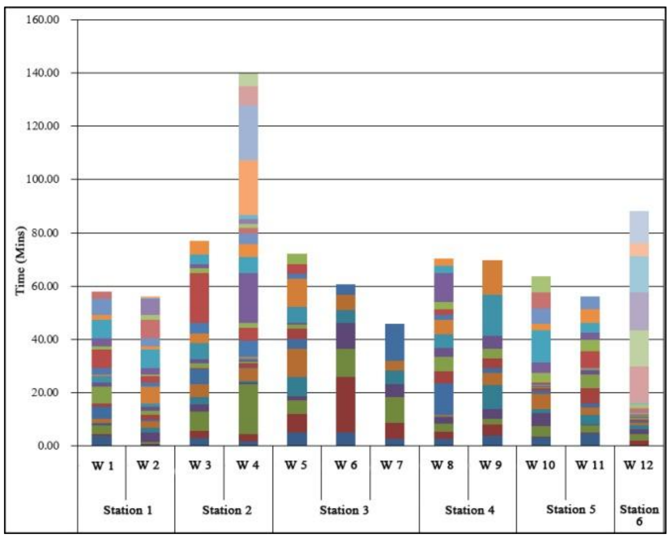
Production time per day = 8 hours or 480 minutes
Production Demand = 2 units per day
Takt time for 1 unit = 480 minutes / 2 units
= 240 minutes / unit
Cycle time = 140.32 minutes

The comparison between cycle time and takt time found that there were huge time lost which was useless and caused bottleneck in the production line. Therefore, the improvement of this production was needed by improving and enhancing the production capacity to 3 unit per day without the overtime. Regarding the indicated production capacity, the cycle time was calculated as follow:

Production time per day = 8 hours or 480 minutes
Production Demand = 3 units per day
Takt time for 1 unit = 480 minutes / 3units
= 160 minutes / unit

The transferring time of automobile's body from station to station was 2 minutes and the equipment preparation time was about 10 minutes. Due to the complexity of the electric equipment in this model, the allowance was needed for 30 minutes in order to check and fix in case of any errors. Therefore, the assembly time was increased equal to 42 minutes. The standard of efficient lost is 10% to 20% at average of 15%

Hence, one automobile production time is (160 – 42) x (1x0.15) =100.3 minutes ~100 minutes so cycle time is 100 minutes or 6,000 seconds.




* W = worker

**Figure 3: Bottleneck Station**

As shown in Figure 2, station no. 2 caused the bottleneck in production line due to its production time exceeded 100 minutes (140.32 minutes). Therefore, line balancing was needed in order to get the expected units which were 3 units per day.

The selected jobs (Job no.) which were electrical wires assembly in the cabin, blanket assembly and fuel control assembly were transferred to station no. 3.

**RESULTS**

After the line balancing implementation, work flow was arranged and cycle time was not exceeded 100 minutes. The bottleneck in the production line was solved. The productivity was enhanced from 2 units to 3 units per day without overtime which was able to cut off 2,820 minutes (48 hours) for overtime hours equal to 101,760 baht.

The line balancing implementation of each station was under 100 minutes and reached the production target which was 3 units per day. Production efficiency can be calculated from equation (1).

$$\text{Production efficiency} = \frac{\text{Total working time of all workers}}{\text{Maximum time * number of workers}} \times 100$$

Table 1 showed the implemented design works.

**TABLE 1**
**STATION TIME AFTER THE IMPLEMENTATION**

| | Station 1 | | Station 2 | | Station 3 | | Station 4 | | Station 5 | | Station 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After |
| W 1 | 57.85 | 57.85 | | | | | | | | | | |
| W 2 | 56.07 | 56.07 | | | | | | | | | | |
| W 3 | | | 76.84 | 76.87 | | | | | | | | |
| W 4 | | | 140.32 | 86.64 | | | | | | | | |
| W 5 | | | | | 68.22 | 68.22 | | | | | | |
| W 6 | | | | | 60.61 | 65.57 | | | | | | |
| W 7 | | | | | 45.94 | 66.41 | | | | | | |
| W 8 | | | | | | | 70.07 | 70.07 | | | | |
| W 9 | | | | | | | 69.76 | 69.76 | | | | |
| W 10 | | | | | | | | | 63.55 | 63.55 | | |
| W 11 | | | | | | | | | 56.02 | 56.02 | | |
| W 12 | | | | | | | | | | | 88.20 | 88.20 |

W = worker

**Labour Productivity**

Monthly demand is 54 units per month. The production line before line balancing implementation was 216 hours with labour productivity at 25%. After the implementation, the production time reduced to 144 hours which was able to increase labour productivity to 37%. This operational research result was able to reduce overtime , cost and enhance the productivity efficiency as shown in table 2.

**TABLE 2**
**LABOUR PRODUCTIVITY**

| | Before | After | Improvement Result |
|---|---|---|---|
| Cycle time (min) | 240 | 100 | -140 |
| Production efficiency (%) | 50.81 | 79.37 | +28.57 |
| Labour productivity (%) | 25 | 37 | +12 |
| Productivity (unit per day) | 2 | 3 | +1 |
| Overtime (Baht per month) | 101,760.00 | 0.00 | -101,760. |

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