Manpower Planning of Assembly Line Part A005TG2991ZJ at PT. Mitsubishi Electric Automotive Indonesia, Jawa Barat

Chyntia Ramadina[1], Ineu Widaningsih Sosodoro[2]
[1,2] Faculty of Engineering, Industrial Engineering Department, President University
Jl. Ki Hajar Dewantara
Kota Jababeka,Cikarang, Bekasi - Indonesia 17550
Email: chyntia.ramadina@yahoo.co.id, inesosodoro@yahoo.co.id

ABSTRAK

Ketidakpastian pada permintaan pasar mobil mempengaruhi penyusunan rencana produksi pada masing-masing industri otomotif. Mencapai jumlah yang tepat dari permintaan aktual hampir tidak mungkin karena permintaan itu sendiri pun tidak pasti. Seiring dengan meningkatnya permintaan, operator tambahan diperlukan untuk meningkatkan jumlah output dan sebaliknya. Perencanaan tenaga kerja berguna dalam mengendalikan masalah tersebut. Output dan jumlah operator yang dibutuhkan dapat diperkirakan oleh sebab itu, memenuhi permintaan menjadi lebih mudah. PT. Mitsubishi Electric Automotive Indonesia disingkat sebagai MEAINA merupakan perusahaan otomotif, sedang mengalami masalah yang berkaitan dengan perencanaan tenaga kerja. Perencanaan tenaga kerja untuk jalur perakitan alternator yang memproduksi model A005TG2991ZJ saat ini terbatas. Selain itu, estimasi perencanaan tenaga kerjanya agak kasar. Dalam mengatasi masalah ini, yamazumi chart dan precedence diagram digunakan untuk membantu penataan workstation yang secara langsung mempengaruhi perencanaan tenaga kerja. Dengan menggunakan dua metode tersebut, peningkatan jumlah output dan persentase line balancing diharapkan akan diperoleh. Hasil dari penelitian ini mengkonfirmasi bahwa ada peningkatan dalam jumlah output, sedangkan persentase line balancing sedikit menurun, namun ada peningkatan yang signifikan dalam output bulanan dan persentase line balancing yang terdeteksi pada perencanaan tenaga kerja yang menggunakan 20 operator.

Keywords: *Permintaan Pasar, Perencanaan Tenaga Kerja, Jalur Perakitan.*

ABSTRACT

Uncertainty presents on cars market demands affect in arranging the production plan of each automotive industry. Achieve the exact number of actual demand is nearly impossible since the demand itself is uncertain. As the demand increase, additional operators are needed to increase the output and vice versa. Manpower planning is useful in controlling such problems. The output and number of operators needed can be estimated hence, fulfilling demand then become easier. PT. Mitsubishi Electric Automotive Indonesia shortened as MEAINA is an automotive company has an issue regarded its manpower planning. Manpower plan for alternator assembly line producing model A005TG2991ZJ currently has been limited. Besides, the estimation of manpower plan is pretty rough. In overcoming this problem, yamazumi chart and precedence diagram are used to support the arrangement of workstations which directly affect to the manpower plan. By using the two method, improvement in output and line balancing percentage is expected to be obtained. The results confirmed that there is an improvement in the number of output, while line balancing percentage is slightly decline, nevertheless a significant improvement in both monthly output and line efficiency is detected on manpower plan of 20 operators.

Keywords: *Market Demand, Manpower Planning, Assembly Line.*

1. Introduction

PT. Mitsubishi Electric Automotive Indonesia (MEAINA) is facing a problem in assigning manpower for alternator production line model A005TG2991ZJ. The number of demand received for the model has always been irregular from period to period which leads the need of MEAINA to carefully control its production. Engineering department at MEAINA overcame this demand fulfillment issue by create Manpower Planning. Manpower planning used in MEAINA is a spreadsheet of workstations arrangements. The stations are arranged in such a way to keep the total time in each stations are approximately same or balance. While keeping it balance, total number of stations are also kept in minimum so that the number of operator assigned for the line is also minimum. This activity or planning is called manpower planning since there is a step of assigning the number of operators (manpower) to the line which determined by the first action which is workstation arrangement. In the end of man power planning, monthly output is calculated theoretically by multiplying the daily output with total working hour for a month. Currently for part A005TG2991ZJ, available man power plan is only for greater output which used 20 until 22 operators and the output is said has not reach the optimum number yet. Limited manpower plan for smaller output could drive MEAINA spend more cost if suddenly the trend of demand go downhill hence, manpower plan for smaller output needs to be established.

In order to identify the cause of being unable to obtain optimum output, direct observation to the line was conducted. From the observation, it was found that the arrangement of workstations has not been appropriate. Moreover, the total time spent in each station was not balance. Such circumstances lead into the inefficiency of using the time since cycle time of producing one model could be higher. As a result, the number of output produced cannot fulfill customer demand. To get highly output of assembly line, it is needed to determine the optimum number of resources in terms of work stations and manpower. (Khumbar, 2014)

Hence, overcome such problems, precedence diagram can be constructed to determine which work elements are supposed to be joined in one station without breaking the flow of the line. And to equalize the total time in each stations, yamazumi chart will be applied to detect which work elements that has higher cycle time that is better to be allocated with the other process. The two method applied is aimed to maximize current process so there will be also an improvement in the quantity of output produced.

2. Methods

In order to run the analysis, some data are required to be gathered. The data used in this research are mostly based on historical data that have been used at MEAINA. After the data gathered, it will be calculated and analyzed using methods listed below.

2.1 Takt Time

In order to achieve the demand from customers, Takt time is used to compute the amount of time that a factory is allowed to produce a unit of the product (Oh, 2010). The data used for calculating Takt time are obtained from production schedule of alternator assembly. Takt time is computed as the formula written below.

$$\text{Takt Time} = \frac{\text{Available Operating Time (sec/day)}}{\text{Demand (pieces/day)}} \quad (1)$$

2.2 Yamazumi Chart

Yamazumi chart is used to create an image of the structure of the work done by a person or entire members of a team by stacking the activities as it is stated by Eaton (2013). According to Townsend (2012), the chart helps in rebalance work content to achieve the demand from customers. In order to achieve it, the work at each station should rebalance to make all process under or at Takt time. In order to establish the chart, working elements and each of its cycle time is needed, the data can be seen as follows on Table 1.

Table 1. List of Working Elements of Alternator Assembly Process

No.	Process Name	Cycle Time (in sec)	Predecessor
1	Press bush + nut	8.07	-
2	Rectifier installation	3.98	1
3	Regulator assembly	12.87	-
4	Regulator installation	1.88	3
5	Screw tightening to rectifier and regulator	8.06	2,4
6	Torque tightening for rectifier and regulator	8.07	5
7	Nut and torque tightening for terminal B	9.66	6
8	Terminal (B) (L) clamping	5.91	7
9	Flux application	2.72	8
10	Soldering plate	11.49	9
11	Insert brush pin to rear assembly	4.43	10
12	Stator lead wire forming	7.21	-
13	Stator installation	9.08	11,12

Table 1. List of Working Elements of Alternator Assembly Process (cont'd)

No.	Process Name	Cycle Time (in sec)	Predecessor
14	Connect stator lead wire and diode lead wire	9.2	13
15	Flux application and Solder 3-phase wire	24.89	14
16	Rear bearing & SPL washer installation & press fit to rotor	10.3	-
17	Spacer (R) installation to rotor assembly	3.82	16
18	Front bearing press-fit	5.04	-
19	Visual check and marking soldering result	4.74	18
20	Supply retainer to front bracket	2.44	19
21	Tightening and torque screw retainer	17.79	17,20
22	Installation of front bracket assembly to rotor assembly	3.05	15
23	Install spacer (P) and pulley to rotor shaft, and temporary tightening of pulley nut and washer	6.24	21
24	Pulley nut tightening	13.56	23
25	Friction check	15.41	24
26	Front and rear assembly inspection	12.92	22,25
27	Engagement	4	26
28	Check assembly result	6.93	27
29	Align adjustment and through bolt supply/tightening	29.13	28
30	Noise check (motoring)	8.05	29
31	Appearance / Span check	12.69	30
32	Performance tester and installation B-Terminal Cover	19.85	31
33	Name plate fixing & marking	14.7	32
34	Packing	7.5	33

2.3 Precedence Diagram

According to Pycraft, et al (2000), precedence diagram is a graphical representation of the ordering of work elements which consist of product or service total work content. The diagram is defined by a circle which represent each work element and connected by arrows which indicate the sequence of work elements. As the diagram constructed, there are two rules implemented which is written in the following statements:

- The circles are constructed as far to the left as possible.
- The arrows should not draw in vertical.

The precedence diagram will be useful in arranging the workstation, so that the arrangement will be more structured and prevent the flow of part from going backward. The data used for precedence diagram is working elements and predecessor(s).

2.4 Number of Workstation Formula

The calculation using the number of workstation formula will be useful in determining the number of minimum stations needed for the least number of operator used in manpower plan which is 15 operator used in total. The data needed for calculating using Equation 2 are total processing time and cycle time.

$$Nt = \frac{T_{wc}}{T_c} \quad (2)$$

2.5 Arrange Manpower Planning

After calculating yamazumi chart, precedence diagram and number of workstation, arrangement of workstations is done. Noted that this step is important since manpower plan is arranged, starting from the arrangement of the workstations. To arrange the workstations, firstly pay attention to yamazumi chart, then precedence diagram. Any work elements that has processing time exceed the standard or takt time, should be merged with the other work element by seeing the precedence diagram. Merge the work element with the closest predecessor or any work element which lies next to the exceeded work element that has cycle time below the value of takt time. In arranging the work station, it is best that the total time of workstation is no further than the standard time or Takt time. Next, assign number of operator to each station. Assign two operators for the station which has total time exceed or closer to the value of takt time. After that, arrange the plan for the use of 15 operators until 22 operators using the original format of the spreadsheet created and provided by engineering department of PT. MEAINA.

2.6 Data Analysis

In this stage, after all the data already calculated, analysis of the result is done. In this research, the analysis is done by comparing the result with previous manpower planning. Any identified differences and improvements are stated and explained.

3. Result and Discussion

Currently, there is only manpower plan which involved 20 until 22 operators within, for the assembly of alternator model A005TG2991ZJ which consists 34 working elements in total. In addition to limited manpower plan, the arrangement is quiet rough since it was estimated manually without any specific calculation. The calculation begin with calculating the Takt time in order to know the standard time desired. Both of hours spent and target output are averaged before calculating the Takt time.

3.1 Takt Time

Here below the calculation of standard time desired or Takt time is shown

$$\text{Takt Time} = \frac{18149.2 \text{ sec}}{589 \text{ units}} = 30.81 \text{ seconds/unit}$$

3.2 Yamazumi Chart

In plotting the chart, the data needed is takt time and cycle time or processing time in each processes. Each working elements are plotted in the graph since the initial purpose in using the chart is to investigate which process exceed the standard time desired, which afterwards will be useful in arranging the workstations. The chart can be seen below on Figure 1.

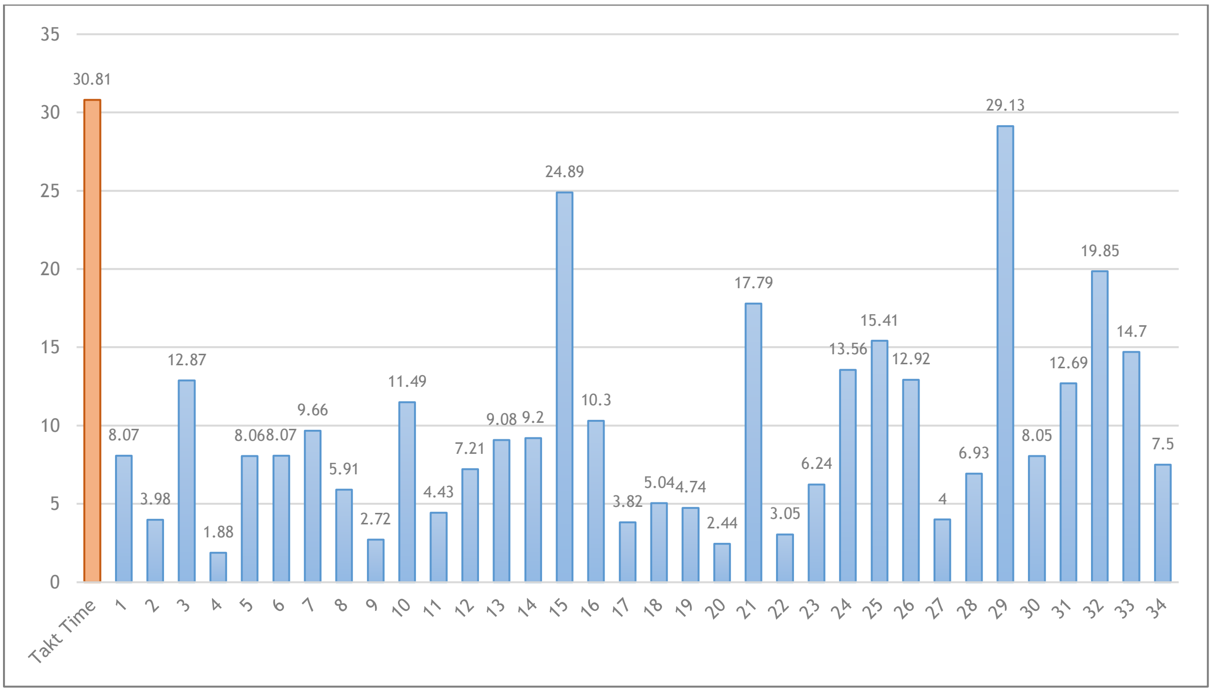

Figure 1. Yamazumi Chart of Assembly Process Model A005TG2991ZJ

Based on Figure 1 above, there is no process which exceed the Takt time. Instead all processes are less than the value of Takt time but, it is clearly seen that the flow of the process is not smooth, it is rather unbalanced. For instance, process 4, 9, 20, 22 and 27 has a very small cycle time compared to the other process while process 15 and 29 spent most time in producing the part. This condition indicated that there could be waiting time or idle time for operators happened during the process. Therefore, appropriate arrangement of workstations is needed to balance the flow and get the most appropriate workstations arrangement which then leads into good manpower plan.

3.3 Precedence Diagram

Since manpower planning in MEAINA is only estimated, this diagram is used for arranging the work stations so that the arrangement will not violated the orders of process and its predecessor. It is also helped in detecting which stations are best joined together. The appearance of precedence diagram can be seen as follows on Figure 2.

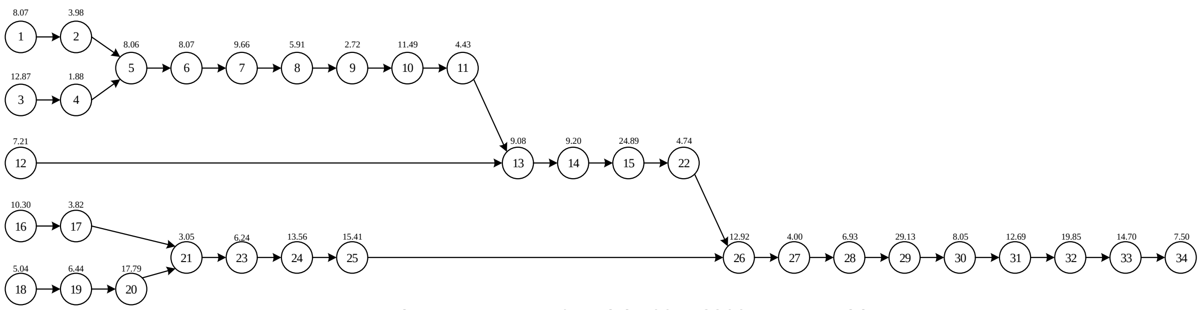

Figure 2. Precedence Diagram of Model A005TG2991ZJ Assembly Process

3.4 Number of Workstations

To calculate the minimum number of workstation for assembling the product, the value of takt time and total processing time are needed. Noted that takt time used in here, act as the substitute of cycle time of the product. The calculation of minimum number of workstations is shown below this passage.

$$N_t = \frac{T_{wc}}{T_c} = \frac{\text{total processing time}}{\text{takt time}} = \frac{356.49 \text{ sec}}{30.81 \text{ sec}} = 11.57 \approx 12 \text{ stations}$$

3.5 Arrangement of Manpower Plan

The arrangement is started by estimating which elements are better merged in one station, based on the minimum number of work stations which already calculated in previous section. Arrange the stations by looking the precedence diagram without violated the predecessors. As the arrangement is started, pay attention to the total cycle time or processing time in each stations, the total processing time in each station should be as best as it possible not exceeding the value of Takt time. The result of first arrangement with the maximum number of station which is 12 is shown on Table 2 below this statement.

Table 2. First Arrangement of Workstation

Station	Process	Processing Time (sec)	Total Processing Time (sec)
1	1	8.07	
	2	3.98	
	3	12.87	
	4	1.88	26.8
2	5	8.06	
	6	8.07	
	7	9.66	25.79
3	8	5.91	
	9	2.72	
	10	11.49	
	11	4.43	24.55
4	12	7.21	
	13	9.08	
	14	9.2	25.49

Table 2. First Arrangement of Workstation (cont'd)

Station	Process	Processing Time (sec)	Total Processing Time (sec)
5	15	24.89	24.89
6	16	10.3	
	17	3.82	14.12
7	18	5.04	
	19	4.74	9.78
8	20	2.44	
	21	17.79	
	23	6.24	26.47
9	22	3.05	
	26	12.92	
	27	4	
	28	6.93	26.9
Auto	24	13.56	13.56
Auto	25	15.41	15.41
10	29	29.13	29.13
11	30	8.05	
	31	12.69	20.74
12	32	19.85	
	33	14.7	
	34	7.5	42.05

Apparently, as it can be seen on Table 2 above that there is one station which exceed the value of Takt time which is station 12 with the total processing time of 42.05 seconds, surpassed 30.81 seconds. To overcome this problem later on, the number of operator assigned for that station is added, become two or more. Since the arrangement of stations might be changes in each number of operator used, the line balancing percentage is limited to 50% at least, to avoid bottleneck. Hence, the arrangement which resulted in small percentage of line balancing, which the value is under 50% will be avoided.

Noted that, the two auto processes are not categorized as a station since both of processes are done by automation not by human or operator. As the arrangement has done, manpower planning can be started. It is best started from the smallest number of operator needed and since engineering department requested the plan of 15 until 22 persons, the manpower plan arrangement is started from the use of 15 operators on line and ended up with the use of 22 operators. As the number of operators needed increase, additional operators and stations may be occur. The format used for this manpower plan is based on the format created and set by engineering department of PT.MEAINA. The complete result of new manpower plan can be found on Appendix.

3.6 Comparison

After succeed in arranging the new manpower plan, compare the result of current plan with the new plan. Since current manpower plan existed is only from the use of 20 until 22 person, the comparison is done only by using the plan of 20 until 22 manpower. The comparison of the plans can be seen on Table 3.

Table 3. Current Plan Result Summary

Total Manpower Used	20 Persons	21 Persons	22 Persons
TM (Time (Cycle)) in hour	0.0069	0.0058	0.0056
EFFICIENCY	90%	90%	90%
TL (Line Tact) in hour	0.0077	0.0064	0.0062
TS (Time Standard) in hour	0.1538	0.1344	0.1374
OUTPUT/ HOUR (in pcs)	130	156	160
LINE EFFICIENCY	51%	58%	57%
MONTHLY OUTPUT (381 hours) in pcs	49,536	59,520	61,020

Table 4. Complete New Plan Result Summary

Total Manpower Used	15 Persons	16 Persons	17 Persons	18 Persons	19 Persons	20 Persons	21 Persons	22 Persons
TM (Time (Cycle)) in hour	0.0075	0.0074	0.0071	0.0069	0.0069	0.0058	0.0058	0.0052
EFFICIENCY	90%	90%	90%	90%	90%	90%	90%	90%
TL (Line Tact) in hour	0.0083	0.0083	0.0079	0.0077	0.0077	0.0065	0.0064	0.0058
TS (Time Standard) in hour	0.1245	0.1323	0.1337	0.1384	0.146	0.1298	0.1344	0.1266
OUTPUT/ HOUR (in pcs)	120	121	127	130	130	154	156	174
LINE EFFICIENCY	62%	55%	55%	50%	50%	54%	53%	56%
MONTHLY OUTPUT (381 hours) in pcs	45,898	46,061	48,428	49,536	49,596	58,713	59,520	66,225

Table 5. New Plan Result Summary

Total Manpower Used	20 Persons	21 Persons	22 Persons
TM (Time (Cycle)) in hour	0.0058	0.0058	0.0052
EFFICIENCY	90%	90%	90%
TL (Line Tact) in hour	0.0065	0.0064	0.0058
TS (Time Standard) in hour	0.1298	0.1344	0.1266
OUTPUT/ HOUR (in pcs)	154	156	174
LINE EFFICIENCY	54%	53%	56%
MONTHLY OUTPUT (381 hours) in pcs	58,713	59,520	66,225

As it can be seen on Table 3 and Table 5 above, there is an increasing number of monthly output and line efficiency percentage except on the manpower plan of 21 persons. The output is remained the same but unfortunately the percentage of line efficiency is declining from 58% to 53%. There is also a declining in line efficiency percentage of manpower plan of 22 persons, which is decline from 57% to 56%. However, since the arrangement of station is different in which the new plan is followed the rule which stated that the arrangement of station should not violate the predecessor(s), any values which shows no improvement is neglected and the plan is considered improved. A significant improvement is happened on the plan of 20 OP of manpower plan with a rising percentage from 51% to 54% and an increase of output which in total is 9,177 pcs additional number of output.

4. Conclusion

Based on the analysis of the research, there are several conclusions that can be pulled out. According to yamazumi chart which already established, there are no processes or working elements which exceed standard time desired or Takt time. Based on the comparison done in analysis, the new manpower plan is generally has an improvement on the result. The output of the three manpower plan ranging from 20 until 22 persons has more numbers than current plan, except on plan which use 21 persons. A significant improvement is detected on the plan of 20 persons.

References

1. Eaton, M., The Lean Practitioner's Handbook: BusinessPro Collection, Kogan Page Publishers, London, 2013.

2. Khumbar, S. K., R, N. M., & Satpute, S. P., Assembly Line Production Improvement by Optimization of Cycle Time, Proceedings of 10th IRF International Conference, India, 2014, pp. 124-128.

3. Oh, S. C., Manpower Planning and Cycle-Time Reduction of a Labor-Intensive Assembly Line, Thesis, Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, 2010.

4. Pycraft, M., Singh, H., Phihlela, K., Slack, N., Chambers, S., Harland, C., Johnston, R., Operations Management, Pearson, South Africa, 2000.

5. Townsend, B., The Basics of Line Balancing and JIT Kitting, CRC Press, Boca Raton, 2012.