IMPROVEMENT OF ASSEMBLY LINE: A CASE STUDY OF BUS SEAT MANUFACTURER IN MALAYSIA

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ABSTRACT

Planning schedule is vital for production planning especially for mixed models assembly especially to satisfy the demand from customers. However, in Malaysia quite often transportation companies especially the bus services facing some problems in inefficiency of final assembly line. This study therefore is carried out to enhance the efficiency of a bus seat assembly line in Malaysia. In this study, the actual final assembly line has been analyses using direct time study and then tested by different assembly line systems. The data collected from actual final assembly line include; operating time, processes, and workstation layout. The best assembly line system will be proposed after tested its efficiency rate. The efficiency comparison of actual assembly line and the proposed assembly line system are also highlighted.

Keyword: Assembly line, Efficiency

1.0 Introduction

With the increasing of market competition, the line balancing especially the assembly line balancing plays an important role for the industries to obtain the high quality and lowest cost. "An assembly line consists of a sequence of stations performing a specified set of tasks repeatedly on consecutive product units moving along the line at constant speed" (Bhattacharjee, 1988). "Assembly Line Balancing (ALB) problem is to determine the allocation of the tasks to an ordered sequence of stations such that each task is assigned to exactly one station, no precedence constraint is violated, and some selected performance measure is optimized like minimize the number of stations" (Ponnambalam et al., 2000).

In manufacturing field, planning schedule is vital for production planning especially for mixed models assembly. Assembly line is responsible to satisfy the demand from customers. According to the production manager of bus seat manufacturer, Zakri (Personal communication, December 21st, 2010), the manufacturing company face problem in inefficiency of final assembly line in bus seat manufacturer. In seat assembly line, majority of production is use human workers or manually such as sewing. At the same time, customer demand on seats' pattern and color also slow down the assembly line of bus seats. In local bus industry, they have several types of seats provided by bus manufacturer such as commercial seats, VIP seats, and VVIP seats. When study on bus seats, it actually have differ frame if the size of seats is difference. The design will be change if customers required. All this procedures will cause the process of assembly line become rigid and labored. Therefore, the study tries to determine the efficiency rate of assembly line in bus seat manufacturers. This research will overcome the problem by maximizing the balance line efficiency. It also involves minimizing the number of stations and minimizing the balance line delay time (sum of idle time). result will help the company solve the inefficiency rate of assembly line. Production Manager will gain the improvement of efficiency rate to the assembly line and apply it into the production line. It also help the bus seat manufacturer improve their assembly line balancing with minimize workstation and maximize line efficiency.

2.0 LITERATURE REVIEW

An assembly line consists of work stations arranged along a conveyor belt or a similar mechanical material handling equipment (Becker & Scholl, 2006),. The jobs are consecutively launched down the line and are moved from station to station. At each station, certain operations are repeatedly performed regarding the cycle time (maximum or average time available for each work cycle). The decision problem of optimally partitioning (balancing) the assembly work among the stations with respect to some objective is known as the assembly line balancing problem (ALBP). "If several products or models are manufactured on the same line, the ALBP is connected to a sequencing problem which has to decide on the sequence of assembling the model units" (Yano and Bolat, 1989,). "A mixed-model line produces the units of different models in an arbitrarily intermixed sequence" (Bukchin et al.,2002), whereas a multi-model line produces a sequence of batches (each containing units of only one model or a group of similar models) with intermediate setup operations.

According to Ponnambalam et al. (2000), they are three (3) methods allocated to calculate the efficiency rate of assembly line. Firstly, the Largest Candidate Rule (LCR) has been use by researcher and next overcome its limitation by Kilbridge and Wester's Method (KWM). Then, the third method is the Ranked Positional Weight Method (RPW). According to Rolf Bjorheden (1988), work measurement may be defined as measurement of the input of human and material resources into production and the output of the production process. The measured variables are the consumption of resources and the products of work. For man at work, time consumption, movements and working motions, physical load and psychic load may be measured. For machines and equipment the measurement may involve time consumption, movements and working motions, wear and energy consumption. In addition, the operation (jobs), the production environment and the quantity and quality of products are described.

Time study is one of the most common practices of work measurement. It is used worldwide, in most types of production process. In forestry, results from time study have been used to set "just" piece rate and, most important, to rationalize production. The classical stopwatch study or time study originally proposed by Frederick W. Taylor in 1881. A time study procedure involves timing a sample of a worker's performance and using it to set a standard.

3.0 METHODOLOGY

3.1 Research Instrument

According to Creswell (2003), they are two types of research design that is both quantitative and qualitative research. According to Horna (1994), quantitative research designs are characterized by the assumption that human behavior can be explained by what may be termed "social facts which can be investigated by methodologies that utilize "the deductive logic of the natural sciences". This process is directed towards the development of testable hypotheses and theory which are generalized across settings and in contrast this methodology is more concerned with how a rich, complex description of the specific situations under study will evolve. According to Miles and Huberman (1994), qualitative research is conducted through an intense and/or prolonged contact with a "field" or life situation. These situations are typically "banal" or normal, reflective of the everyday life of individuals, groups, societies, and organizations. In some senses, all data are qualitative; they refer to issues relating to people, objects, and situations. Qualitative research may be conducted in dozens of ways, many with long traditions behind them. As Smith (1992) observed, the terms ethnography, field methods, qualitative inquiry, participant observation, case study, naturalistic methods, and responsive evaluation have become practically synonymous.

For this case study, both qualitative and quantitative method will be used to study the overall case study. For qualitative method, interview will be conducted that help to gained relevant information. On the other hand, observation will be done along the selected assembly line as quantitative method. When the observation done, the data collected will be tested by assembly line system such as_Largest Candidate Rule, Kilbrigde and Wester's method,and Ranked Positional Weight method. The case study conducted on several aspects like time, type of assembly line, and type of assembly system. For example, observations are made at different times and interviews are conducted in several times.

3.2 Data Collection and analysis

Data collection is divided to primary data and secondary data (Yin, 1994). In this study, primary data collected by the interview from production manager. The production manager gives the factory related information to this study are included major problem of final assembly line, number of workstation in final assembly line, workers allowance rate, daily working hour, and daily production rate. Besides that, the production manager also gives the secondary data to researcher such as factory layout, seat's model photo, and image of the factory.

The methods used to analyze all information and data obtained by the study are direct time study and assembly system method (Largest Candidate Rule, Kilbridge and Wester's Method, and Ranked Positional Weight Method). Based on assembly system method, all three methods will be analyzed and it will be selected if one of the methods shows the highest line efficiency and least workstations. For direct time study, it will analyze the task time of each element that shows the normal time (T_{NT}) and standard time (T_{ST}).

4.0 FINDING

The data from case study will shows into table and calculated using assembly line system, which is Largest Candidate Rule method, Kilbridge and Wester's method, and Ranked Positional Weight method. The comparison of three assembly line system will show its efficiency rate, balance delay, and number of workstation.

4.1 The flow chart of final assembly line

The flow chart of assembly line is shown in Figure 1. The whole processes of VIP seats are started with fix up the recliner of seats. Operators will fix up the recliner with spring which acts as adjuster of back. Next, operators will fix the metal frame of back to the recliner. When the metal frame was fixed, it will continue to padding back session. Operators will pad the back by mold polyurethane (PU). After that, operators will wrap the trim cover to the back of seat. The back will screwed with plastic back board after wrapped the trim cover. The operator also will screw the handle and pocket at the top of back and back of plastic back board.

Besides that, the operators will pad the seat cushion on different conveyor. The mold cushion is padded based on customers demand. Then, operators will wrap the seat trim cover. Next, operators will screw the plastic panel on both side of seat cushion and lock the plastic clip on the bottom of seat. Operators also set up an offline workstation to modified armrest plastic part and footrest assembly. In the armrest assembly, operators will fix the metal frame of armrest and screw it with plastic part.

Next, operators will assemble the back and seat. At the same time, operators will assemble armrest and footrest on the seat. When armrest and footrest finish assembled, operators will move the seat to final assembly area. During this area, operators will add metal stand on the bottom of seat and add cushion on stand of seat. Finally, operators will assemble the tight support and seat belt on the seat.

The process begins with fix up recliner, fixing metal frame and end up with final seat belt assembly. The whole proses can be said as

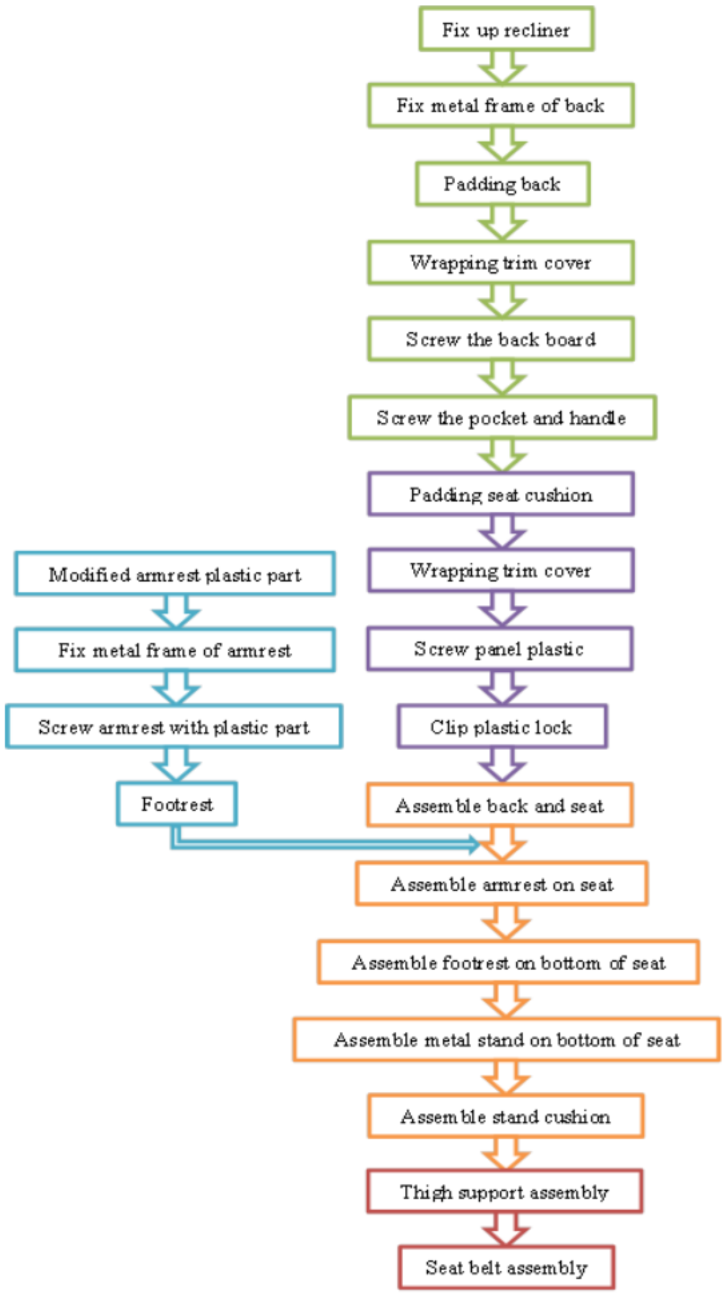

Figure 1: The flow chart of final assembly line

4.2 Time Study of the Final Assembly Line

The following data is the time study of the assembly line

Daily production, (D_d) = 18 seats
Daily working hour, (D_w) = 8.5 hours
Worker allowance = 15%
Normal Time, (T_{NT}) = 106.65 minutes
Standard Time, (T_{ST}) = T_{NT} / (1-Allowance)
= 106.65 / (1-0.15)
= 106.65 / 0.85
= 125.47 minutes
Cycle Time, (T_C) = D_w / D_d
= (8.5 x 60 minutes) / 18
= 510 minutes /18
= 28.33 minutes

Theoretical number of workstation, (w^*)
= 125.47 minutes / 28.33 minutes
= 4.43
= 5 workstations

Line Efficiency, (E)
= 125.47 / (w^* x T_C)
= 125.47 / (5 x 28.33 minutes)
= 125.47 / 141.65
= 0.8858 @ 88.58%

4.3 The Standard Time for Work Elements

Table 1 shows the standard time for each work elements. As longest time taken for the work are for Fix metal frame of armrest (15.25 minutes), followed by Assemble back and seat, Screw armrest with plastic part, Wrapping trim cover, Padding back and so on.

Table 1: Standard time for each work element

No.	Work Element Description	Standard Time (Minute)

1.	Fix up recliner	1.06
2.	Fix metal frame of back	2.12
3.	Padding back	10.06
4.	Wrapping trim cover	10.16
5.	Screw the back board	2.12
6.	Screw the pocket and handle	3.18
7.	Padding seat cushion	3.6
8.	Wrapping trim cover	4.76
9.	Screw panel plastic	2.12
10.	Clip plastic lock	1.06
11.	Assemble back and seat	15.14
12.	Modified plastic part	2.12
13.	Fix metal frame of armrest	15.25
14.	Screw armrest with plastic part	12.71
15.	Footrest	4.23
16.	Assemble armrest on seat	6.03
17.	Assemble footrest on seat	3.49
18.	Assemble metal stand below seat	5.72
19.	Assemble stand cushion	4.66
20.	Thigh support assembly	7.41
21.	Seat belt assembly	8.47

4.4 The Efficiency of the Actual Final Assembly Line

Table 2 shows the work element assignment to station for actual assembly line. Based on the table the efficiency can be calculated as:

Balance line efficiency is computed as

$$E_b = 125.47/[(5)(34.31)]$$
$$= 0.7314 \text{ @ } 73.14\%$$

Balance line delay is computed as

$$d = [5(34.31)] - 125.47/[5(34.31)]$$
$$= (171.55 - 125.47)/171.55$$
$$= 0.2686 \text{ @ } 26.86\%$$

Table 2: Work elements assigned to stations based on actual assembly line

Station	Work Element	T_{ST} (Minute)	T_{SI} (Minute)
1	1	1.06	

	2 3 4 5 6	2.12 10.06 10.16 2.12 3.18	28.7
2	7 8 9 10 11	3.6 4.76 2.12 1.06 15.14	26.68
3	12 13 14 15	2.12 15.25 12.71 4.23	34.31
4	16 17 18 19	6.03 3.49 5.72 4.66	19.9
5	20 21	7.41 8.47	15.88

4.5 The Efficiency of the Final Assembly Line by Using Largest Candidate Rule (LCR) method

Based on Table 3 balance line efficiency is computed as

$E_b = 125.47/[(5)(27.96)]$
$= 0.8975$ @ 89.75%

Balance line delay is computed as

$d = [5(27.96)] – 125.47/[5(27.96)]$
$= (139.8 – 125.47)/139.8$
$= 0.1025$ @ 10.25%

Table 3: Work elements arranged based on T_{ST} value for the Largest Candidate Rule

Station	Work Element	T_{ST} (Minute)	T_{SI} (Minute)
1	1 2 3	1.06 2.12 10.06	

	7 8 9 12	3.6 4.76 2.12 2.12	25.84
2	13 14	15.25 12.71	27.96
3	4 5 6 10 15	10.16 2.12 3.18 1.06 4.23	20.75
4	11 16 17	15.14 6.03 3.49	24.66
5	18 19 20 21	5.72 4.66 7.41 8.47	26.26

5.0 CONCLUSION AND FUTURE RESEACH

In manufacturing field, planning schedule is vital for production planning especially for mixed models assembly. Assembly line play a role factor to satisfied the demand from customers. The bus seat manufacturing company face problem in on time supply to customers' needs and core cause is the weak efficiency of assembly line in bus seat manufacturer. The bus seat manufacturer decided to find out the best method to handle its final assembly line and improve its line efficiency dramatically. Therefore, this research has taking out research objective that to find the best method of assembly line system to the entire company and its efficiency rate for the final assembly line.

In this study, a systematic methodology was developed to design and calculate the efficiency of final assembly line in the seat manufacturer company. It was newly formed and no work study has been carried out before. The actual final assembly line was based on the experience, which set by the production manager. So, the assembly line was under optimum and imbalance. Direct time study had been very effectively used to develop the standard time (T_{ST}) for the actual assembly line in order the line balancing can be carried out to improve the line efficiency.

They are three suggestion shared into these study for the bus seat manufacturer. The manufacturer may apply a better final assembly line by dividing the work elements into smaller task. A minimum rational work element was defined as the smallest practical indivisible task. For example, drilling of a deep hole at one station was to cause a bottleneck situation should be separated into two steps. It will eliminate the bottleneck and increase the tool life. Then, manufacturer is preferred to changing work lead speeds at automatic stations. Through a process increasing the speed or feed combinations at the stations with long process time, and reducing the speed or feed combinations at stations with idle time. Finally, manufacturer is suggested to reduce its pre-assembly components. It should reduce the total amount of work done on the regular assembly line by another assembly cell or by purchasing. Therefore, bus seat manufacturer may prevent its imbalance assembly line with these suggestions.

For the future study, the Ranked Positional Weights method could be implemented in other field of the organization such as to improve the line efficiency of the food industry. Furthermore, other aspect of productivity in the improvement of the assembly line such as cost, quality and many more could be taken into consideration to better improve the assembly line specifically or the company as a whole. The assembly line system has been proven to find the best combination in the assembly line by calculating the line balance efficiency and balance delay in the assembly line of the factory.

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