Process Improvement of Bakelite Manufacturer

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***Abstract*—This research aims to present guidelines for improving the production process for Bakelite powder plastic molding of four major types of cookware handles, including extra-large handle, large handle, flat handle, and pan handle. Reportedly, these four products are manufactured based on similar processes, consisting of powder molding, burr trimming, and filing. This research relies on several techniques and studies, particularly in collecting recent production data and making theoretical analysis to seek causes of problems. Using a fishbone diagram, the obtained data can be analyzed and developed based on the Eliminate Combine Rearrange Simplify (ECRS) principle, which helps in the development of design and facilitates the three manufacturing processes. Aside from time efficiency in production, this can also lead to the increase of productivity per day. Besides, the researcher uses the Predetermined Time System (PTS) for an advanced assessment of time to seek accurate production rates following the design process.**

As the design process is completed and the PTS has been applied, daily production of extra-large handle, large handle, flat handle, and pan handle is estimated to increase from 734, 925, 811, and 517 units per day to 777, 935, 877, and 552 units per day, considered the increase of 5.8%, 1.1%, 8.0%, and 6.7%, respectively.

Index Terms* — process improvement, principle of ECR*S

I. Introduction

Currently, the production of cookware handles using Bakelite powder plastic molding is highly competitive. To satisfy the growing demand for the products, manufacturers, particularly those relying mainly on manpower, have been urged to keep pace with unparalleled product quality and timely delivery, considered the most fundamental and significant requirements to be achieved. This study is conducted for a small-sized manufacturing plant with the application of Bakelite powder plastic molding. Four major products, including extra-large handle, large handle, flat handle, and pan handle, are manufactured with similar processes consisting of powder molding, burr trimming, and filing. According to the study, the researcher has found that the working process is required to be improved. Admittedly, the overall manufacturing aspect still remains inferior due to lack of systematic working processes, which can be resulted from the ineffectiveness of working equipment of each department. In consequence, several required tasks are affected by inconsistency, resulting in unreliable production and delayed delivery.

Before the process improvement[1], the researcher has determined to apply the time efficiency technique into theoretical analysis to obtain total production rates per day. For example[2], unveiled efficiency development for pants production using time efficiency and movement techniques in troubleshooting existing issues. The result was favorable as production time could be reduced from 44.44 minutes to 41.42 minutes, a decrease of 6.79%, while being able to shorten the production processes from 155 to 98, which was reduced by 36.77%. The researcher had also applied the ECRS principle into the improvement of production and design. Similar to researches conducted[3], issues occurred to a manufacturer of doors and windows involved in the inability to meet production targets due to the inferiority of working processes and supportive equipment. Following the improvement, production time of a production line was reduced to 2,018 seconds per round or 23.1%, shifting daily productivity from 27.5 baht to 49.1 baht or a remarkable increase of 78.2%. At the same time[4], noticed that wastefulness occurred to some production lines. This caused a slowdown in productivity as well as pending production in certain production lines. The researcher aimed to increase productivity by reducing the number of employees used in production, while being able to maintain production capacity at the most efficient level. In summary, productivity could be increased from 242 units per person per day to 423 units per person per day or a rise of 75% and pending works in certain production lines were reported to drop from 199 units to 141 units or a decrease of 29%.

In comparing the results following the improvement and design, the researcher has used the PTS for an advanced assessment of time to seek accurate production rates per day. In this case, the standard production time can be acknowledged without requiring direct timing, unveiling a favorable result of improvement without having to make any change in actual production. Studies conducted[5], unveiled the use of the Methods-Time Measurement (MTM) in troubleshooting problems caused to working processes. Workstations were required to be re-positioned, supported by the relocation of egg trays and the rearrangement of eggs in different trays. With reference to improvement methods, the first method could reduce the standard production time to 27.74 seconds in total, while the standard production time

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achieved by the second method was decreased to 17.03 seconds in total.

II. Methodology

A. General Conditions of Production Plant

In this research, the selected production plant is located on an approximate 136-square meter area in Nakhon Pathom province. Although the four products are manufactured based on similar processes, including powder molding, burr trimming, and filing, the only difference is the number of molded products. The powder molding machine can produce only four pieces of pan handle per time, while the other three types of handles can be molded up to eight pieces per time. This production plant has 14 employees altogether, where nine are selected for powder molding, two are responsible for burr trimming, and three have been ordered to work on filing. There are two types of the powder molding machine: two heads and four heads. In performing daily operations, one employee will take responsibility in controlling and monitoring the 2-head powder molding machine. It is obvious that employees of the powder molding and burr trimming departments are exposed to similar working behaviors. Powder molding and burr trimming employees are stationed at their own desks, with pieces of work piling in front of them. One after another, each piece of work will be picked up for molding.

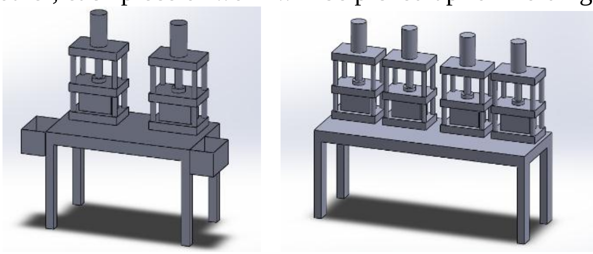

Figure 1. two types of the powder molding machine : two heads and four heads

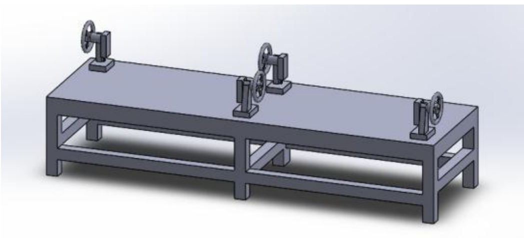

Figure 2. Table of burr trimming process

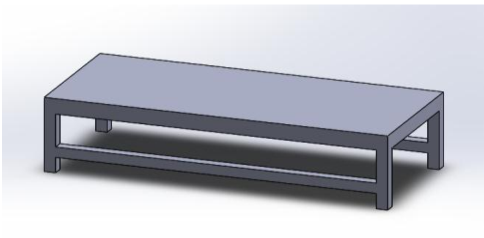

Figure 3. Table of filing process

B. Calculation of Standard Time Prior to Process Improvement

In calculating the standard production time for each department, the researcher has determined to put each task into categories to facilitate accurate timing. The researcher wants to acquire the information based on the normal distribution principle and 30 samples of information have been gathered. At the confidence level of 90% and the relative accuracy rate of 10%, the calculation can be implemented by the following formula.

$$N = \left[\frac{20\sqrt{n\sum x_i^2-(\sum x_i)^2}}{\sum x_i}\right]^2 \quad (1)$$

$$rel.acc. = \frac{t_{\frac{\alpha}{2},v} \times S_{\bar{X}}}{\bar{X}} \times 100\% \quad (2)$$

According to the 30 samples of information for extra-large handle, tasks can be divided into three minor processes and the number of timing round and the relative accuracy rate can be calculated by using the above-mentioned formula. Referring to (N) at the confidence level of 90% and the relative accuracy rate of 10%, the 30 samples of information for one minor process appear to be adequate, thanks to the calculation result that unveils a smaller amount of information compared to the amount of collected samples, where the relative accuracy rate still remains within 10% as targeted. After that, the standard production time before process improvement can be calculated by using Equation (3) and (4).

$$NT = RT \times PR \quad (3)$$
$$ST = NT \times (1+AF) \quad (4)$$

According
RT = Representative Time
PR = Rating Factor
NT = Normal Time
ST = Standard Time
AF = Allowance Factor

For the advanced assessment of time, the researcher has prepared tables with specific details aiming for accurate assessment as follows:

Personal Allowance = 5%
Fatigue Allowance = 15%
Delay Allowance = 5%
Total = 25%

TABLE I. Calculated Results of Pre-improved Normal Time and Standard Time.

Product	NT	AF	ST	Cycle time (min/piece)
large handle	4.52	0.25	5.65	0.71
extra-large handle	5.7		7.12	0.89
flat handle	5.14		6.43	0.80
pan handle	4.04		5.04	1.26

TABLE II. AVERAGE PRODUCTIVITY PER DAY (CALCULATED).

Product	Average productivity per day		
	8 Working hours	*3.5* hours Overtime	Total
large handle	679	296	975
extra-large handle	538	235	773
flat handle	597	260	857
pan handle	380	166	546

After obtaining the information on calculated production capacity of the four products, the researcher can proceed with accuracy verification for the obtained information by consulting with a representative of the production plant for comparison. As a result of comparison, the obtained and calculated information is quite similar to the information on actual production capacity. As the relative accuracy rate remains at only 5%, it can be concluded that the obtained and calculated information can be used for further analysis

TABLE III. AVERAGE PRODUCTIVITY PER DAY (MEASURED FROM FACTORY).

Product	Average productivity per day		
	8 Working hours	3.5 hours Overtime	Total
large handle	645	280	925
extra-large handle	511	223	734
flat handle	566	245	811
pan handle	360	157	517

C. Problem Analysis and Production Process Improvement

The researcher has analyzed each department's problems in production by using the ECRS technique in design, as part of the intention to generate greater operational improvement for each department.

- Powder Molding

Problem: The researcher has found that the biggest problem occurred in the powder molding department is the difficulty in employees' body movement. Employees have to move back frequently to pick up each equipment to be implemented. Despite having boxes of equipment installed on both sides of the molding machine, employees seem to get used to piling daily tasks on their own desks. Another difficulty is the position of Bakelite powder bowls. Many employees prefer to conveniently place big bowls of Bakelite powder along the distance between molding machines and this causes difficulty in performing tasks

Solutions: The researcher has applied the Simplify technique by designing a box used for collecting the equipment waiting for molding. The box has a sloping design, which can efficiently help employees in collecting their unfinished equipment. The bottom of the box has a space for placing a bag of Bakelite in case where the substance is required to be filled up. Employees can immediately fill Bakelite without having to walk to the original location, where the substance is placed as shown in Picture 4

Moreover, with the similar technique, the researcher has created a Bakelite container resembling the box of equipment. The sloping design of the container ensures that Bakelite can flow to preferred directions. As the container will be placed in the middle between two molding machines, Bakelite can flow in two directions and will stop in front of the machines, ensuring that Bakelite can be used in a speedier and more convenient manner as shown in the pictures.

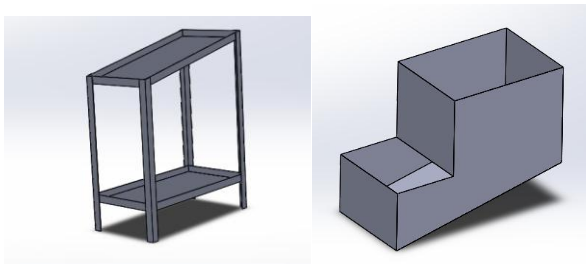

Figure 4. New box used for collecting the equipment.

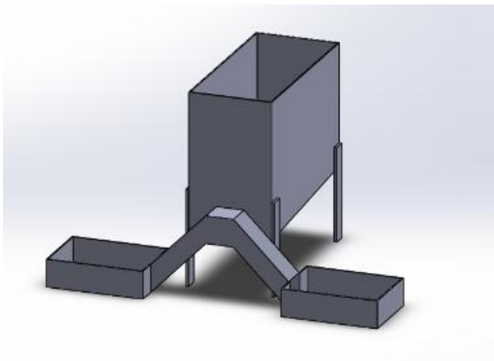

Figure 5. New box used for collecting the Bakelite.

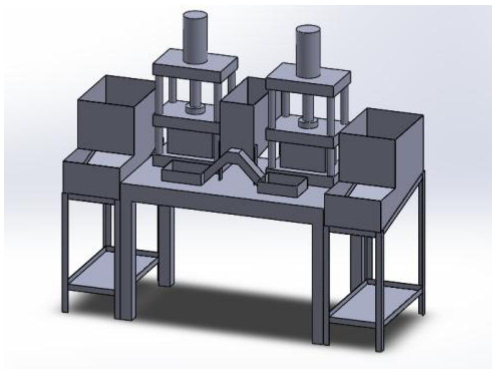

Figure 6. Powder molding machine type two heads Improved

- Burr Trimming and Filing

Problems: For these two departments, the researcher has found similar problems. One of them is the height of working desks. Employees have to use seat cushions to match up with the height of their working desks. Another problem is the relatively big size of the working desk. Basically, employees always scatter unfinished equipment on their desks and it appears to be quite difficult to reach for one after another. At the same time, employees of these two departments have many body movements as they are required to walk a relatively long distance to collect bags of finished equipment from the powder molding department. Employees are also forced to move bags full of trimming or filing scraps to a faraway area in the production plant

Solutions: The researcher uses the Simplify technique by designing a sloping box to facilitate employees in collecting the equipment, while adjusting the height of the working desks conforming to the standard height. The researcher also applies the Eliminate technique which helps eliminate an unnecessary requirement, saying there is no need to walk a long distance to grab an empty bag from its original location to collect trimming or filing scraps. At the filing desk, there is a space designed to keep empty bags to ensure that an unnecessary activity mentioned above is eliminated.

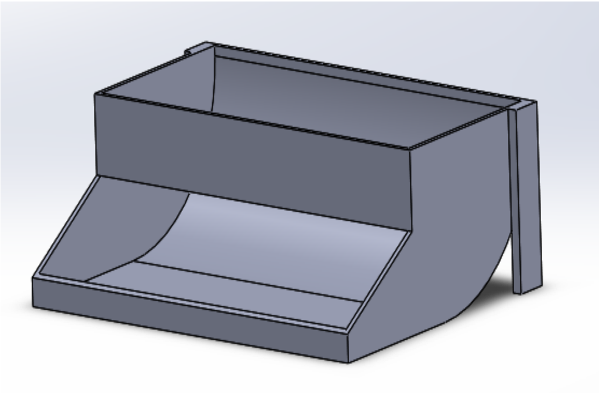

Figure 7. New box used for collecting the equipment.

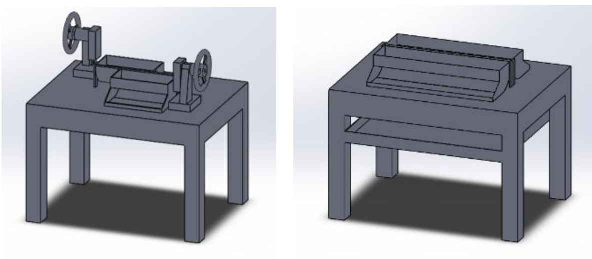

Figure 8. Table of burr trimming and filing process Improved

D. *Calculation of Standard Time after Process Improvement*

After completing the design of the new equipment, the researcher has applied the PTS for the calculation of time by initially relying on the MTM. The table unveils motions of an employee's left and right hands. Apparently, motions have been analyzed to eliminate unnecessary movements of the body. For the standard time of burr trimming and filing machines, it is quite obvious that the two activities have constant timing and the researcher has undoubtedly relied on the obtained timing in making an analysis. The table below unveils the use of MTM in analyzing the filing of flat handles.

TABLE IV. MTM ANALYSIS IN CUTTING PROCESS OF FLAT HANDLE PRODUCT

Detail of activities						
Left Hand	Motion		TMU		Motion	Right Hand
Reach to catch a work piece	R12B	12.9	23.4	10.5	R14A	Reach to cutting machine
Catch a work piece	G1j3 A	2	2	2	G1A	Catch a cutting machine
Move a work piece to cutting machine	M5A	7.3	7.3			Catch a cutting machine
Hold a work piece on hand					0.01	Cutting process
Move a work piece to a storage bag	M1A	2.5	2.5			Catch a cutting machine
Put a work piece to storage bag	RL1	2	2			Catch a cutting machine

From the table above, you will get the following time.

Total Time	= 37.2	TMU
	= 37.2 x 0.036	
or	= 1.3392	Second
	= 0.02232	Minute
	= 0.032	Minute

Moreover , normal Time Burr Trimming of flat handles is 0.032 minute

III. RESULTS

The researcher uses the MTM in making analysis for all production processes of all products, while calculating the standard time by remaining the advanced assessment of time at 25%.

TABLE V. CALCULATED RESULTS OF IMPROVED NORMAL TIME AND STANDARD TIME.

Product	NT	AF	ST	Cycle time (min/piece)
large handle	0.59	0.25	0.7375	0.73
extra-large handle	0.71		0.8875	0.88
flat handle	0.63		0.7875	0.78
pan handle	1		1.25	1.25

TABLE VI. IMPROVED AVERAGE PRODUCTIVITY PER DAY (CALCULATED).

Product	Average productivity per day		
	8 Working hours	3.5 hours overtime	Total
large handle	651	284	935
extra-large handle	540	237	777
flat handle	610	267	877
pan handle	384	168	552

IV. DISCUSSION

This research has unveiled improvement guidelines and methods with the application of the ECRS technique. The analysis of operational problems and equipment used in production helps generate greater production efficiency as the rates of productivity per day are estimated to increase. The analysis is made for three production processes, where the new equipment has been introduced to the powder molding department. The use of boxes containing the unfinished equipment and Bakelite powder offers greater effectiveness and convenience of daily operations to employees. For the burr trimming and filing departments, the researcher has adjusted the height of working desks, while introducing the box used for collecting the equipment to be located in the actual working area. Comparing the results of process improvement and daily production capacity, all products are improved with increasing production rates specified below

TABLE VII. COMPARISON OF PRE-IMPROVED AND IMPROVED AVERAGE PRODUCTIVITY PER DAY

Product	Average productivity per day	
	pre-improved	improved
large handle	925	935
extra-large handle	734	777
flat handle	811	877
pan handle	517	552

As the design process is completed and the PTS has been applied, daily production of extra-large handle, large handle, flat handle, and pan handle is estimated to increase from 734, 925, 811, and 517 units per day to 777, 935, 877, and 552 units per day, considered the increase of 5.8%, 1.1%, 8.0%, and 6.7%, respectively

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Chaniporn Phuakphewvong conducted the research and collected the data.

Punnamee Sachakamol analyzed the data and constructed the research paper.

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