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Time Study and Motion Analysis using Basi Maynard Operation Sequence Technique (MOST) in Pro Time Estimation Software: A Case Study of the Button Making Process in SIUE MakerLab

Chigozie Valentine Ugo-Njoku

SIUE School of Engineering, Department of Industrial Engineering, Southern Illinois University, Edwadsville, Email: cugonjo@siue.edu, ORCID: https://orcid.org/0009-0003-8141-6322

Abstract: Efficiency and productivity are vital aspects of any assembly process, and time study and motion analysis play a crucial role in optimizing these factors. This research presents a detailed study of the button making process in the Southern Illinois University Edwardsville's MakerLab using ProTime Estimation Software. The objective of this project is to understand the concept of time studies otherwise known as work measurements, build proficiency in the usage of the ProTime Estimation Software, evaluate the efficiency and productivity of the button making process in the MakerLab, identify potential areas for improvement and contribute valuable insights. ProTime Estimation Software was employed as a powerful tool for real time data acquisition and analysis because this software allows for precise measurement and observation of each step in the process, enabling the establishment of accurate time standards for different work elements. The project outcome concludes that the button making process in the SIUE MakerLab is relatively efficient and productive, but there is room for improvement by reducing the setup time, minimizing the idle time, and optimizing the layout and workflow.

Keywords: MakerLab, ProTime Estimation Software, SIUE, Productivity, Optimization

1. INTRODUCTION

In today's highly competitive global marketplace, industrial organizations are continually striving to enhance their operational efficiency and productivity. Achieving such improvements necessitates a thorough understanding of the underlying manufacturing processes and a data-driven approach to optimization. Industrial engineering, as a field, plays a pivotal role in facilitating these improvements by employing scientific and systematic methods to analyze, design, and enhance manufacturing processes. A fundamental aspect of industrial engineering is the practice of time study and motion analysis, which serves as the cornerstone for identifying inefficiencies, bottlenecks, and areas for improvement in manufacturing operations (Jay, 1981).

This graduate final year project is my attempt to explore the realm of comprehensive time study and motion analysis within the manufacturing sector. The focus of this study is the button-making process, a small but essential operation, within the Southern Illinois University Edwardsville (SIUE) MakerLab. This project aims to leverage the power of ProTime Estimation software to conduct an in-depth analysis of the button-making process, with the goal of improving operational efficiency. The investigation into the button-making process serves as an illustrative case study that can be extrapolated to other manufacturing environments, highlighting the broader significance of this research (Kanawaty, 1992).

1.1 Background

The MakerLab at SIUE is a multidisciplinary fabrication facility that provides students, faculty, and community members with access to cutting-edge equipment for prototyping, design, and production. MakerLab is dedicated to fostering innovation and hands-on learning, enabling individuals to turn their creative ideas into tangible products. The facility encompasses various machinery and processes, including 3D printing, laser cutting, CNC machining, and traditional manufacturing techniques. Among these, the button-making process is a prime example of a small-scale production activity that benefits from the principles of industrial engineering. Button production involves a series of interconnected steps, including cutting, molding, and assembly. As with any manufacturing operation, the efficiency of this process is critical not only for maintaining a steady supply of buttons to meet demand but also for minimizing costs and maximizing resource utilization (Karger & Bayha, 1987). In an era marked by Industry 4.0, Smart Manufacturing, and Lean principles, data-driven decision-making and process optimization are becoming increasingly crucial. Manufacturing organizations are turning to technologies and methodologies that empower them to adapt and remain competitive in a dynamic business landscape.

1.2 Rationale for this Study

The rationale behind this study is multifaceted. Firstly, button production, although seemingly straightforward, embodies many principles found in more complex manufacturing processes. By conducting a detailed analysis of this small-scale operation, the study serves as an accessible and practical example for me to hone my understanding and skills in time study and motion analysis.

Secondly, MakerLab represents a microcosm of modern manufacturing, where agility and adaptability are essential. Within such an environment, systematic process improvement is an asset (Karim et al., 2016). The outcomes of this research have the potential to significantly impact the efficiency and effectiveness of button production within the MakerLab, leading to benefits such as reduced lead times, increased resource utilization, and a more streamlined operation. These advantages can extend beyond MakerLab and inspire other manufacturing facilities to embrace similar practices.

Thirdly, the research study employs ProTime Estimation software, a state-of-the-art tool for real-time data acquisition and analysis in the field of industrial engineering. ProTime Estimation software is an exemplar of technology's role in facilitating and expediting the data collection and analysis process. Its utilization in this study demonstrates how contemporary software solutions can be leveraged to advance the field of industrial engineering (Proplanner, ProTime Estimation User Guide, 2023).

1.3 Objectives of the Study

The overarching objective of this study is to conduct a comprehensive time study and motion analysis of the button-making process in the SIUE MakerLab, using ProTime Estimation software. The specific objectives can be outlined as follows:

1. To assess the current state of the button-making process, including time requirements, resource utilization, and labor allocation.
2. To identify areas within the process that could benefit from improvements in terms of efficiency, productivity, and overall effectiveness.
3. To propose data-driven recommendations for enhancing the button-making process, with the aim of reducing production time, optimizing resource allocation, and improving worker productivity (Konz & Johnson, Work Design: Industrial Ergonomics, 2000).
4. To evaluate the potential impact of the recommended improvements on the overall efficiency and competitiveness of the MakerLab's button production operation.
5. To extend the insights gained from this case study to highlight the broader implications of systematic time study and motion analysis in the field of industrial engineering and modern manufacturing (Mishra, Agnihotri, & Mahindru, 2014).

2. LITERATURE REVIEW OF RELATED WORKS

In the realm of industrial engineering, time study and motion analysis have long been recognized as indispensable tools for enhancing manufacturing processes. The systematic evaluation of time and motion not only forms the foundation of process optimization but also underpins a variety of methodologies that drive efficiency improvements in production environments (Sellie, 1992).

2.1 Historical Development

Time study, also known as work measurement, emerged as a fundamental concept in industrial engineering during the late 19th and early 20th centuries (Sellie, 2001). Frederick W. Taylor often considered the "father of scientific management," pioneered time and motion studies in the United States. Taylor's work laid the groundwork for systematic process analysis and the development of time standards, fostering greater efficiency in manufacturing (Smith, 1978). His scientific approach sought to identify the "one best way" to perform tasks by meticulously analyzing each motion and its corresponding time requirement.

Taylor's contributions were followed by Frank and Lillian Gilbreth, who expanded on the concept of motion analysis. The Gilbreths introduced the idea of motion-saving and efficiency-boosting techniques, emphasizing that the elimination of wasteful or unnecessary motions could lead to significant productivity gains (Sellie, 1992).

Over the years, these pioneering concepts evolved into broader methodologies for process improvement, with organizations such as the American Society of Mechanical Engineers (ASME) and the International Labor Organization (ILO) developing standardized methods for time study and work measurement (Zhou, 2023). These methodologies set the stage for the modern practice of time study and motion analysis, shaping industrial engineering principles as we know them today (Barnes, 1980).

2.2 Methodologies for Time Study and Motion Analysis

Time study is based on the careful observation and measurement of work activities. A fundamental principle in time study is the determination of standard times for each task within a process, allowing for consistent evaluation and comparison. One of the most renowned time study techniques is the "predetermined motion time system," which utilizes pre-established standard times for basic movements, facilitating the estimation of total work content (Genaidy, Agrawal, & Miltal, 1990).

In motion analysis, various methodologies have been developed to categorize and assess motions. The "therbligs" system, introduced by the Gilbreths, is one such technique. It breaks down work into a set of fundamental motions, each associated with a specific time standard. The classification of motions into therbligs helps identify areas where motion can be minimized, resulting in improved efficiency (Pandey, Deshpande, & Gunjar, 2016).

The application of time study and motion analysis methodologies is often supported by technological tools. ProTime Estimation software, a key component of this research project, is an example of a modern tool designed to expedite data collection and analysis in real time. Such software allows for the precise measurement and observation of activities, making it an invaluable asset for industrial engineers (Proplanner, ProTimeEstimation 2016 Software).

2.3 Time Study and Motion Analysis in Manufacturing

Time study and motion analysis have been extensively applied in manufacturing industries to optimize processes. In manufacturing, the identification of time standards for various operations helps in planning and scheduling, as well as resource allocation. Furthermore, motion analysis techniques contribute to ergonomic design and the elimination of non-value-adding motions (Meyers & Stewart, 2002). Lean manufacturing principles also incorporate time study and motion analysis to eliminate waste and enhance efficiency. The concepts of "value-added" and "non-value-added" activities are central to lean thinking, with time study being a crucial tool for distinguishing between the two (Rajashekar, & Ramamurthy, 2018). This focus on eliminating non-value-added activities aligns with the principles of the button-making process study, which aims to optimize each step for maximum efficiency.

2.4 Methods of Setting Time Standards

Setting accurate time standards is essential for effective time study and motion analysis, and several methods have been developed for this purpose. Each method serves a distinct role in determining the time required for various tasks and activities within a process (Polk, 1984).

2.4.1 Estimation

Estimation is one of the most straightforward methods for setting time standards. This approach relies on the judgment and experience of experts or workers familiar with the tasks in question. By extrapolating from their expertise, estimators can provide reasonably accurate time standards. However, this method is subject to variability and may not always yield consistent results (Maynard, Stegemerten, & Schwab, 1948).

2.4.2 Historical Records

Historical records leverage past data and records to establish time standards. By analyzing records of previous performance, organizations can derive averages and trends, which serve as a basis for setting time standards. This method is particularly useful when tasks remain relatively consistent over time, allowing for the extrapolation of historical data (Aft, 2001). This method does not account for efficiency.

2.4.3 Work Measurement Techniques

2.4.3.1 Direct Time Study:

Direct time study is a systematic approach that involves the observation and measurement of an individual's or a machine's performance in real time. This method entails tracking the time required to complete a task or motion precisely. By recording individual task times and aggregating them, time standards are established. Direct time study provides highly accurate standards but may be resource-intensive and there is no way to establish standard time before production begins (Bishop, 2001). Mathematically,

$$T_n = T_{obs} * PR$$

$$T_{std} = T_n * \left(1 + A_{pfd}\right)$$

$where$:

$T_n = Normal\ Time\ in\ minutes$

$T_{obs} = Observed\ Time\ in\ minutes$

$PR = Performance\ Rating; recorded\ as\ percentage\ and\ applied\ as\ decimal$

$T_{std} = Standard\ Time$

$A_{pfd} = Allowance\ factor\ for\ the\ task\ to\ which\ it\ is\ applied$

2.4.3.2 Predetermined Motion Time Study:

Predetermined motion time study is a method that divides work into basic elements, each associated with predetermined times. The overall amount of time needed for a given task is then determined by combining the elements. This method can be used to set the standard time either before the task is in production, or for an existing task as it streamlines the time study process by utilizing pre-established data for elemental motions. Common predetermined motion time systems include the Methods-Time Measurement (MTM) and MODAPTS (Modular Arrangement of Predetermined Time Standards) systems (Matias, 2001). The **therbligs** system, as introduced by the Gilbreths, can be considered a precursor to predetermined motion time study.

2.4.3.3 Standard Data Systems:

Standard data systems provide standardized time values for common work elements and motions. These systems categorize tasks and activities into predefined categories, each associated with a known standard time. Industrial engineers can then use these standard data systems to quickly estimate the time required for various operations. Prominent examples include the **MOST** (Maynard Operation Sequence Technique) system, **Predetermined Time Standards (PTS)**, and **Work-Factor** systems (Konz, Time Standards, 2001).

2.4.3.4 Work Sampling:

Work sampling, also known as **activity sampling**, is a statistical method for setting time standards. Instead of continuously observing tasks, work sampling involves taking random samples of an employee's work over a period, providing a statistically sound representation of the time spent on various activities. This approach is especially useful for tasks with high variability and fluctuating workloads. Work sampling is advantageous when precise measurement of every task is impractical (Niebel & Freivalds, 2003).

2.5 Significance of Setting Accurate Time Standards

The choice of method for setting time standards depends on the specific context, task complexity, and available resources (Zhuo, 2023). Regardless of the method used, the significance of accurate time standards cannot be overstated. Precise time standards are pivotal in:

- **Workforce Productivity:** Accurate time standards contribute to improved labor productivity by ensuring that workers are provided with a realistic and fair amount of time to complete their tasks.

- **Resource Allocation:** Time standards aid in optimal resource allocation, including labor, equipment, and materials, as they provide a basis for planning and scheduling.

- **Cost Reduction:** Efficient time standards assist in reducing operational costs by minimizing idle time and resource wastage.

- **Process Optimization:** Reliable time standards enable organizations to identify and eliminate inefficiencies, bottlenecks, and non-value-added activities.

- **Performance Evaluation:** Time standards provide a basis for evaluating employee performance, incentivizing continuous improvement.

- **Quality Control:** Time standards are integral to maintaining quality control by ensuring that workers have adequate time for inspections and quality checks.

- **Operational Flexibility:** Accurate time standards allow for greater adaptability.

3. METHODOLOGY/ DATA ANALYSIS

3.1 Definition and Documentation of the Standard Method:

The methodology is structured to systematically gather data, analyze each step of the button-making process, and establish a baseline for further improvement. The foundational step was to specify and record the typical procedure, often referred to as the one-best-method, for making a button. This step is essential for subsequent time study and motion analysis activities. In the context of button making, the one-best-method encompasses a standardized sequence of steps that, when executed optimally, result in the production of a button with minimal time and resource input. The condition of the work units was established before any task is performed and likewise, the condition of the output was established after the task is performed. This is because if a work unit does not meet the requirements for both initial and subsequent processing, which may require a change from the recommended procedure. In this project, the before and after figures of the buttons are represented below:

Figure 1: 2.25" work unit (input) before task

Figure 2: 2.25" work unit (output) after task

The three important attributes of interest in this project were the accuracy, precision, and speed of response of the work measurements.

3.1.1 Selection of Operators:

To ensure a representative and accurate depiction of the button-making process, operators were selected based on their familiarity with the task. Skilled individuals from MakerLab, including both students and staff, were chosen to perform the button-making process during the data collection phase. This selection criterion ensured that the participants possess the necessary expertise to execute the one-best-method and contribute valuable insights into the intricacies of the process.

3.2 Data Collection

3.2.1 Video Recording:

The button-making process was recorded using high-quality video equipment. This recording technique allows for a detailed analysis of each step, capturing the sequence of actions, tool usage, and time spent on individual tasks. Video recording is essential for later review and verification of observations in the ProTime planner software, ensuring the accuracy of the documented one-best-method.

3.2.2 Time Tracking:

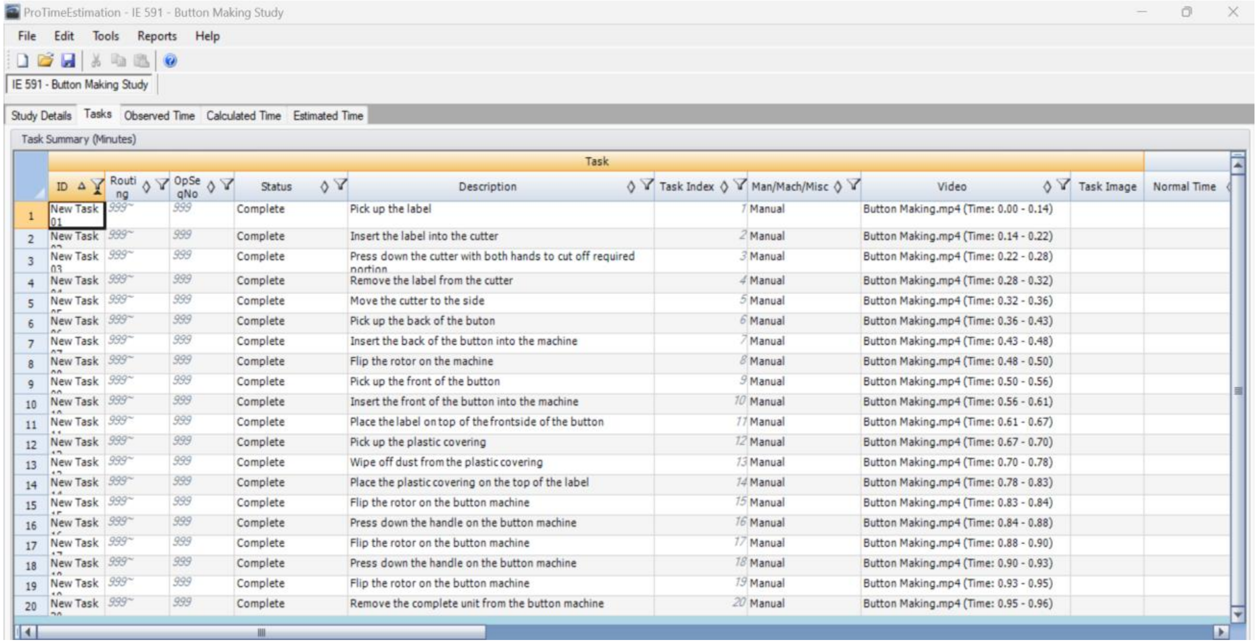
Simultaneously, a dedicated time-tracking system was employed to record the duration of each step in the button-making process. Participants were equipped with wearable devices that allowed precise measurement of the time taken for each action. This real-time tracking provided quantitative data to complement the qualitative insights gained from video recording, facilitating a comprehensive analysis of the process efficiency.

3.2.3 Observational Notes:

In addition to video recording and time tracking, detailed observational notes were taken. These notes captured qualitative aspects of the one-best-method, including ergonomic considerations, potential sources of inefficiency, and any deviations from the standardized process. Observational notes served as a qualitative supplement to quantitative data, offering a holistic view of the button-making process.

3.3. Analyzing the work elements for the task:

The figure below is a snapshot from proplanner that shows the various work elements involved in completing this task.



Task Summary (Minutes)

	Task									
	ID	Routing	OpSeqNo	Status	Description	Task Index	Man/Mach/Misc	Video	Task Image	Normal Time
1	New Task 01	999~	999	Complete	Pick up the label	1	Manual	Button Making.mp4 (Time: 0.00 - 0.14)		
2	New Task	999~	999	Complete	Insert the label into the cutter	2	Manual	Button Making.mp4 (Time: 0.14 - 0.22)		
3	New Task 03	999~	999	Complete	Press down the cutter with both hands to cut off required portion	3	Manual	Button Making.mp4 (Time: 0.22 - 0.28)		
4	New Task	999~	999	Complete	Remove the label from the cutter	4	Manual	Button Making.mp4 (Time: 0.28 - 0.32)		
5	New Task	999~	999	Complete	Move the cutter to the side	5	Manual	Button Making.mp4 (Time: 0.32 - 0.36)		
6	New Task	999~	999	Complete	Pick up the back of the buton	6	Manual	Button Making.mp4 (Time: 0.36 - 0.43)		
7	New Task	999~	999	Complete	Insert the back of the button into the machine	7	Manual	Button Making.mp4 (Time: 0.43 - 0.48)		
8	New Task	999~	999	Complete	Flip the rotor on the machine	8	Manual	Button Making.mp4 (Time: 0.48 - 0.50)		
9	New Task	999~	999	Complete	Pick up the front of the button	9	Manual	Button Making.mp4 (Time: 0.50 - 0.56)		
10	New Task	999~	999	Complete	Insert the front of the button into the machine	10	Manual	Button Making.mp4 (Time: 0.56 - 0.61)		
11	New Task	999~	999	Complete	Place the label on top of the frontside of the button	11	Manual	Button Making.mp4 (Time: 0.61 - 0.67)		
12	New Task	999~	999	Complete	Pick up the plastic covering	12	Manual	Button Making.mp4 (Time: 0.67 - 0.70)		
13	New Task	999~	999	Complete	Wipe off dust from the plastic covering	13	Manual	Button Making.mp4 (Time: 0.70 - 0.78)		
14	New Task	999~	999	Complete	Place the plastic covering on the top of the label	14	Manual	Button Making.mp4 (Time: 0.78 - 0.83)		
15	New Task	999~	999	Complete	Flip the rotor on the button machine	15	Manual	Button Making.mp4 (Time: 0.83 - 0.84)		
16	New Task	999~	999	Complete	Press down the handle on the button machine	16	Manual	Button Making.mp4 (Time: 0.84 - 0.88)		
17	New Task	999~	999	Complete	Flip the rotor on the button machine	17	Manual	Button Making.mp4 (Time: 0.88 - 0.90)		
18	New Task	999~	999	Complete	Press down the handle on the button machine	18	Manual	Button Making.mp4 (Time: 0.90 - 0.93)		
19	New Task	999~	999	Complete	Flip the rotor on the button machine	19	Manual	Button Making.mp4 (Time: 0.93 - 0.95)		
20	New Task	999~	999	Complete	Remove the complete unit from the button machine	20	Manual	Button Making.mp4 (Time: 0.95 - 0.96)		

Figure 3: Work element time for individual tasks in proplanner

It is generally understood that operators may perform differently on different tasks, therefore the performance levels were graded and recorded independently to ensure accuracy and consistency.

3.3.1 Number of work cycles to be timed:

It is important to determine the number of work cycles to be timed for this project, because the times of corresponding elements vary statistically across different work cycles. Given that time-studies are a sampling technique, increasing the size of the sample increases the estimate with optimal validity or otherwise, cost of taking the time study. Therefore, we need to determine an optimum number of cycles using the mathematical equation below:

$$n = \left(\frac{t_{\propto/2} * s}{k * \bar{x}}\right)^2$$

Where:

$t_{\propto/2} = given\ constant\ values$

$s\ (sample\ standard\ deviation) = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$

$k = a\ proportion\ that\ specifies\ the\ interval\ size$

$\bar{x} = average\ of\ observed\ times\ collected\ during\ the\ study$

An initial 10 readings were collected on all the work elements to determine the optimal number of cycles to time for this study. Based on the sample, the mean time is $\bar{x} = 1.49\ mins$ and standard deviation of the sample $(s) = 0.36$ and level of confidence is 95%. To guarantee that the true element times fall within ±10% of the average:

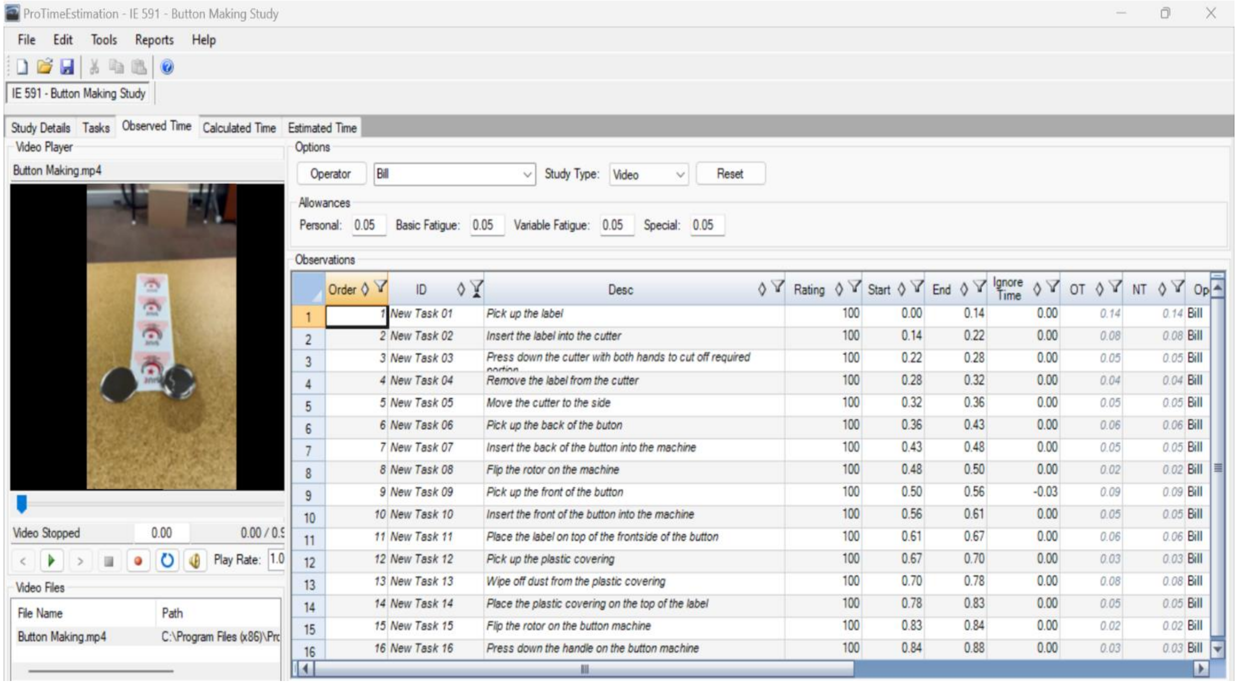
Since in the t distribution there is $10 - 1 = 9$ degrees of freedom, then $t_{\propto/2}$ at 95% level of confidence $(\propto/2 = 0.025)\ is\ 2.262$. With the figures above, it is determined that:

$$n = \left(\frac{2.262 * 0.36}{0.10 * 1.49}\right)^2 = 29.87$$

This was rounded to a total of 30 cycles. Twenty extra work cycles' worth of data were gathered, as ten cycles had been previously timed.

3.4. Observed Time for the Work Elements:

Because the focus of this project is in applying the predetermined motion time system, it is important to establish that in analyzing the data, the timing was recorded in proplanner in time measurement units (TMU) and 1 TMU = 0.036 sec. The normal time to complete individual work elements were determined in proplanner software and shown in the image below:



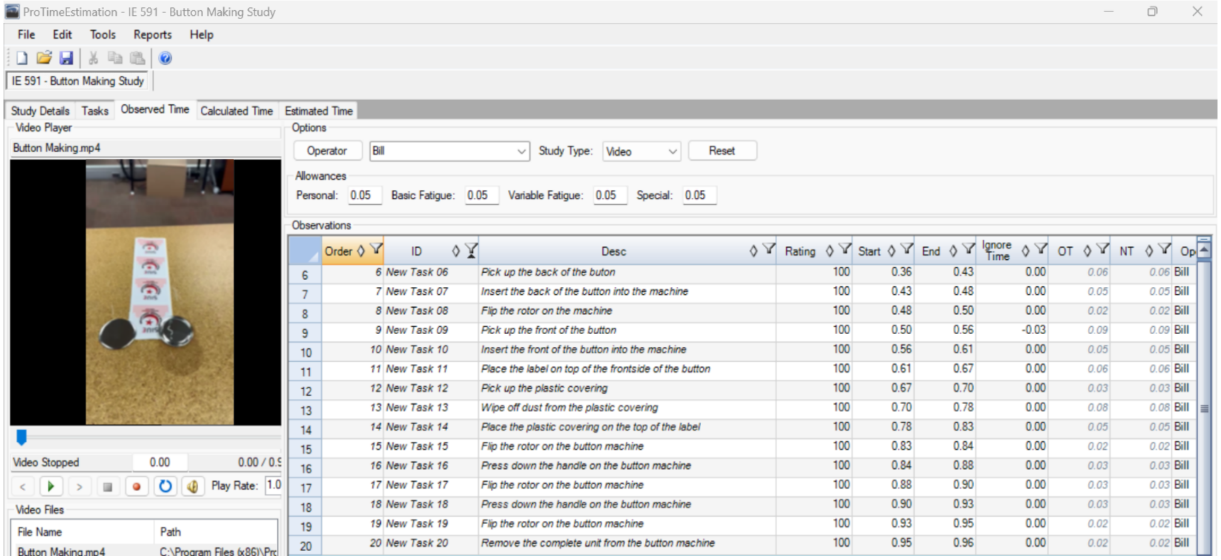
Operator: Bill
Study Type: Video

Personal: 0.05 Basic Fatigue: 0.05 Variable Fatigue: 0.05 Special: 0.05

File Name	Path
Button Making.mp4	C:\Program Files (x86)\Pr

	Order	ID	Desc	Rating	Start	End	Ignore Time	OT	NT	Op
1	1	New Task 01	Pick up the label	100	0.00	0.14	0.00	0.14	0.14	Bill
2	2	New Task 02	Insert the label into the cutter	100	0.14	0.22	0.00	0.08	0.08	Bill
3	3	New Task 03	Press down the cutter with both hands to cut off required portion	100	0.22	0.28	0.00	0.05	0.05	Bill
4	4	New Task 04	Remove the label from the cutter	100	0.28	0.32	0.00	0.04	0.04	Bill
5	5	New Task 05	Move the cutter to the side	100	0.32	0.36	0.00	0.05	0.05	Bill
6	6	New Task 06	Pick up the back of the buton	100	0.36	0.43	0.00	0.06	0.06	Bill
7	7	New Task 07	Insert the back of the button into the machine	100	0.43	0.48	0.00	0.05	0.05	Bill
8	8	New Task 08	Flip the rotor on the machine	100	0.48	0.50	0.00	0.02	0.02	Bill
9	9	New Task 09	Pick up the front of the button	100	0.50	0.56	-0.03	0.09	0.09	Bill
10	10	New Task 10	Insert the front of the button into the machine	100	0.56	0.61	0.00	0.05	0.05	Bill
11	11	New Task 11	Place the label on top of the frontside of the button	100	0.61	0.67	0.00	0.06	0.06	Bill
12	12	New Task 12	Pick up the plastic covering	100	0.67	0.70	0.00	0.03	0.03	Bill
13	13	New Task 13	Wipe off dust from the plastic covering	100	0.70	0.78	0.00	0.08	0.08	Bill
14	14	New Task 14	Place the plastic covering on the top of the label	100	0.78	0.83	0.00	0.05	0.05	Bill
15	15	New Task 15	Flip the rotor on the button machine	100	0.83	0.84	0.00	0.02	0.02	Bill
16	16	New Task 16	Press down the handle on the button machine	100	0.84	0.88	0.00	0.03	0.03	Bill

Figure 4: Observed normal time for work elements



Operator: Bill
Study Type: Video

Personal: 0.05 Basic Fatigue: 0.05 Variable Fatigue: 0.05 Special: 0.05

File Name	Path
Button Making.mp4	C:\Program Files (x86)\Pr

	Order	ID	Desc	Rating	Start	End	Ignore Time	OT	NT	Op
6	6	New Task 06	Pick up the back of the buton	100	0.36	0.43	0.00	0.06	0.06	Bill
7	7	New Task 07	Insert the back of the button into the machine	100	0.43	0.48	0.00	0.05	0.05	Bill
8	8	New Task 08	Flip the rotor on the machine	100	0.48	0.50	0.00	0.02	0.02	Bill
9	9	New Task 09	Pick up the front of the button	100	0.50	0.56	-0.03	0.09	0.09	Bill
10	10	New Task 10	Insert the front of the button into the machine	100	0.56	0.61	0.00	0.05	0.05	Bill
11	11	New Task 11	Place the label on top of the frontside of the button	100	0.61	0.67	0.00	0.06	0.06	Bill
12	12	New Task 12	Pick up the plastic covering	100	0.67	0.70	0.00	0.03	0.03	Bill
13	13	New Task 13	Wipe off dust from the plastic covering	100	0.70	0.78	0.00	0.08	0.08	Bill
14	14	New Task 14	Place the plastic covering on the top of the label	100	0.78	0.83	0.00	0.05	0.05	Bill
15	15	New Task 15	Flip the rotor on the button machine	100	0.83	0.84	0.00	0.02	0.02	Bill
16	16	New Task 16	Press down the handle on the button machine	100	0.84	0.88	0.00	0.03	0.03	Bill
17	17	New Task 17	Flip the rotor on the button machine	100	0.88	0.90	0.00	0.03	0.03	Bill
18	18	New Task 18	Press down the handle on the button machine	100	0.90	0.93	0.00	0.03	0.03	Bill
19	19	New Task 19	Flip the rotor on the button machine	100	0.93	0.95	0.00	0.02	0.02	Bill
20	20	New Task 20	Remove the complete unit from the button machine	100	0.95	0.96	0.00	0.02	0.02	Bill

Figure 5: *Observed Time for work elements contd.*

3.5. Calculated Time for the Work Elements:

Based on methods-time measurement, the Maynard Operation Sequence Technique (MOST) is a high-level predefined motion time system. Based on the idea that objects move according to a pattern of essentially constant body motions and actions, this project made use of the Basic MOST at a 15% allowance (5% each for personal, fatigue and delays). This implies that depending on the object being transported and the specifics of the job activity, the pattern's details are the only things that change. Basic MOST makes use of motion aggregates, also known as activity sequence models, which deal with moving objects. These aggregates include:

1. General move – operates in the GET, PUT and RETURN order of objects free to move in space.
2. Controlled move – operates in the GET, MOVE, and RETURN order of objects in contact with its surroundings.
3. Tool use – involves utilizing tools and GET TOOL, PLACE TOOL, TOOL ACTION, PLACE TOOL and RETURN is the order it goes in.

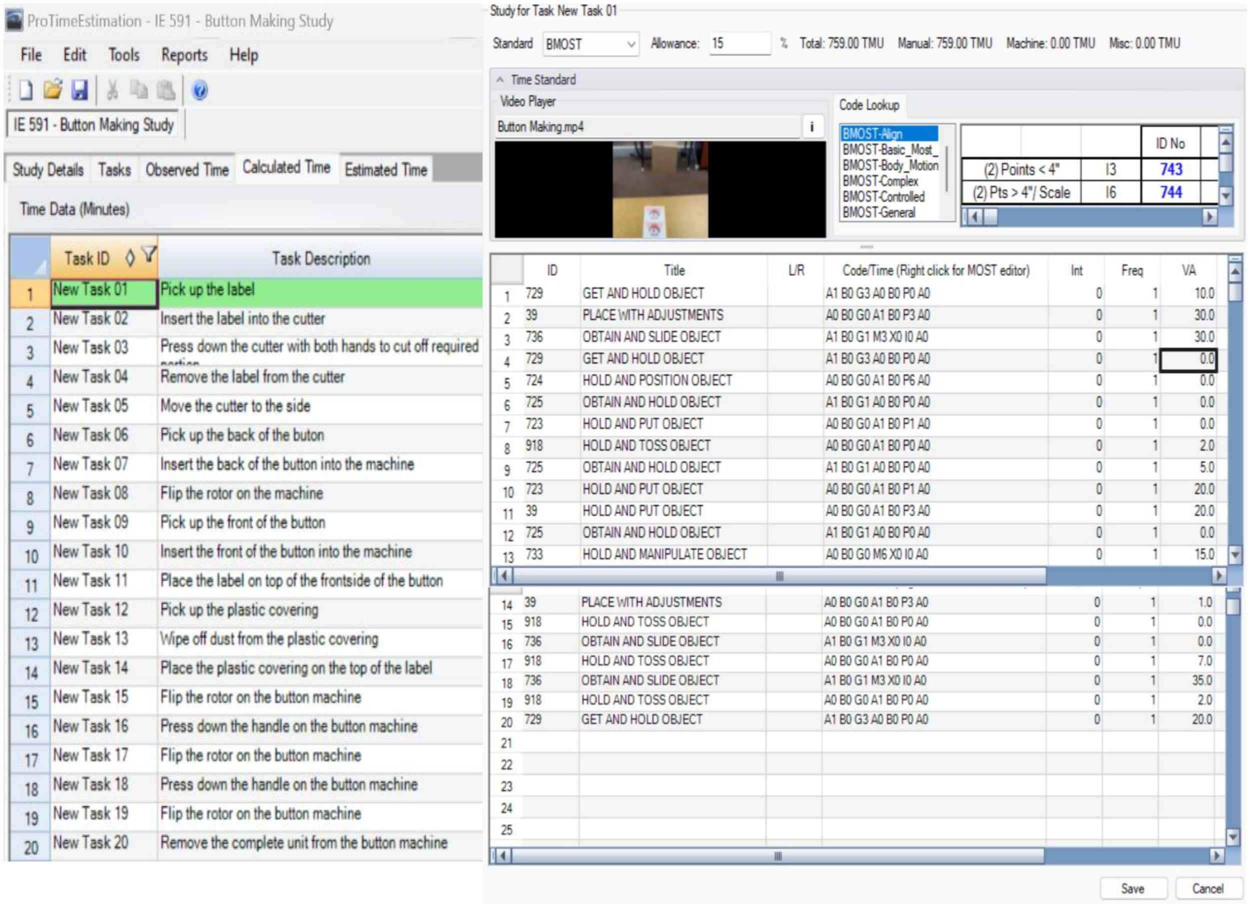
Activity	Order Model	Sub Tasks
General Move	[ABG] [ABP] [A]	A – Action distance
		B – Body Motion
		G – Gain Control
		P - Place
Controlled Move	[ABG] [MXI] [A]	M – Move Controlled
		X – Process Time
		I - Align
Tool Use	[ABG] [ABP] [*] [ABP] [A]	*F - Fasten
		*L – Loosen
		*C – Cut
		*S – Surface Treat
		*R - Record
		*M - Measure

Figure 6: Order Model of Basic M.O.S.T. (S., Rajashekar, & Ramamurthy, 2018)

The Basic Maynard Operation Sequence Technique for determining an activity’s cycle time classifies the activities into value-added, semi-value-added and non-value-added activities. It is based on these three classifications, that a value index is assigned to each activity, to determine the time measurement unit (TMU) using the formula:

$$TMU = \sum Index\ Values * 10 * frequency$$

The figure below shows data of the tasks for this project and the basic Maynard operation sequence technique calculations in the ProTime software:



Study for Task New Task 01

Standard: BMOST

Allowance: 15 %

Total: 759.00 TMU

Manual: 759.00 TMU

Machine: 0.00 TMU

Misc: 0.00 TMU

			ID No
	(2) Points < 4"	I3	743
	(2) Pts > 4"/ Scale	I6	744

	Task ID	Task Description
1	New Task 01	Pick up the label
2	New Task 02	Insert the label into the cutter
3	New Task 03	Press down the cutter with both hands to cut off required portion
4	New Task 04	Remove the label from the cutter
5	New Task 05	Move the cutter to the side
6	New Task 06	Pick up the back of the buton
7	New Task 07	Insert the back of the button into the machine
8	New Task 08	Flip the rotor on the machine
9	New Task 09	Pick up the front of the button
10	New Task 10	Insert the front of the button into the machine
11	New Task 11	Place the label on top of the frontside of the button
12	New Task 12	Pick up the plastic covering
13	New Task 13	Wipe off dust from the plastic covering
14	New Task 14	Place the plastic covering on the top of the label
15	New Task 15	Flip the rotor on the button machine
16	New Task 16	Press down the handle on the button machine
17	New Task 17	Flip the rotor on the button machine
18	New Task 18	Press down the handle on the button machine
19	New Task 19	Flip the rotor on the button machine
20	New Task 20	Remove the complete unit from the button machine

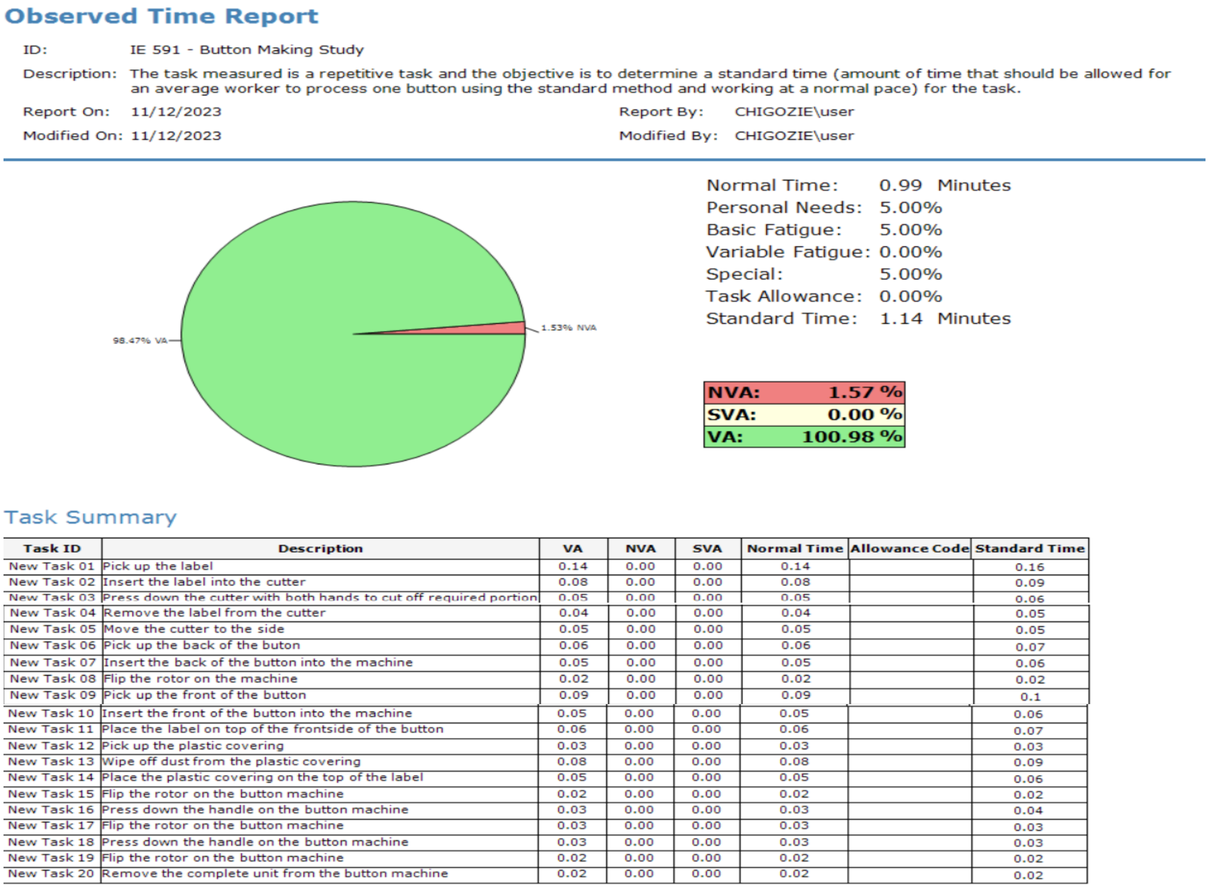
	ID	Title	L/R	Code/Time (Right click for MOST editor)	Int	Freq	VA
1	729	GET AND HOLD OBJECT		A1 B0 G3 A0 B0 P0 A0	0	1	10.0
2	39	PLACE WITH ADJUSTMENTS		A0 B0 G0 A1 B0 P3 A0	0	1	30.0
3	736	OBTAIN AND SLIDE OBJECT		A1 B0 G1 M3 X0 I0 A0	0	1	30.0
4	729	GET AND HOLD OBJECT		A1 B0 G3 A0 B0 P0 A0	0	1	0.0
5	724	HOLD AND POSITION OBJECT		A0 B0 G0 A1 B0 P6 A0	0	1	0.0
6	725	OBTAIN AND HOLD OBJECT		A1 B0 G1 A0 B0 P0 A0	0	1	0.0
7	723	HOLD AND PUT OBJECT		A0 B0 G0 A1 B0 P1 A0	0	1	0.0
8	918	HOLD AND TOSS OBJECT		A0 B0 G0 A1 B0 P0 A0	0	1	2.0
9	725	OBTAIN AND HOLD OBJECT		A1 B0 G1 A0 B0 P0 A0	0	1	5.0
10	723	HOLD AND PUT OBJECT		A0 B0 G0 A1 B0 P1 A0	0	1	20.0
11	39	HOLD AND PUT OBJECT		A0 B0 G0 A1 B0 P3 A0	0	1	20.0
12	725	OBTAIN AND HOLD OBJECT		A1 B0 G1 A0 B0 P0 A0	0	1	0.0
13	733	HOLD AND MANIPULATE OBJECT		A0 B0 G0 M6 X0 I0 A0	0	1	15.0
14	39	PLACE WITH ADJUSTMENTS		A0 B0 G0 A1 B0 P3 A0	0	1	1.0
15	918	HOLD AND TOSS OBJECT		A0 B0 G0 A1 B0 P0 A0	0	1	0.0
16	736	OBTAIN AND SLIDE OBJECT		A1 B0 G1 M3 X0 I0 A0	0	1	0.0
17	918	HOLD AND TOSS OBJECT		A0 B0 G0 A1 B0 P0 A0	0	1	7.0
18	736	OBTAIN AND SLIDE OBJECT		A1 B0 G1 M3 X0 I0 A0	0	1	35.0
19	918	HOLD AND TOSS OBJECT		A0 B0 G0 A1 B0 P0 A0	0	1	2.0
20	729	GET AND HOLD OBJECT		A1 B0 G3 A0 B0 P0 A0	0	1	20.0
21							
22							
23							
24							
25							

Figure 7: *Calculated time for work elements using activity sequence models of Basic MOST*

From the worksheet above, the total calculated TMU = 759.00 TMU. Since 1 TMU = 0.036 sec, this means that it should take a pre-calculated time of 27 seconds to produce one button.

4. RESULTS

From the generated report of this project from proplanner software attached below, it is shown that by implementing the basic Maynard Operation Sequence Technique of the predetermined motion time system, the standard time for completing an individual work unit with a cumulative 15% of allowance for personal, fatigue and delays should be 1.14 minutes. For an 8-hr shift, the SIUE MakerLab should meet a demand of 421 buttons daily.



Observed Time Report

ID: IE 591 - Button Making Study

Description: The task measured is a repetitive task and the objective is to determine a standard time (amount of time that should be allowed for an average worker to process one button using the standard method and working at a normal pace) for the task.

Report On: 11/12/2023 Report By: CHIGOZIE\user

Modified On: 11/12/2023 Modified By: CHIGOZIE\user

Normal Time:	0.99 Minutes
Personal Needs:	5.00%
Basic Fatigue:	5.00%
Variable Fatigue:	0.00%
Special:	5.00%
Task Allowance:	0.00%
Standard Time:	1.14 Minutes

NVA:	**1.57 %**
SVA:	**0.00 %**
VA:	**100.98 %**

Task Summary

Task ID	Description	VA	NVA	SVA	Normal Time	Allowance Code	Standard Time
New Task 01	Pick up the label	0.14	0.00	0.00	0.14		0.16
New Task 02	Insert the label into the cutter	0.08	0.00	0.00	0.08		0.09
New Task 03	Press down the cutter with both hands to cut off required portion	0.05	0.00	0.00	0.05		0.06
New Task 04	Remove the label from the cutter	0.04	0.00	0.00	0.04		0.05
New Task 05	Move the cutter to the side	0.05	0.00	0.00	0.05		0.05
New Task 06	Pick up the back of the buton	0.06	0.00	0.00	0.06		0.07
New Task 07	Insert the back of the button into the machine	0.05	0.00	0.00	0.05		0.06
New Task 08	Flip the rotor on the machine	0.02	0.00	0.00	0.02		0.02
New Task 09	Pick up the front of the button	0.09	0.00	0.00	0.09		0.1
New Task 10	Insert the front of the button into the machine	0.05	0.00	0.00	0.05		0.06
New Task 11	Place the label on top of the frontside of the button	0.06	0.00	0.00	0.06		0.07
New Task 12	Pick up the plastic covering	0.03	0.00	0.00	0.03		0.03
New Task 13	Wipe off dust from the plastic covering	0.08	0.00	0.00	0.08		0.09
New Task 14	Place the plastic covering on the top of the label	0.05	0.00	0.00	0.05		0.06
New Task 15	Flip the rotor on the button machine	0.02	0.00	0.00	0.02		0.02
New Task 16	Press down the handle on the button machine	0.03	0.00	0.00	0.03		0.04
New Task 17	Flip the rotor on the button machine	0.03	0.00	0.00	0.03		0.03
New Task 18	Press down the handle on the button machine	0.03	0.00	0.00	0.03		0.03
New Task 19	Flip the rotor on the button machine	0.02	0.00	0.00	0.02		0.02
New Task 20	Remove the complete unit from the button machine	0.02	0.00	0.00	0.02		0.02

CONCLUSION AND RECOMMENDATION

Through meticulous data collection, analysis, and the definition of the one-best-method, this study has provided a foundation for process improvement to enhance the efficiency of the button production process. As seen from the result in the previous section, the current process, although relatively efficient with a value-added percentage of 100.98%, has a non-value adding percentage of 1.5% during the cutting phase. Introducing parallel processing or optimizing the sequence of tasks could alleviate congestion points, ensuring a smoother flow of the production process. Thus, process improvement efforts should be made to get rid of this non-value-added proportion of work elements by reorganizing the workstation, redistributing tasks, or implementing a just-in-time production strategy to synchronize each phase seamlessly.

The one-best-method, as documented through video recordings, time-tracking data, and observational notes, served as a benchmark for evaluating the current state of the button-making process. This standardized sequence of steps provided a clear understanding of the optimal approach to button production within MakerLab. In conclusion, working on this real-life research independently has provided me with a hands-on experience and deepened understanding of the concept of time studies and motion analysis. Through the numerous training resources provided to me by the Proplanner company, I have also developed proficiency in usage of their ProTime Estimation software.

Future Work

This project was limited to the Basic Maynard Operation Sequence Technique (MOST) of the predetermined motion time study. Future scholars could attempt to evaluate the same process, by utilizing some other methods-time measurement (MTM) also available in the ProTimeEstimation software such as MTM1, MTMB, MTMUAS, MTMMEK, MODAPTS, MaxiMost. It would be interesting to see what the standard time for this process would be if other MTMs are used.

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