Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2021, 8(4):157-166**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Analysis of Work Time Measurement with Work Sampling Method and Method Time Measurement (MTM)

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Abstract Production planning plays an important role in making production scheduling, one of which is working time measurement. The research was conducted in cosmetic companies in the Quality Control (QC) section, more precisely QC Formulations. After QC formulation, there is a production process; this process already uses an automatic machine, which is required scheduling for the operating hours of the machine. While the QC formulation process is still manually using human power, it is necessary to measure the working time to know the standard time on the formulation QC to schedule production and operating hours of the machine to not cause lost costs due to delayed production. The method used to measure working time in this study is to use the method directly (work sampling) and indirectly (MTM). The measurement results using methods time measurement obtained normal time obtained by 32 seconds/unit and the default time obtained by 39 seconds/unit. Based on work sampling methods obtained results with normal time obtained by 36.6 seconds/unit and the default time obtained by 43 seconds/unit. The MTM method produces a more efficient raw time of 9.3% compared to the work sampling method.

Keywords Measurement of Working Time, MTM, Work sampling

Introduction

Competition in the industry is getting stronger, and every company will always improve performance to last a long time. In a company with a mass-production type, production planning plays an important role in making production scheduling, one of which is the measurement of working time.

Cosmetics company located in Depok, West Java. There is a Quality Control section that has two parts, namely QC ruahan and QC formulation. The jobdesk for QC Ruahan is to check the raw materials by sampling viscosity/viscosity and odour check. QC formulation is to continue the work of basic products made from QC Ruahan, namely sampling products, checking ph, and releasing the product into the final product for the job desk.

After the QC process is implemented, then the product can be released for production. The production process already uses an automated machine, which requires scheduling for the machine's operating hours. It relates to QC formulation, which is a process that must be done before the goods are produced. The QC formulation process is still manually using human power, so it is necessary to measure the working time to know the standard time on QC formulation to schedule production and operating hours of the machine to not cause lost costs due to delayed production. Besides, the result of this problem is increased working hours so that the company has to spend additional costs and the opportunity lost from the demand that is not successfully met [1].

Currently, the company uses the standard time measurement method directly, namely the work sampling method. This study analyses work time measurement results using indirect methods, namely time measurement method and direct work sampling [2].

Materials and Methods

Measurement of working time is an activity to determine the time required by an operator or worker (who has the average ability or is well trained) in carrying out a work activity with normal conditions and tempo [3], [4]. Measurement of working time can be classified into two, i.e., direct and indirect methods [5], [6], [7]. Direct measurement is a measurement done where the work is measured by using stop hours *(stopwatch time study)* and work sampling (work *sampling*). On the contrary, indirect work measurement is a calculation of working time where the researcher does not have to be in the place of work measured and the working time is determined by reading the available time tables; there are three methods, namely *Methods Time* Measurement, *Work Factor*, and *Maynard Operation Sequence Technique* [8].

Work Sampling Methods

The work *sampling* method is suitable for non-repetitive work, observation, and long working time [9]. This working time is divided into productive (P) and unproductive (NP) time to get real-time without including waiting, queuing, or other activities that are not included in work activities (chatting, lazing, going to the toilet, and other personal [10]. After obtaining productivity data from the QC productivity assessment from the above formulations, calculate the productive and non-productive as in Table 1.

$$\%\ \text{Productivity} = \frac{\text{number of productive activity}}{\text{amount of observation}}\ \text{x}\ 100\%$$

Table 1: Calculation of productive percentages and non-productive QC Formulations

Activities	**Day 1**					**Amount**
	1	**2**	**3**	**4**	**5**	
Productive	115	110	116	120	119	580
Non-Productive	35	38	36	34	28	171
Amount	150	148	152	154	147	751
% Productive	76.67%	74.32%	76.32%	77.92%	80.95%	77.23%

Based on the calculation of productivity, obtained average productive of 77.23% and non-productive by 22.77%.

A. Data Adequacy Test

Example of calculation of adequacy of observation data day 1:

$$N' = \frac{k^2(1-p)}{S^2 p}$$

$$N' = \frac{2^2(1-0.76)}{0.1^2\ x\ 0.76}$$

$$N' = 126{,}3\ \approx 127$$

After the calculation of data adequacy obtained following Table 2, [8].

Table 2: Data Adequacy Calculation Results

Observation of the day	**Productive**	**Non Productive**	**N**	**N'**	**Description**
1	76.67%	23.33%	150	127	N > N', Enough Data
2	74.32%	25.68%	148	141	N > N', Enough Data
3	76.32%	23.68%	152	126	N > N', Enough Data
4	77.92%	22.08%	154	100	N > N', Enough Data
5	80.95%	19.05%	147	106	N > N', Enough Data

Based on the calculation of data adequacy on 5 QC implementers in formulation, N>N' value is obtained for each job so that the data is declared sufficient.

B. Data Uniformity Test

From the observation data that has been collected, the calculation is continued to see the uniformity of the data.

Example of calculation of uniformity of observation data day 1:

- UCL (Upper Control Limit)

$$UCL = p + 3\sqrt{\frac{p(1-p)}{n}}$$

$$UCL = 0.76 + 3\sqrt{\frac{0.77(1-0.76)}{150}}$$

$$UCL = 87.30\%$$

- LCL (Lower Control Limit)

$$LCL = p - 3\sqrt{\frac{p(1-p)}{n}}$$

$$LCL = 0.76 - 3\sqrt{\frac{0.77(1-0.76)}{150}}$$

$$LCL = 66.69\%$$

After the calculation of adequacy of data obtained results as in Table 3,[8]:

Table 3: Data Uniformity Calculation Results

Observation of the day	Productive	N	UCL	LCL	Description
1	76.67%	150	87.30%	66.69%	Uniform Data
2	74.32%	148	87.30%	66.69%	Uniform Data
3	76.32%	152	87.30%	66.69%	Uniform Data
4	77.92%	154	87.30%	66.69%	Uniform Data
5	80.95%	147	87.30%	66.69%	Uniform Data

Based on the calculation of uniformity of data on 5 QC implementers in formulation, all data is obtained from upper control and lower control limits so that the data is declared uniform.

Rating Factor Determination

Westinghouse points are used to calculate normal time, where the cycle time obtained from the study multiplies *Westinghouse points*. *Rating factor* or adjustment of workers from each element of activity is determined by *Westinghouse*[11], obtained rating factor value of 1.12 as in Table 4.

Table 4: Rating Factor Determination

Westinghouse Determination	QC Formulations	
Skill	B2	+0.08
Effort	C2	+0.02
Condition	C	+0.02
Consistency	D	0
Total	0,12	
Rf	1,12	

Determination of Allowance

The *allowance* value is influenced by energy factors issued, work attitude factors, work movement factors, eye fatigue factors, working temperature factors, atmospheric state factors, and environmental factors [12]. The looseness obtained results as in Table 5.

Table 5: Determining Allowance

Factors	Sub-Factors	Reference	Allowance %
Power expended	Work on the table, stand up	0.0 – 6.0	6
Work attitude	Upright body, two legs focused	1.0 – 2.5	2
Work movement	Free swing from the shoulders	0	0

Eye fatigue	Meticulous work	6.0 – 7.5	7
Workplace temperature conditions	Medium 13-22	5 – 0	0
Atmospheric conditions	Good	0	0
Good environmental conditions	Clean, healthy, bright with low noise	0	0
Total			15

MTM Methods

Methods Time Measurement is a procedure that analyzes each set of manual operations according to the basic movements required [13-14]. At the stage of data processing Methods Time Measurement, the steps that must be done include [13]:

1. Create a map of the right hand and left hand,
2. Divide the work movement over the elements of movement,
3. Converting into MTM data tables,
4. Accumulating unit units or time measurement units (TMU). 1 TMU = 0.036 seconds,
5. Perform normal time calculations
6. Perform the default time calculation.

Here is the process of processing uptime data by *Method Time Measurement* method in QC Formulation. In QC Formulation, there are five activities. The five activities are:

1. Sampling Sample Products (1)
2. pH Checks (2)
3. Product Release (3)
4. CPB Contents (4)
5. Contents of Logbook pH (5)

MTM divides the working movements over the elements of the Movement [14]:

a. Reach is a basic movement element used to move a hand or finger to a specific destination.
b. Transporting (Move) is carrying an object from a location to a specific destination.
c. Turning (Turn) is turning hands either empty or carrying loads.
d. Apply Pressure, the basic pressing movement, provides a full-time cycle of components related to other movements.
e. Holding (Grasp) the goal to master/control some objects both with fingers and hands.
f. Direct (Position) to merge, direct or install one object with another object.
g. Release is a basic movement to free control over an object by finger or hand.
h. Removing a raft (Dissamble or Disengage) is used to separate contacts between one object and another.
i. Eye Movements (Eye Times) to move and focus the eyes.

Left Hand and Right Hand Chart

Time measurement is performed by observing the map of the left hand and right hand of each examination. Observations are made by observing from the video that has been taken, then analyzing the movement of each movement made by employees in QC Formulations while doing their work as in Table 6.

Table 6: Map of Right Hand and Left Hand Sampling Work Sample Products

Right and Left-Hand Chart (Chart Operator)		
Job	Sampling Sample Products	
Department	Quality Control	
WORKSTATIONS	Formulation	
MAP NUMBER	1	
MAPPED BY	-	
DATE MAPPED	-	
№	LEFT HAND	RIGHT HAND

	ELEMENTS OF THE WORK MOVEMENT	Symbol	TIME (TMU)	TIME (TMU)	Symbol	ELEMENTS OF THE WORK MOVEMENT
1	Shut up	D	32,9	32,9	RE, G, M	Retrieving Products
2	Shut up	D	2	2	R1	Laying Out Products
3	Retrieving a CheckSheet Sheet	RE, G, M	32,9	32,9	G	Holding a Pen
4	Holding a CheckSheet Sheet	H	10	10	U	Checklist CheckSheet Sheet
	Total TMU		77,8	77,8		
Ringakasan						
Total Time (TMU)			77,8			
Number of Products			One pcs			

After the time calculation is performed using the right-hand map and left-hand map for each work element obtained, cycle time is shown in Table 7.

Table 7: Cycle Time Recapitulation (seconds)

№	Working Elements	Cycle Time (Ct) Seconds
1	Sampling Sample Products	3,41316
2	Check pH	2,78532
3	Product Release	7,59348
4	CPB Contents	7,45596
5	Contents of Logbook pH	7,00812

Data Uniformity and Adequacy Test

From the observation data that has been collected, the calculation is continued to see the uniformity of the data and the adequacy of the data.

a. Data Uniformity Test

1. Sampling Sample Products

In sampling, the sample product results in a cycle time (C_t) with an average of 2.78532 seconds and a standard deviation of 0.011641. The results of the calculation of uniformity can be seen in Table 8.

Table 8: Results of Sampling Uniformity Calculation of Sample Products

Sampling Sample Products		
N	TMU	Seconds
1	77.8	2.8008
2	77.2	2.7792
3	77.3	2.7828
4	77.1	2.7756
5	77	2.772
6	77.2	2.7792
7	77.7	2.7972
8	77	2.772
9	77.8	2.8008
10	77.6	2.7936
	$\bar{x}$	2.78532
UCL		2.820242
LCL		2.750398
S		0,011641

2. Check pH

The pH, checking process produces a cycle time (C_t) with an average of 3.41316 seconds and a standard deviation of 0.019308. The results of the Sampling Uniformity Calculation of pH Check can be seen in Table 9.

Table 9: Results of Sampling Uniformity Calculation of pH Checks

Check pH		
N	**TMU**	**Seconds**
1	95.8	3.4488
2	95.1	3.4236
3	94	3.384
4	95	3.42
5	94.8	3.4128
6	94.7	3.4092
7	94.6	3.4056
8	95	3.42
9	95.1	3.4236
10	94	3.384
	$\bar{x}$	3.41316
UCL		3.471085
LCL		3.355235
S		0.019308

3. Product Released

Releasing the product produces a cycle time (C_t) with an average of 7.59348 seconds and a standard deviation of 0.048775. Results of Sampling Uniformity Calculation Released Products in Table 10.

Table 10: Results of Sampling Uniformity Calculation Released Products

Product Released		
N	**TMU**	**Seconds**
1	209.3	7.5348
2	210.5	7.578
3	212.6	7.6536
4	211.4	7.6104
5	209.7	7.5492
6	212.3	7.6428
7	211	7.596
8	212.8	7.6608
9	209	7.524
10	210.7	7.5852
$\bar{x}$		7.59348
UCL		7.739806
LCL		7.447154
S		0.048775

4. CPB Contents

In the filling process, the product produces a cycle time (C_t) with an average of 7.45596 seconds and a standard deviation of 0.036573. The results of the CPB content sampling uniformity calculation can be seen in Table 11.

Table 11: CPB Content Sampling Uniformity Calculation Results

CPB Contents		
N	**TMU**	**Seconds**
1	205.9	7.4124
2	207.1	7.4556
3	207.2	7.4592
4	205.6	7.4016
5	208.3	7.4988
6	206	7.416
7	207.6	7.4736
8	207.4	7.4664
9	208.7	7.5132
10	207.3	7.4628
$\bar{x}$		7.45596
UCL		7.56568
LCL		7.34624
S		0.036573

5. Contents of Logbook pH

The product produces a cycle time (Ct) with an average of 7.00812 seconds and a standard deviation of 0.036002. Sample Uniformity Test of Logbook Contents pH in Table 12.

Table 12: Sampling Uniformity Test of Logbook pH Contents

Contents of Logbook pH		
N	**TMU**	**Seconds**
1	193.6	6.9696
2	193.8	6.9768
3	194.9	7.0164
4	195.7	7.0452
5	194.5	7.002
6	193.2	6.9552
7	195.3	7.0308
8	195.1	7.0236
9	196.4	7.0704
10	194.2	6.9912
$\bar{x}$		7.00812
UCL		7.116126
LCL		6.900114
S		0.036002

The data uniformity test results show that no data is out of the upper control limit (UCL) and lower control limit (LCL), meaning that all data is uniform and can be continued to the next test, namely the data adequacy test.

b. Data Adequacy Test

Adequacy tests are conducted to determine whether the number of observations made is sufficient for data needs. Table 13 shows the results of the data adequacy test.

Table 13: Data Adequacy Calculation Results

№.	**Working Elements**	**N**	**N'**	**Description**
1	Sampling Sample Products		0,02515153	Enough Data
2	Check pH		0,04608332	Enough Data
3	Product Released	10	0,05941274	Enough Data
4	CPB Contents		0,03464869	Enough Data
5	Contents of Logbook pH		0,03800255	Enough Data

Based on the calculations made with a confidence level of 95% and a level of thoroughness of 5%, the data taken is sufficient.

Rating Factor Determination with Westinghouse Method

The Westinghouse way determines the rating factor or adjustment of workers from each element of the activity. Westinghouse points are used to calculate normal time, where the cycle time obtained from the study multiplies *Westinghouse points.* The results of determining the Rating Factor of each activity element can be seen in Table 14.

Table 14: Rating Factor of Each Element of Activity

Westinghouse Determination	Check pH		Sampling Sample Products		Product Released		CPB Contents		Contents of Logbook pH	
Skill	B1	+0.11	B2	+0.08	B2	+0.08	B2	+0.08	B2	+0.08
Effort	B2	+0.08	C1	+0.05	B2	+0.08	C2	+0.02	C1	+0.05
Condition	C	+0.02	C	+0.02	C	+0.02	C	+0.02	C	+0.02
Consistency	D	0	D	0	D	0	D	0	D	0
Total		0,21		0,15		0,18		0,12		0,15
Rf		1,21		1,15		1,18		1,12		1,15

Determination of Allowance

The *allowance* value is influenced by energy factors issued, work attitude factors, work movement factors, eye fatigue factors, working temperature factors, atmospheric state factors, and environmental factors [12]. The large *allowance factor is* shown in Table 15.

Table 15: Determining Allowance

Factors	Sub-Factors	Reference	Allowance %
Power expended	Work on the table, stand up	0,0 - 6,0	6
Work attitude	Upright body, two legs focused	1,0 - 2,5	2
Work movement	Free swing from the shoulders	0	0
Eye fatigue	Meticulous work	6,0 - 7,5	7
Workplace temperature conditions	Medium 13-22	5 - 0	0
Atmospheric conditions	Good	0	0
Good environmental conditions	Clean, healthy, bright with low noise	0	0
Total			15

Results & Discussion

Normal Time and Default Time of Work Sampling Method

Once determined, the rating factor can be calculated as the amount of normal time needed to create a production unit with a total observation time of 14400 seconds and 340 units of products produced. The normal Time formula is as follows:

$$\text{Normal Time} = \frac{\text{Percentage of productive x Number of Observation Time}}{\text{Number of products}}\ x\ RF$$

$$\text{Normal Time} = \frac{77.23\%\ \text{x}\ 14400\ \text{detik}}{340\ \text{unit}}\ x\ 1{,}12$$

$$\text{Normal Time} = 36{,}6\ \text{second}$$

After doing the normal time calculation (N_t), then do the calculation of standard time (S_t) by considering allowance with the following formula:

$$\text{Standard Time} = \text{Normal Time x}\ \frac{100\%}{100\% - \text{Allowance}}$$

$$\text{Standard Time} = 36.6 \text{ x } \frac{100\%}{100\% - 15\%}$$

$$\text{Standard Time} = 43 \text{ second}$$

MTM Method - Normal Time and Default Time

Use equations to find normal time by calculating the cycle time (Ct) of the average observations that have been made using the formula $N_t = C_t \ x \ Rf$ *(Westinghouserating factor)* [11]. then obtained results:

Table 16: Normal Time Calculation

Working Elements	Cycle Time (Ct) Seconds	Rating Factor (Rf)	Normal Time (Nt) Seconds	Rounding Normal Time
1	3,41316	1,21	4,1299236	4
2	2,78532	1,15	3,203118	3
3	7,59348	1,18	8,9603064	9
4	7,45596	1,12	8,3506752	8
5	7,00812	1,15	8,059338	8

Calculating Default Time

After performing the normal time calculation (N_t), the standard time calculation (S_t). Here's the calculation formula:

$$\text{Standard Time} = Normal\ Time\ x\ \frac{100\%}{100\% - Allowance}$$

Table 17: Default Time Calculation

Working Elements	Normal Time (Nt) (Seconds)	Allowance (i) (%)	Standard Time (St) (Seconds)	Rounding Normal Time
1	4	15%	4,858733647	5
2	3	15%	3,768374118	4
3	9	15%	10,54153694	11
4	8	15%	9,824323765	10
5	8	15%	9,481574118	9

The analysis of working time with the MTM method and the Work sampling method is shown in Table 18.

Table 18: Method Comparison

№	MTM	Work Side
1.	Each element of the movement is divided into classes based on the work movement	Division based on productive and non-productive movements
2.	The unit used is TMU	Calculation based on percentage
3.	The normal time of 32 seconds	The normal time of 36.6 seconds
4.	The default time of 39 seconds	The default time of 43 seconds

Table 18 shows the MTM method has a normal time of 32 seconds and a default time of 39 seconds. The *work sampling* method has a default time of 36.6 seconds and a normal time of 43 seconds. The results showed that the MTM method had a normal time and a smaller standard time than the Work S*ampling* method. The MTM method produces a more efficient raw time of 9.3% compared to *the work sampling* method. The analysis of the differences between the two methods lies in the different elements of the workers' movement and workers' productivity. The two methods' time calculation is based on the already available tables by the first standardizing the working method used.

Conclusion

The measurement results using *methods time measurement* obtained normal time obtained by 32 seconds/unit and the default time obtained by 39 seconds/unit. Based on *work sampling methods* obtained results with normal time obtained by 36.6 seconds/unit and the default time obtained by 43 seconds/unit. The MTM method produces a more efficient raw time of 9.3% compared to *the work sampling* method. From the research, the measurement time methods time *measurement* is better than the methods of *work sampling*. Companies can recommend time measurement *methods* because calculations pay attention to the movement and unit units in TMU.

Acknowledgment

Thank you to The Research Center of Mercu Buana University, which has financed and helped implement this research.

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