International Conference on Small and Medium Enterprise Development
Innovation and Sustainability in SME Development

Bali, June 14 – 16, 2012

Line Assembling Investigation of Three Wheels Bicycle Using Time Measurement Method at Pt X.

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Abstract

Production activities always require the best method, the best place and the best time. Time analysis required to determine the length of time to complete work. PT X is one medium enterprise company in Indonesia assembles a three wheels bicycle type F-586. Based on the production floor observation known that the assembly process of the three wheels bicycle done manually. Unbalance of task at work stations make the assembling process takes longer time than it should. This study will measure the time of each working element needed to assembly the product. Observation and measurement describe there are 31 of working elements. The average of the longest working element time take place at element no.23 is 304 seconds and the average of the shortest working element time take place at element no.2 is 2.83 seconds. The largest standard deviation is equal to 1.66 second take place at working element no. 24 and for the smallest standard deviation is 0.27 second take place at working element no 13.

Key word: time measurement, work elements

1. Background

In any human activity, both daily activities and production activities would require a method, time and place. In order to achieve the best goal of activities will require the best method, the best place and the best time. (Sukania, 2012). Analysis of time required to determine the length of time to complete work assignments, so it can be determined the best time. Analysis of the time is also determine the time allowance required by the workers. Study of time should be followed by research of the labor movement during an activity because its helps to find an efficient and an effective motions. The motions study can be conducted by directly observe the workers or by record the worker activities using a video camera and then analyze it by turning in a slow speed. The third factor considered is the conditions of work that includes a place or work stations and work environment. This is a very important factor because the time needed to completing the job will take longer if the workplace is inadequate and the work environment does not support.

PT X is a medium enterprise in the industrial product assembly, established in 1986 with 40 employees and produces two types of bicycles. Today, PT. X has an employee approximately 500 peoples, consist of various levels of education. Base on the results of the preliminary studies it is known that the main problems faced in the assembly process of the three wheel bicycle is the target not achieve. The individually assembling process to assemble three wheel bicycle components become a finished product is thought make the enterprise not achieving the target of 160 units / day

To resolve the problem, it is necessary to correct the system assembly process. The companies that have a mass production type, which involves a large number of components must be assembled, production planning activities provide an important role to regulate the operations or assignment to the line production. Balance of the works is the combination of works assignments to the operator or operator groups that occupies a particular workplace. When the planning is not appropriate, then some workstations on the line assemblies have a different production rate.

The un balance of assembling speed causing to the accumulation of materials or intermediate products between the work stations. Other side effects are compensated lost cost and negative psychological for workers. One of the most important variable to be considered in setting a production line is the working time data element. Therefore, this study will analyze the time required by each element of work that can be an input to create a balanced assembly lines.

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2. Time Measurement

Time measurement can be done in 2 ways, namely directly and indirectly. The first way is done directly in the place where certain jobs are being implemented. There are two methods of direct measurement by using a stopwatch and work sampling. Indirect time measurement method is done by calculating the time without visiting the worker.

The second way to measure the working time were performed by reading the available tables consist of the elements of the work and elements of the movement. The purpose of the time measurement is to get the standard time for completion of work by a reasonable way by a normal worker who works within the best system.

To obtain a working time data, then it is not enough just to do some measurements using a stop watch, but must be considered such things as working conditions, number of measurements, and others. Steps to obtain an optimal measurement of working time is set a goal of the measurement, conducting preliminary investigation, describe the work into elements of work, setting measurement equipment.

Working time measurement is an activity to observe the workers and record the time of it works. Steps of working time measurement are as follows:

2.1. Preliminary measurements

Preliminary measurements goal is to find out how many times the measurement should be taken to a desired accuracy and level of confidence. The calculation steps are as follows:

a. The measurement results are grouped into sub-groups and then calculate the mean of each sub-group.

b. Calculation of the sub-groups average (Walpole, Ronald E., 1995):

$$\bar{x} = \frac{\sum \bar{x}_i}{k}$$

where: $\bar{x}_1$ is the average value of the sub-group
k is the number of sub-group

c. Calculation of the the standard deviation

$$\sigma = \sqrt{\frac{\sum \left(x_j - \bar{x}\right)^2}{n-1}}$$

where: n is the number of preliminary observations and
Xj is the working time value

d. Calculation of the the standard deviation of the sub-groups average:

$$\sigma_x = \frac{\sigma}{\sqrt{n}}$$

where n is the size of subgroups

2.2. Test of data uniformity

Test of data uniformity aims to determine whether the results of measurement of time is quite uniform or not. The data in a uniform condition when the value of data located within the the control limits. Range control limits are Upper Control Limit (UCL and the Lower Control Limit (LCL). The formula is:

UCL = $\bar{\bar{X}} + 3.\sigma_x$

LCL = $\bar{\bar{X}} - 3.\sigma_x$

2.3 Calculation of the data sufficiency

Sufficiency data calculation is done after all the average value of a sub-group within the control limits. The data sufficiency formula is:

$$N' = \left(\frac{z}{occurationslevel} \frac{\sqrt{N\sum X_j^2 - \left(\sum X_j\right)^2}}{\sum X_j} \right)^2$$

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Where: N 'is the minimum amount of data measurement
The amount of data is enough if the required minimum number of measurements is theoretically less than or equal to the number of preliminary measurements (N')

2.4. Accuracy and confidence level

Time measurements aimed to find the actual time in completing the work. The ideal measurement is the huge number of measurement to get a true data. Accuracy level and confidence level is a reflection of the desired degree of level measurement . Accuracy level of measurement show a maximum deviation of the actual completion time, which is usually expressed in percent. While the magnitude of the confidence level show that the results obtained accuracy was eligible, which is also expressed in percent.

3. Working maps

Working maps is a tool that describes the work activities in a systematic and clear way, (Sutalaksana, 2005). Through these maps we can see all of the steps or treatment of a work piece or materials, starting from the entrance to the factory, then describe all the work steps, such as transportation, machinery operation, inspection and assembly, to be a finished products, both end products or a component of an end product. A good understanding of a working map will help to improve the methods of production. Basically all the improvements are intended to reduce overall production costs. Thus working map is a good tool to analyze a job to simplifying planning job improvement.

The working map is divided into two major groups based on the activities. The first working map used to analyze the overall work activities. The overall working maps consists of the Operations Process Chart (OPC), Process Flow Chart (FPC), chart Process Working Group (GPC), Flow Diagram (FD) and Assembly Chart (AC). The second working map includes a local working map that consist of Map of Man- Machine, Map of Right Hand and Left Hand

The overall working map involves all of the necessary working systems to create a product. While a local working map describes the local activities of employer. If it involve just only one work system, usually involve people and facilities in limited quantities. Both maps will show the close relationship of working system in order to completing a product if it involves some work stations, which are related with each other. For example an assembling company has several production machines or several work stations. In this case the smoothness of the whole production process will greatly depend on the smoothness of each work station. So to enhance the overall processes, it should be correct or enhance at first of any work systems in order to obtain the best working stations.

4. Research methodology

The research methodology is a step by step and frame of mind to formulate, analyze, and solve problems. From preliminary observations is known that the assembling process of a bike from the beginning to the final product assembled by one person. The main problem is the targets of 160 units / day not achieved, so it causing further problems in terms of economy and time. The data collected are:

a. The relationships between the elements of the work involved in a production line and described it on the precedence diagram.
b. The time data of each elements of the assembling process. Data were collected using a stop watch. Each elements of work is measured 20 times

5. Data and discussion

a. Data normality test performed

Data normality test performed to determine whether the operation time data of work has met the normal distribution or not. Data were considered normaly if the data follow a normal curve and qualify to Kolmogorov - Smirnov normality test. For $\alpha = 5\%$, D Table 0.294 with N = 20.

Based on data from the first working element, that is the installation of the left rear wheel axle, the maximum value of the test statistic D = 0.287. It can be concluded the time data of the first working element have a normal distribution. More calculations of (Element no 1: the left rear wheel axle assembly) stated in Table 1.

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Table 1.Calculation of normality test data (Element no 1: the left rear wheel axle assembly)

Xi (second)	Frequency	Cummulative frequency	Fs (Xi) Cummulative	Z	Ft (Xi) Cummulative	Ft (Xi)-Fs(Xi)
3,30	1	1	0,03	-2,08	0,0187	0,0145
3,31	1	2	0,07	-2,07	0,0192	0,0475
3,82	1	3	0,10	-1,25	0,1056	0,0056
3,83	1	4	0,13	-1,23	0,1930	0,0240
4,13	1	5	0,17	-0,75	0,2266	0,0599
4,32	1	6	0,20	-0,44	0,3300	0,1300
4,57	1	7	0,23	-0,04	0,4840	0,2507
4,57	1	8	0,27	-0,04	0,4840	0,2173
4,73	1	9	0,30	0,22	0,5870	0,2870
4,75	1	10	0,33	0,25	0,5987	0,2657
4,75	1	11	0,37	0,25	0,5987	0,2320
4,87	1	12	0,40	0,45	0,6735	0,2735
4,94	1	13	0,43	0,56	0,7121	0,2788
4,99	1	16	0,47	0,64	0,7387	0,2720
5,03	1	15	0,50	0,71	0,7611	0,2611
5,03	1	16	0,53	0,71	0,7611	0,2278
5,05	1	17	0,57	0,74	0,7702	0,2036
5,15	1	18	0,60	0,90	0,8117	0,2117
5,23	1	19	0,63	1,03	0,8395	0,2062
5,48	1	20	0,67	1,43	0,9218	0,2551

Then to test whether data of element no 1 (the left rear wheel axle assembly) have a uniform distribution and the data is sufficient, then the following steps taken :

a. Total of 20 time data were grouped into subgroups, each subgroup consisted of 5 cycles of time. Examples for work element no. 1 that is the left rear wheel axle assembly:

Table 2. Cycle Time Work Element 1

Sub-group	Cycle time data (seconds)					Sum	Average	Sum of squares
1	3,30	3,83	4,73	5,03	5,48	2,237	4,474	500,4169
2	4,94	4,13	1,57	4,99	5,15	23,78	4,756	565,4884
3	5,23	5,03	3,31	3,82	4,57	21,96	4,392	482,2416
4	4,32	4,75	5,05	4,87	4,75	23,74	4,748	263,5876
						91,85	18,37	2111,7384

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b. The average value of the subgroups calculation.

$$X = \frac{18,37}{4} = 4,5925$$

c. The standard deviation of cycle time data calculation.

$$\delta = \sqrt{\sum \frac{(3,30-4,5925)^2 + (3,83-4,5925)^2 + \ldots\ldots\ldots + (4,75-4,5925)^2}{20-1}}$$

$$\delta = 0,620$$

d. The standard deviations from the average value of the subgroup calculation.

$$\delta X = \frac{0,620}{\sqrt{5}} = 0,277$$

e. The Upper Control Limit (UCL) and the Lower Control Limit (LCL) calculation.

UCL = 4.5925 +3 (0,2,77) = 5.4235
LCL = 4,5925-3 (0.277) = 3,715

These control limits are used to determine data whether uniform or not. If all data are within the control limit then the data is considered uniform.

f. The sufficiency data calculation.

$$N' = \left[\frac{(1,65/0,05\sqrt{20(3,30+383^2+\ldots\ldots+4,75^2) - (3,30+3,83+\ldots\ldots+4,75)^2}}{(3,30+3,83+\ldots\ldots 4,75)} \right]^2$$

N'= 18,86

Because N' < 20, then the data taken has been sufficient. So the cycle time for the working element no 1 is 4.5925 seconds

Table 3 below shows 31 of the working elements data and figure 1 show the precedence diagram of three wheel bike assembling processes

Table 3. Working elements sequence of the three wheel bike assembly process

No	Name of working element	Pre- element	Average Cycle Time (seconds)	Standard deviation
1	Left rear wheel axle assembly	-	4.59	0.62
2	924KMD left horn ring assembly	1	2.83	0.31
3	Left rear wheel assembly	2	11.89	0.86
4	Ring two 9.5 left assembly	3	2.97	0.39
5	Pin R left assembly	4	5.42	0.47
6	Left round hubcap assembly	5	4.93	0.34
7	Right rear wheel axle assembly	6	3.99	0.40
8	924KMD right horn ring assembly	7	2.85	0.32
9	Right rear wheel assembly	8	10.89	0.41
10	Right-ring diameter 9.5 assembly	9	2.93	0.41
11	Right pin R assembly	10	5.31	0.31
12	Right round hubcap assembly	11	4.85	0.28
13	Pedal shaft 8360 with frog bosh assembly	-	12.17	0.26

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Table 3. Working elements sequence of the three wheel bike assembly process (continued)

No	Name of working element	Pre- element	Average Cycle Time (seconds)	Standard deviation
14	Pedal shaft with the front wheel assembly	13	13.24	0.42
15	Oval hubcap shaft with pedal shaft assembly	14	10.50	0.47
16	T iron with pedal shaft assembly	15	11.14	0.42
17	Pedal with pedal shaft assembly	16	8.56	0.31
18	Clamps with pedal shaft assembly	17	6.32	0.45
19	Mirror holder and locker using TT Ø8X5 / 8 "12 H assembly	-	56.77	1.50
20	Rubber and handle bar assembly	19	82.72	1.64
21	Framework of the handle bar to the rear frame using 886 assembly	12,20	24.63	1.19
22	Nail spatboard with handle bar assembly	21	24.32	1.38
23	Handle bar set with front wheel assembly	18,22	304.33	1.64
24	Saddle to the frame assembly	23	32.13	1.66
25	Saddle bolt assembly	24	65.86	1.41
26	Seat to the frame assembly	25	38.97	0.82
27	Back rest with the frame assembly	26	134.96	0.84
28	Cap with back rest assembly	27	12.15	0.83
29	Front basket with 2 bolts assembly	28	158.83	0.84
30	Rear basket with 2 bolts assembly	29	88.05	1.13
31	Mirrors assembly	30	24.17	0.62
			1173,33	

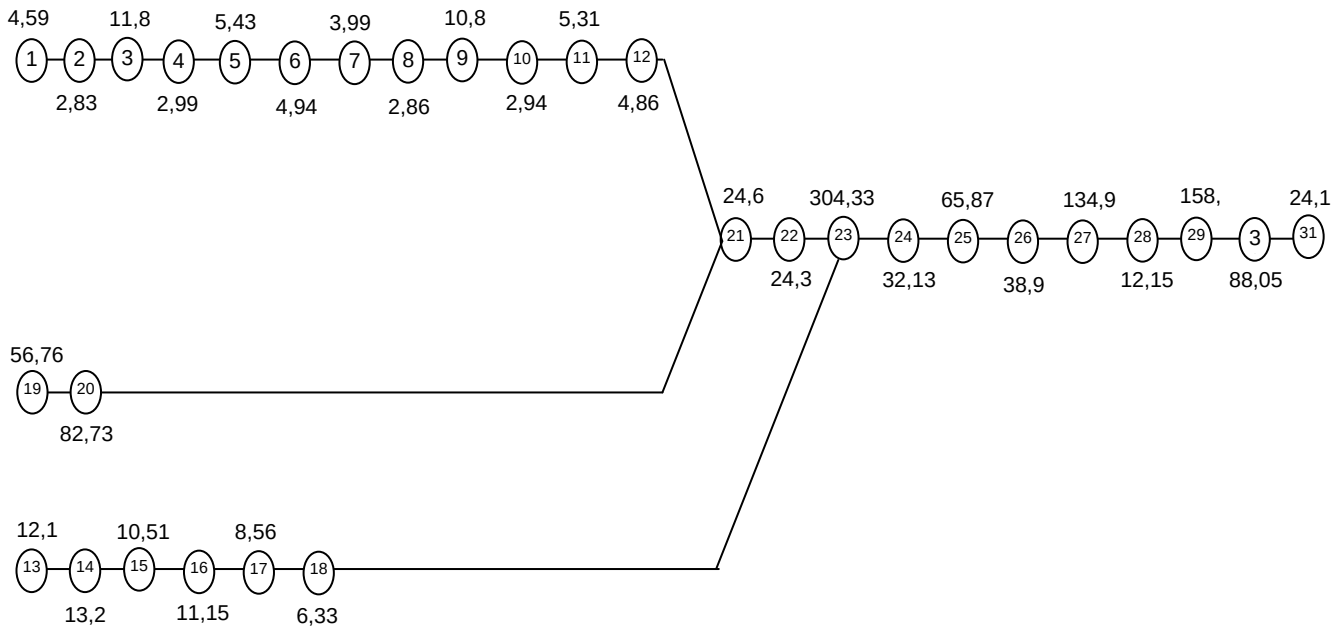

Fig. 1. Precedence diagram of the three wheel bicycle assembly

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6. Analysis

Based on the observation of the work step in the assembling process, we obtained 31 pieces the work elements. The average time and standard deviation for each element of work is obtained from the measurement results as much as 20 times by using a stop watch.

From the calculations obtained that the longest average time is 304.33 seconds take place at work element number 23 (Handle bar set with front wheel assembly) and the fastest average time is 2.83 seconds, take place at work element number 2 (924KMD left horn ring assembly). The largest standard deviation is 1.66 seconds take place at work element number 24 (Saddle to the frame assembly) and the smallest standard deviation is 0.26 seconds take place at working element number 13 (Pedal shaft 8360 with frog bosh assembly). Total time to complete product assembly with existing method is 1173,33 seconds.

Based on standard deviation values, its obtained information that the assembly line has been observed in steady state enough, where most of the work elements have a relative small standard deviation.

7. Conclusion

Based on floor observations known the existing method is not effective enough because the assembly process of a product from the beginning to become a finished product done by one person only. The sequence of the assembly process and the working element time data are very importance input in order to improve the methode so the assembly cycle time becomes shorter.

References

Sukania, I Wayan., 2012. Perbaikan Metode Perakitan Steker Melalui Peta Tangan Kiri dan Tangan Kanan, Prosiding TINDT 2012 FT Untar.

Sutalaksana, Ifkar., Ruhana Anggawisastra., Jann H. Tjakraatmadja. 2005.Teknik Perancangan Sistem Kerja, Bandung, jurusan Teknik Industri ITB.

Walpole, Ronald E., 1995, Pengantar Statistika, Jakarta, Gramedia Pustaka Utama.

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