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Analysis of Work Load and Total Operator Needs on Final Inspection of Work Station

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***Abstract*— This study aims to determine the number of ideal operators according to the company condition. This research uses work measurement method and analyzed by Yamazumi Chart. The research object is three selected operators from the final inspection work station. The study results concluded that, the new Takt time conditions for 120 seconds, then the company allocates 3 operators, the average work loading or it's Manpower efficiency in that part is only 60 percent. But if the company allocates 2 operators only, the average work loading or man power efficiency reaches 90 percent. Based on the calculation according to the method used, then the operator needs in that part with the new Takt time conditions are 2 operators.**

Keywords—manpower; takt time; work measurement; yamazumi chart

I. INTRODUCTION

The globalization era requires companies to streamline production activities to minimize production costs. The work system requires operator skills to produce products in according to the schedule. Along with unstable request number, the production line should adjust to the development of product demand. The production line must be able to streamline the available resources in maximizing work productivity. Work measurement is an activity to determine the time of an operator in carrying out work processes with normal conditions and time. Work measurement relates to the time required to complete a job based on psychological and physiological factors [1]. Measurement of working time aims to get the standard time in completing the normal work in a working system that has been running well. Stopwatch used in the work measurement to obtain cycle times [2]. The methods of stopwatch reading which often used are Continuous Timing (the stopwatch is run continuously and will stop when the observation has been completed), Repetitive Timing (the stopwatch is read simultaneously and each time the deduction process is finished, the stopwatch number is returned to 0) and Accumulative Timing (involves two or more stopwatch, the second stopwatch will start after the first stopwatch has finished measuring, and when the second stopwatch stops measuring the third stopwatch will work). The results of the work measurement as a reference for setting the standard time with notice to ratings and allowance factors.

Standardized time is a reference in determining the number of operators according to the product to be made. Takt time is the time required for production to produce one product in the production process. The calculation of takt time is based on actual sales and data planning data by involving the amount of time allocated in producing. Cycle time is the actual time that an operator needs to complete a work cycle including doing manual work and running [3]–[5]. Cycle time is used to calculate work loading as a basis for calculating the number of operators needed The research on performance measurement mostly discusses about the optimization of operator work to get the ideal working time [2], [6]–[8]. Whereas research about work time by paying attention to products produced by the company is not done much.This research try to find the ideal time for operator according to the company condition.Determination of operator number is helped by Yamazuimi graph and notice Flexible manpower line concept.

Flexible manpower line is a line which can produce with a flexible number of people without decreasing productivity even though the amount of production needs change [9], [10]. This method as a basic for calculating the need for an effective workforce[11]. This concept is perfect for production that relies on human labor in the production process in order to face fluctuations in customer demand. Yamazumi chart is a graph that describes the balance between the standard time of each

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operator (cycle time) with the standard time set by the company (takt time)[3]. Yamazumi's graph is described by combining beam graphs with line graphs. Where the beam graph indicates the standard time of each operator (cycle time) and the line graph indicates the standard time set by the company (takt time). The advantage compared to other graphics is,it can compare between cycle time and takt time, so that it can be seen that the operator has advantages or lacks time in working and can optimize it. This study aims to determine the actual work loading of Final Inspection operator. Loading work which is exists as a reference to determine the ideal number of operators in accordance to the company needs. This concept hopefully can determine the ideal needs for the company and paying attention to the factors which is affecting to the operator ability so can increase the work productivity.

II. RESEARCH METHOD

There are two types data should be collected, namely primary and secondary data. Primary data will be obtained by conducting direct observation in the field, including actual data from direct observation such as: observation data of work time from each operator (Time study), cycle time of each operator (Cycle time), work element of each operator, and working time of each element. The method was used to collect the data is measuring working time directly using Stopwatch. Whereas secondary data will be obtained by studying the existing company data, such as effective work time (working days and hours), customer volume orders, standardization of existing work, etc. To obtain these data, the author interview the employee and the work leader until all the data needed for this research is fulfilled.

Table 1. Preliminary Data

No.	Required Data	Data Collection Method			Data Retrieval Objects
		• Observation	• Interview	• Files	
1	Effective working hours		•	•	HRD, Production
2	Customer order			•	Marketing, PPIC
3	Work element time data		•	•	Production
4	Working time measurement data	•			Production
5	*Cycle time*	•			Production

The objects are the operators in the work station Final Inspection. The research will focus on 3 operators in this work station section, namely operator 1, operator 2 and operator 3.

Data is processed by measuring operator working time. The result is analyzed to get the ideal standard time. The work measurement step is to determine the data adequacy test, verifying the uniformity of data, calculate the normal time by observing the factor rating, calculating the standard time and time schedule. Data analysis use Yamazumi Graph

$$N' = \left[k/s\sqrt{\frac{(N\sum X^2)-(\sum X)^2}{\sum X}}\right]^2 \quad (1)$$

$$UCL = \bar{X} + \mathrm{k}.\sigma \quad (2)$$

$$LCL = \bar{X} - \mathrm{k}.\sigma \quad (3)$$

$$\sigma = \sqrt{\frac{\sum[x-\bar{x}]^2}{N-1}} \quad (4)$$

$$\text{Cycle Time} = \frac{\sum Xi}{N} \quad (5)$$

$$\text{Normal Time} = \text{Cycle Time x Rating Factor} \quad (6)$$

$$Standard\ Time = Cycle\ Time\ x\ \frac{100}{100-all} \quad (7)$$

$$T = Ta / D \quad (8)$$

$$Efisiensi\ Man\ Power = \frac{Necessary\ MP}{Actual\ Allocation\ MP} \quad (9)$$

$$Necessary\ Man\ Power = \frac{\sum CT\ Operator}{Takt\ Time} \quad (10)$$

N' : Theoretical Observation Data
N : Observation Data Actually
K : Level of Confidence
S : Degree of Accuracy
UCL : Upper Control Limit
LCL : Lower Control Limit
σ : Standard Deviation
X : average observation data (mean)
T : Takt Time
Ta : Time Avaibility
D : Demand

III. RESULTS AND DISCUSSION

Before Data collection uses working hours of production processes outside of break time. Working hours run three shifts per day in the final inspection line and operate based on the company standard working hours. Effective time of work in a day is around 1230 minutes with 60 minutes of rest time and 10 minutes of 5S activity for each shift. Work time measurement is done by direct observation in the field. The work measurement method use direct measurement of work with a stopwatch study. The study of work measurement can be seen in table 2.

Based on the data above, data adequacy test is made. From the results of testing the adequacy of data for work measurement with a 95% confidence level and the degree of accuracy of 5% obtained by operator 1 shows the value of N '= 0.38, operator 2 shows the value of N' = 1.1, and operator 3 shows the value of N '= 0.87, while N = 10. Because the value of N 'is smaller than N, it can be stated that the data used is sufficient to proceed to the next stage. From the results of testing the data equal for measurement of operator work 1, operator 2, and operator 3 indicate that all measurement results

data fall within the control limit with a 95% assurance level. When the data is equal, it can be used for the next step.

Table 2 Result of Performance 3 Operator of Final Inspection

Operator : Final Inspection 1			Operator : Final Inspection 2			Operator : Final inspection 3		
Measurement	**Time (X)**	**X^2**	**Measurement**	**Time (X)**	**X^2**	**Measurement**	**Time (X)**	**X^2**
1	57.4	3294.8	1	53.1	2819.6	1	53.3	2840.9
2	59.4	3528.4	2	54.1	2926.8	2	55.8	3113.6
3	57.8	3340.8	3	56.7	3214.9	3	55.5	3080.3
4	57.2	3271.8	4	55	3025	4	53.8	2894.4
5	57.4	3294.8	5	55.7	3102.5	5	56.5	3192.3
6	59.2	3504.6	6	56.9	3237.6	6	57.7	3329.3
7	58.6	3434	7	54.1	2926.8	7	54.3	2948.5
8	58.9	3469.2	8	56.8	3226.2	8	55.8	3113.6
9	59.1	3492.8	9	53.3	2840.9	9	55.2	3047
10	59.8	3576	10	56.8	3226.6	10	56.7	3214.9
$\bar{x}$	58.5		$\bar{x}$	55.3		$\bar{x}$	55.5	
$\sum X$	584.8		$\sum X$	552.5		$\sum X$	554.6	
$(\sum X)^2$	341991		$(\sum X)^2$	305256.3		$(\sum X)^2$	307581.2	
$\sum X^2$	34207.2		$\sum X^2$	30546.6		$\sum X^2$	30774.8	

Table 3. Normal Time

Operator	Cycle Time	Rating Factor	Normal Time
1	58.5	1.01	59.1
2	55.3	1.05	58.1
3	55.5	1.02	56.6

Table 4. Standard Time

Operator	Normal Time	*Allowance (All)*	Standard Time
1	59.1	19	72.9
2	58.1	19.5	72.2
3	56.6	19.5	70.3

Table 5. Tack Time

Item	Period	
	Before Month (N)	After Month (N+1)
Effective working time per day (Ta). (seconds)	73800	73800
Order Customer per day (D). (unit)	3277	2465
Takt time (T) per unit	**22.5**	**30**

Before calculating the normal time, we should determined the adjustment factor (Rating Factor) first. The synthesis method was used to determine the adjustment factor in this research. The average rating factor obtained, becomes a rating factor for all elements of work for each work station or operator concerned. In determining the standard time, the allowance must be determined in advance. This standard time is used to calculate takt time.

To facilitate the analysis, the related processed data has described first in the form of Yamazumi Chart. Based on the data depicted in the Yamazumi Chart, it can be calculated regarding the loading of work for each operator.

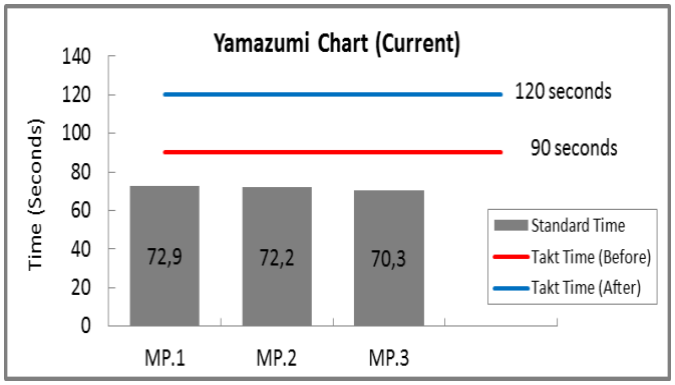

Figure 1. Yamazumi Chart (Current) Final Inspection

Do Based on the loading analysis of Final Inspection, operator work in two different Takt time conditions,there are Loading work operator 1 at Takt time 90 seconds is 81.0%, and at Takt time 120 seconds is 60.8%. Loading operator work 2 at Takt time 90 seconds is 80.2%, and at Takt time 120 seconds is 60.2%. Loading the operator's work 3 at Takt time 90 seconds is 78.1%, and at Takt time 120 seconds is 58.6%. At takt time of 120 seconds, each operator's work loading is lower than Takt time 90 seconds. If the Takt time of 120 seconds is running while the allocation number of the operator is not changed (subtraction), then the waiting time (idle) of each operator will increase. So that the operator efficiency of the Final Inspection work station is low.

Table 6. Final Inspection Operator Needs Analysis

Cycle Time			∑ *Cycle Time* (seconds)	*Takt Time* (seconds)	Operator Requirement
72.9	72.2	70.3	215.4	90	2.4 → (3)
				120	1.8 → (2)

From table 6 can be seen that the needs of operator with two different takt time conditions, namely; The operator's ideal requirement under takt time 90 seconds is 2.4 manpower. If the actual allocation number of operators is 3 manpower, then the condition is considered still relevant. The operator's ideal requirement under the takt time of 120 seconds is 1.8 manpower. If the actual allocation number of operators 3 manpower, then the condition is considered irrelevant, because the allocation number of operator should be 2 man power. We can calculate man power efficiency at takt time of 120 seconds and 90 seconds from the above conditions. When takt time 120 seconds and the allocations number of operators still remain with 3 manpower, then the efficiency of manpower is only 60%. But if the allocation operator with 2 manpower, then the man power efficiency reached 90%. This 90% efficiency is even higher when compared to the current takt time 90 seconds which is man power efficiency only 80% with the 3 man power allocation of operator.

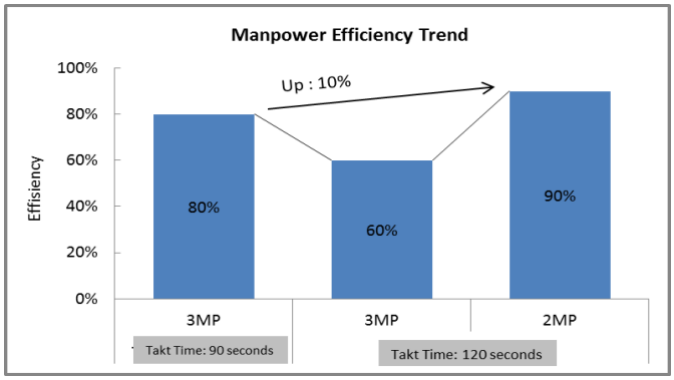

Figure 2,. Manpower Efficiency Trend Chart

After analyzing the work loading and calculating the number of operators on current and future conditions, the proposal is to perform the efficiency (decrease) of the number of operators at the Final Inspection Line work station from 3 manpower to 2 manpower. This recommended proposal aims to maintain and improve the company's profit by adjusting the amount of labor utilization (input) to the needs of production amount (output).

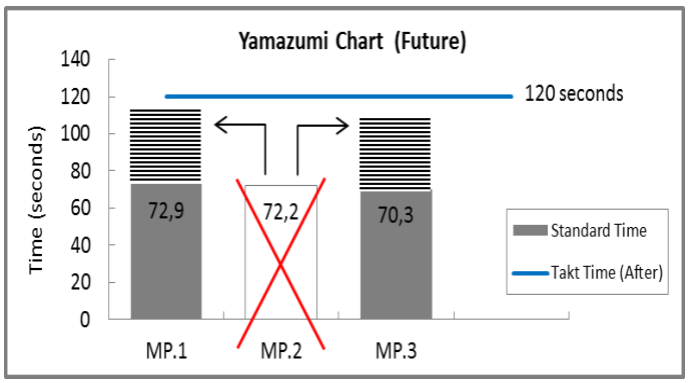

Fig. 3. Yamazumi Chart (Future) Final Inspection

Reduction in the number of employees will have an impact on loading the operator's work where if using 3 operators efficiency manpower will occur by 60%. Reduction in the number of employees will increase the efficiency of manpower to 90% by taking into account the workload of operators.

Table 7. Proposed Improvent Analysis

Takt time (second)	Initial Condition (current)			Proposed Condition (Future)		
	Operator	Cycle time (seconds)	Loading Work (%)	Operator	Cycle time (seconds)	Loading Work (%)
120	1	72.9	60.8%	1	109.0	90.8 %
	2	72.2	60.2%			
	3	70.3	58.6%	2	106.4	88.7 %

IV. CONCLUSION

Based on the results of the research has been done in the Final Inspection work station section, it can be concluded that if the new takt time condition (120 seconds), the company still allocates 3 operators, then the average work load or Manpower efficiency in that section is only 60%. But if the company allocates 2 operators only, then the average work loading or Manpower efficiency reaches 90%. Based on the calculation in accordance with the method used, then the operator needs in that part with the new takt time condition (120 seconds) is 2 people operators. This research can be continued with the application of kaizen to help ease the burden on the operator.

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