Stopwatch Method For Assembly Line Production

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ABSTRACT
Work measurement is one of the most crucial factors in determining how productive a service or product organisation is. The methods used evaluate the strategy adopted and the amount of time required to finish a task. It makes it easier to cut back on spending and waste. This study includes a few direct observational stopwatch time study strategies. The discussion of various time concepts, such as observed time, normal time, and standard time, will provide opportunity to more clearly conceptualise the concept of work measurement. The assembly line used to make plastics on this study's assembly line had a computed standard time of 767.96 seconds and a normal time of 599.0 seconds.
Key words: Work measurement, Stopwatch method, normal time, observed time, standard time, assembly line

I.   INTRODUCTION

Through a variety of scientific methodologies, changes and progress are brought to the industrial and business fields that are both practically and economically beneficial. Productivity is one of the key factors that determines whether a firm will succeed. The ratio of output to input often serves as a quantitative measure of productivity. The cost of the goods or services produced, as well as the resources used to make it, including labour, capital, raw materials, and energy, are included in the output. Partial and total production are two ways to describe it [1].

One of the most important strategies for increasing productivity is work measurement. The method entails calculating the work in terms of standard time. The standard time is mainly established using methods like time study, work sample predetermined motion time study (PMTS), and the standard data technique. This method and time study were first created by F.W. Taylor and were titled "Scientific task and job rating" [12].

Time study is the most widely used method to determine standard time. It is a technique of finding out the standard time to do a given job, based upon the method of measurement of work, with consideration of allowances such as fatigue, and unavoidable delays [2].

Time studies are carried out through job analysis, technique standardisation, and time study combined, respectively [3]. Numerous manufacturing processes can make use of work measures. This study is carried out based on plastic industry where resin, raw material, is being produced into a wide variety of shapes. Weighing, dissolving, mixing, injecting, finishing, assembling, and packaging are further processes used in the above manufacturing process. The procedure is carried out using both automatic and manual methods. Because they frequently happen at assembly workspaces, bottlenecks cannot be avoided.The primary goals of standard time determination are process standardisation, waste reduction, movement elimination, capital investment reduction, and quantitative systematisation of work using acknowledged standards [6].The objective of this study is to determine the standard time of assembly process and study various time study methods used to evaluate it.

II.   LITERATURE REVIEW
Time Study Concept

Time study is the skill of watching and keeping track of how long it takes to complete each specific task in an industrial operation [7]. Time study is referred to as a work measurement technique by the ILO (International Labor Organization) for recording the times and work

rates for the specified job carried out in the specified environment and for obtaining data on the amount of time required to complete the job at a specified level of performance [5]. In other words, it is the calculation of the amount of time needed for a skilled and well-trained individual to do a certain work in a typical setting [4]. There are several time study methodologies, including the stopwatch approach and traditional data analytical estimation [8].

Standard time is the end product of time studies [2]. The collection of diverse jobs' standard times results in the standard data catalogue [8].

Major reason for studying time

Time study and work measuring techniques are used for a variety of tasks, such as (1) planning and scheduling work, (2) determining standard operating costs, (3) creating budgets, estimating product costs, calculating machine efficiency, (5) establishing the foundation for a payment control of labour costs [2], (6) making purchases or decisions, (7) balancing the work of group of operators, (8) estimating delivery dates, and (9) calculating the amount of time needed to generate a certain inventory level [8].

III.   RESEARCH METHODS

The quantitative approach used to address research problems is known as research methodology. Here, stopwatch time study is being utilised to determine the time. The above-mentioned plastic manufacturing firm are the source of the study which is carried based on. The information is gathered and examined using various stopwatch method techniques. Both secondary and primary data are being used in this study. While secondary data were gathered through textbooks, charters, numerous periodicals, and prior study articles, primary data were acquired through firsthand observations and exclusive interviews. Data analysis was done after data collection in a number of processes.The methods listed below were used to determine standard time:

1.   performed a stopwatch study,
2.   documented the findings,
3.   timed each element,
4.   computed the normal time, established allowances, and
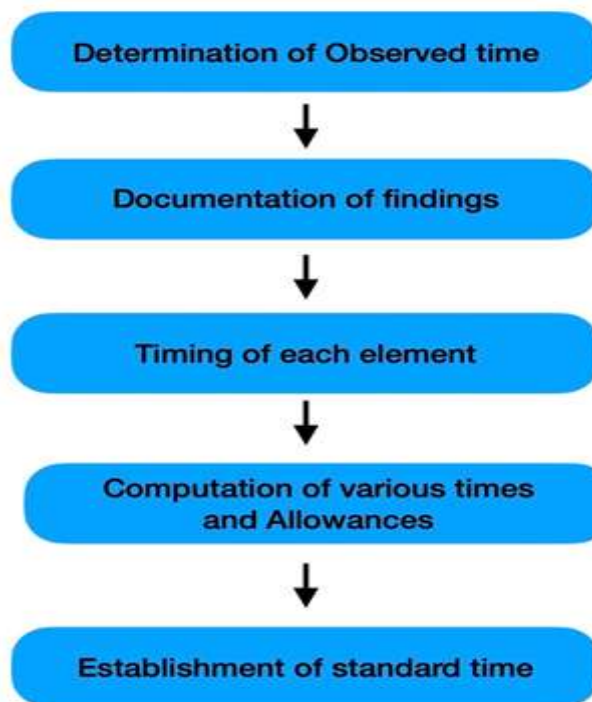5.   established the standard time

Fig 1: Research Methods

IV. DATA ANALYSIS AND DISCUSSION

1. Observed time

The stopwatch method is the work measurement approach employed in this investigation. There are 5 different production procedures in the assembly line. Every time, a stopwatch has been used to record how long it takes to complete activities. To quickly determine the average trial duration, data are taken for subgroups.

Sub groups	Time recorded(s)					Average
Tasks	1	2	3	4	5	
1	600	400	450	460	560	494
2	570	500	670	450	650	568
3	432	569	478	459	560	499.6
4	590	590	567	670	568	597

Table 1: Observed time

$$n = \left(\frac{40\sqrt{\Sigma t^2 - (\Sigma t)^2}}{\Sigma t}\right)^2$$

Here, to determine the sample size, by theory of work sampling, the equation below is used.

Where, $'t'$ is observation time in seconds. The sample size decision depends on the confidence level of the result. In motion time study, 2σ (standard deviations) are used which ensures $95.45\pm5\%$ success rate [9]. The confidence level with standard deviations is given below:

Confidence level	Level of Significance	$Z_{\alpha/2}$
99%	1%	2.575
95%	5%	1.96
90%	10%	1.645

Table 2: The confidence level with standard deviations [10].

2. Control Charts

Control charts are the instruments used to assess the statistical control of a manufacturing or business process [11]. Control is used to evaluate the data's consistency. It is a tool for quality assurance. It displays a situation of normal distribution. Control limit determinations often employ the 3σ limit (99.7% confidence). Accordingly, there are only three chances in a thousand$(1:1000)$that a point will go outside its bounds [3].
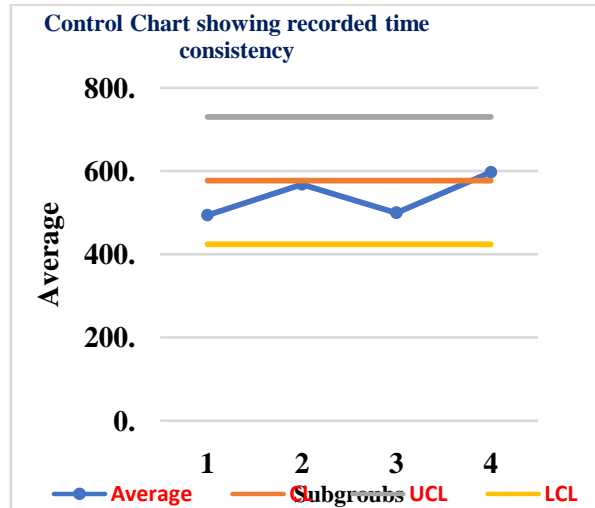
Fig 2: Control Chart showing recorded time consistency.

3. Normal Time

Utilizing the performance rating factor [7], it needs to be normalised. The ratio of a worker's performance level to the standard performance expected determines their performance rating [8].

Good Skill(C1)	**+0.06**
Good Effort(C2)	**+0.05**
Average Condition(D)	**0.00**
Average Consistency(D)	**0.00**
Total	**+0.11**

Table 1: Selected performance rating criteria for the assembly line.

Westinghouse system is one of rating performance scheme. There is skill, effort, condition, and consistency. In the Westinghouse method, there are six classes of each factor as shown in above table.

Based on observation and Westinghouse table, performance rating of operator at assembly line was observed. Then the normal time is calculated using the relation:

$$normal\ time = Observed\ time\left(\frac{Rating\ in\ percent}{100}\right)$$

SKILL			EFFORT		
+ 0.15	A1	Super skill	+ 0.13	A1	Super skill
+ 0.13	A2		+ 0.12	A2	
+ 0.11	B1	Excellent	+ 0.1	B1	Excellent
+ 0.08	B2		+ 0.08	B2	
+ 0.06	C1	Good	+ 0.05	C1	Good
+ 0.03	C2		+ 0.02	C2	
0.00	D	Average	0.00	D	Average
- 0.05	E1	Fair	- 0.04	E1	Fair
- 0.10	E2		- 0.08	E2	
- 0.16	F1	Poor	- 0.12	F1	Poor
- 0.22	F2		- 0.17	F2	
CONDITION			CONSISTENCY		
+ 0.06	A	Ideal	+ 0.04	A	Ideal
+ 0.04	B	Excellent	+ 0.03	B	Excellent
+ 0.02	C	Good	+ 0.01	C	Good
0.00	D	Average	0.00	D	Average
- 0.03	E	Fair	- 0.02	E	Fair
- 0.07	F	Poor	- 0.04	F	Poor

Table 2: Westinghouse table [10]

From the above data, the normal time is calculated to be 599.01s.

4. Standard Time

To the normal time determined above, several allowances are added to determine standard time. Allowances are added to compensate idle time because employees are incapable of working continuously [8]. It provides flexibilities to employees for taking breaks and to engage in other activities. There are several various kinds of allowance, including personal, fatigue, and delay allowances [7].

$$Standard\ \ time = Normal\ \ time\left(\frac{100}{100 - Allowance\ \ in\ \ \%}\right)$$

The ILO divides allowances into two categories: variable allowances and constant allowances. In table 4, various allowance types that the ILO recommends are listed. Following careful inspection, some considerations for allowances for assembly line workers that need to be made include:

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%**

Table 3: Selected allowance criteria for assembly line(with reference to table 4)

With the above calculated allowance, the standard time of the operation is 767.96s per product.

Variable	Allowance (%)	Factor	Allowance (%)
A. Constant allowances		Atmospheric conditions (heat and humdity)-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
70	22		
Bad light			
Slightly below recommended	0		
Well below	2		
Quite inadequate	5		

Table 4: ILO recommended allowances[9]

V.   CONCLUSION

One of the methods for measuring work is the stopwatch method. It entails keeping track of the amount of time needed to complete a certain task before figuring out normal and standard time from the directly observed time. When determining standard time, performance rating is taken into account together with the inclusion of allowances. The average time for the aforementioned data set was determined to be 599.01 and 767.96 seconds, respectively. Each of the three different time periods has a distinct meaning. The stopwatch time study is recommended because it is easier and less expensive than other techniques.

REFERENCES

- Ishwar Bhiradi , B.K.Singh, "Work Measurement Approach For Productivity Improvement In A Heavy Machine Shop", 5 th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) December 12th–14th, 2014, IIT Guwahati, Assam, India, 2014.
- A. Freivalds, "Niebel's Methods, Standard, and Work Design," McGraw-Hill, 2009.
- A. Karanjkar, "Manufacturing and Operations Management", Nıralı Prakashan, 2008. [4] Ralph M. Barnes, "Motion and Time Study Design And Measurement Of Work," John Wiley & Sons, Inc, 1980 [5] International Labour Organisation (ILO), "Introduction to Work Study," Universal Publishing Corp., India. , Third Revised Edition, 1986.
- Ralph M. Barnes, "Motion and Time Study Design And Measurement Of Work," John Wiley & Sons, Inc, 1980
- International Labour Organisation (ILO), "Introduction to Work Study," Universal Publishing Corp., India. , Third Revised Edition, 1986.
- Prakash C, Prakash Rao B, Shetty DV, Vaibhava
- S. Application of time and motion study to increase the productivity and efficiency. Journal of Physics: Conference Series. 2020;1706(1):012126.

- Jain M. Time Study: Definition, objectives and advantages (with formula) [Internet]. Your Article Library. The Next Generation Library; 2016 [cited 2022Nov16]. Available from: https://www.yourarticlelibrary.com/cost-accounting/time-study/time-study-definition-objectives-and-advantages-with-formula/90524
- Khana OP. Industrial Engineering and Management. 1st ed Dhanpat Rai Publishers, INDIA; 2017.
- Hartanti L. Work measurement approach to determine standard time in assembly line [Internet]. Academia.edu. IRAJ International Journals; 2016 [cited 2022Nov16]. Available from: https://www.academia.edu/86985671/Work_Measurement_Approach_to_Determine_Standard_Time_in_Assembly_Line
- Kiernan D. Natural Resources Biometrics [Internet]. Chapter 2: Sampling Distributions and Confidence Intervals | Natural Resources Biometrics. Open SUNY Textbooks; 2020 [cited 2022Nov16]. Available from: https://courses.lumenlearning.com/suny-natural-resources-biometrics/chapter/chapter-2-sampling-distributions-and-confidence-intervals/
- Admin. Control charts: Types of Control Charts and features [Internet]. BYJUS. BYJU'S; 2021 [cited 2022Nov16]. Available from: https://byjus.com/maths/control-charts/
- 2 BAB. Bab 2 kajian literatur 2.1 Pengenalan - Universiti malaya [Internet]. Udemy. [cited 2022Nov16]. Available from: http://studentsrepo.um.edu.my/1708/3/BAB_2.pdf