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Submission date: 01-Oct-2021 07:48AM (UTC+0700)
Submission ID: 1662072274
File name: 1-Work_measurement_approach__B.Lusi.pdf (373.03K)
Word count: 1667
Character count: 9326

WORK MEASUREMENT APPROACH TO DETERMINE STANDARD TIME IN ASSEMBLY LINE

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Abstract— Productivity measure output to input. Work measurement is a tool to increase productivity of industrial and business area. The aim of this research is to determine standardtime of assembly process. The research was conducted at a manufacture industry in Indonesia that produce plastic product. Several production lines in company are using manual process, for example assembly work station, where as a bottleneck workstation. Work measurement is conducted in order to improve the productivity of assembly workstation. Time study is working measurement technique consisting time measurement of worker that doing jobs in normal pace. Performance rating and allowance are added into observed time to calculate standard time.

Index Terms— Productivity, Work measurement, Time Study, Standard Time.

I. INTRODUCTION

Changes continually taking place in industrial and business area must be considered both economically and practically. The way an industrial or business can grow and has sustainability is by increasing its productivity. Productivity is the key to determine the success of a company. Generally productivity is described as the ratio of output to some or all of the resources used to produce the output. Operationalized as the ratio of output to input, the productivity measures aims at identifying how efficiently the resources in a system are used in producing the desiredoutput [1].

Measurement of work is a fundamental tool that results in increased productivity. Work measurement technique is mainly used to quantify the work content related with a job, in terms of the standard time. Setting of the time standard is done using the four techniques mainly these are the time study, work sampling predetermined motion time study and the standard data method. Establish time standard for produce a product at work station is the important thing to do. It is related to productivity. Method study and work measurement are two principal activities of work study which originated in the work of F. W. Taylor [1]. Time study is the most widely method that used to determine standard time. It is a technique of establishing an allowed time standard to perform a given task, based upon measurement of work content of the prescribed method, with due allowance for fatigue and personal and unavoidable delays [2]. Time study is accomplished by performing analysis of work, standardization of methods and making time study respectively [3].

In this study, work measurement is conducted at plastics manufacturing. Resin, raw material, is being formed into a wide variety of shapes. Following steps are followed on production process: weighing, dissolution, mixing, injection, finishing, assembly, and packaging. The process is done manually and automation. Bottleneck often occurs at assembly workstation. The objective of this study is to determine standard time of assembly process. The main reason to determine standard time is to establish adequate workloads of workstation in order to increase productivity.

II. LITERATURE REVIEW

Time Study

Time study is used to determine the time required by a qualified and well trained person working at a normal pace to do specific task [4]. ILO describes time study as a work measurement technique for recording the times and rates of working for the elements of specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance [5].

The result of time study is called the standard time. It means the time required to perform the operation with the conditions fully qualified, trained operator, working at standard pace and exerting average effort. Certain fundamentals requirements before conduct time study should be made. There are methods or part of the method has been altered, the operator should be thoroughly acquainted with the new technique before the operation is studied. Also, the method must be standardized for the job before the study begins [2].

Uses for Time Study

Time study and the other method of measuring work are used for many purposes including: determining schedules and planning work, determining standard cost and as an aid in preparing budgets, estimating cost of product, determining machine effectiveness, basis for a payment, basis for labor cost control

III. RESEARCH METHOD

A research methodology is used to describe steps to solve problem. The problem is observed in plastic manufacturing company. The data are collected and analyzed according the requirements. Primary and secondary data is used in this research.
Primary data were obtained through observation and interview. While secondary data were collected from reference book, journal and previous research related to research this subject.
Data analysis was conducted after data collection that divided into several steps. Following procedures is followed in getting standard time: conduct stopwatch time study, record the details, measure the time of each element, determine standard rating, calculate the normal time, determine the allowance, and determine the standard time.

IV. DATA ANALYSIS AND DISCUSSIONS

Observed Time

In this study, work measurement is using stopwatch time study. Stopwatch time study is used to measures time that needed by worker to complete a task at a normal pace. Observation was conducted at assembly work station. Operators start the task with lifting the component from previous workstation and then joining components and put it to next workstation. The equipment required to conduct time study is stopwatch that used to record times. The times are classified into subgroup and to get average time.
Table I present observed time based on stopwatch time study.

Table I. Observed

Subgroup	Observed Time (Second)					Average (Second)
1	440	454	445	511	444	458.8
2	414	451	431	434	514	448.8
3	441	453	499	431	443	453.4
4	513	421	441	441	482	459.6
					Total	1820.6

To determine the sample size needed for a time study is refer to (1). A 95 percent confidence level and ±5 percent precision are used in this study. It means that the sample size is sufficient.

$$N' = \left(\frac{40\sqrt{(N\Sigma t^2-(\Sigma t)^2}}{\Sigma t}\right)^2 \qquad (1)$$

Where, t is observed time.

Control Chart

Control chart is used to test the consistency of the time study data. Fig 1 shows that a plotted point inside the control limits. It indicates that normal condition have been present during stopwatch time study. The 3-sigma limit is ordinarily used in determining the upper and lower control limits. This means that there are only three chances in 1000 that a point will fall outside the limits owing to a chance cause [3].

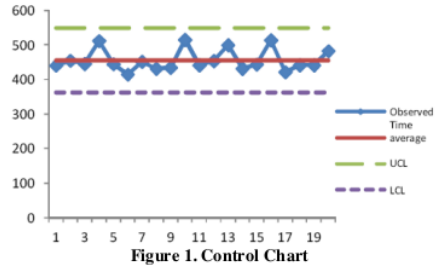

Figure 1. Control Chart

Normal time

Observed time is not the actual time required to accomplish the work for operator. It is normalized using the performance rating factor. Performance rating is an evaluation method that considers the effectiveness operator doing work. Then it will be applied to obtain the normal time. The performance rating of the worker is important because it helps to quantify the worker during the operation. Westinghouse system of rating describes four factors for rating performance. There are skill, effort, conditions and consistency. In Westinghouse method, there are six classes of each factor as shown in Fig II. Based on observation and evaluate operator according Westinghouse table, performance rating of operator at assembly line was:

Good skill, C1	+0.06
Good effort, C1	+0.05
Average condition, D	0.00
Average consistency, D	0.00
Total	0.11

$$normal\ time = observed\ time \times \frac{rating\ in\ percent}{100} \qquad (2)$$

Refer to (2), the normal time for this operation is 505.22 second

Figure II. Westinghouse Performance Rating

Skill ratings			Environmental condition Ratings		
+0.15	A1	Superskill	+0.06	A	Ideal
+0.13	A2	Superskill	+0.04	B	Excellent
+0.11	B1	Excellent	+0.02	C	Good
+0.08	B2	Excellent	0.00	D	Average
+0.06	C1	Good	-0.03	E	Fair
+0.03	C2	Good	-0.07	F	Poor
0.00	D	Average	Consistency ratings		
-0.05	E1	Fair	+0.04	A	Perfect
-0.10	E2	Fair	+0.03	B	Excellent
-0.16	F1	Poor	+0.01	C	Good
-0.22	F2	Poor	0.00	D	Average
Effort ratings			-0.02	E	Fair
+0.13	A1	Excessive	-0.04	F	Poor
+0.12	A2	Excessive			
+0.10	B1	Excellent			
+0.08	B2	Excellent			
+0.05	C1	Good			
+0.02	C2	Good			
0.00	D	Average			
-0.04	E1	Fair			
-0.08	E2	Fair			
-0.12	F1	Poor			
-0.17	F2	Poor			

Standard time

Standard time is derived by adding allowance to normal time. Allowance is frequently added, which will force the worker to stop the work, and do other things. There are categories of allowance, first, personal allowance, second, fatigue allowance, and third, delay allowance. Environmental aspects were also used to obtain allowances. Equation (3) is used to determine the standard time.

$$standard\ time = normal\ time \times \left(\frac{100}{100 - allowance\ in\ \%}\right) \quad (3)$$

In order to determine allowances of operator, this is based on allowances that are recommended by International Labor Organization (ILO). ILO standard is classified into two categories, constant and variable allowance, to calculate worker allowances. Table II presents ILO recommended allowances.

Based on observation and evaluate operator according ILO recommended allowances, allowances of worker at assembly line was:

Basic fatigue allowance	4%
Standing allowance	2%
Muscular energy	0%
Bad Light	2%
Atmospheric Conditions	10%
Near/Close Attention	0%
Noise Level	2%
Mental Strain	1%
Monotony	1%
Tediousness	0%
Total	22%

The standard time for assembly line is then computed, refer to (2), as 646.05 second per product. In a 7-hour workday per shift, an operator can produce 455 products per shift. This standard time can be used to determine efficiency and increase worker performance in assembly workstations. Then the bottleneck will be treated using time study method. This method explains the best way to improve production quantity and quality and increase productivity.

Table II ILO Recommended Allowances Variable Allowa

Variable	Allowance (%)	Factor	Allowance (%)
A. Constant allowances		Atmospheric conditions (heat and humidity)-variable	0-100
Personal allowance	5	Close attention:	
Basic fatigue allowance	4	Fairly fine work	0
B. Variable allowances:		Fine or exacting	2
Standing allowance	2	Very fine or very exacting	5
Abnormal position allowance:		Noise level:	
Slightly awkward	0	Continuous	0
Awkward (bending)	2	Intermittent - loud	2
Very awkward (lying, stretching)	7	Intermittent - very loud	5
Use of force, or muscular energy (lifting, pulling, or pushing):		High-pitched - loud	5
Weight lifted, pounds:		Mental strain	
5	0	Fairly complex process	1
10	1	Complex or wide span of attention	4
15	2	Very complex	8
20	3	Monotony	
25	4	Low	0
30	5	Medium	1
35	7	High	4
40	9	Tediousness:	
45	11	Rather tedious	0
50	13	Tedious	2
60	17	Very tedious	5
70	22		
Bad light			
Slightly below recommended	0		
Well below	2		
Quite inadequate	5		

CONCLUSION

Work measurement should be carried out by industrial and business area to increase productivity. Before conducting time study, it is much necessary to select the worker that qualified and experienced to perform a specific task or operation at normal pace. The worker should know the standardized method to accomplish task or operation. The performance rating factor and allowance factor that used in this study are based on analysts' judgments; therefore, need reviews and retraining of work-study analysts to keep calibrating the standard times. Time standard as a result of time study may be used for cost control, scheduling and wage and budget estimation.

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