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Analysis of Motion and Time Study in the Stamp Batik Production Process

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ABSTRACT

This study aims to determine the standard time required to complete the stamped batik production process and to analyze worker movements. The processing time for each activity must be standardized to facilitate production scheduling, and the movements performed should be effective and efficient.The method used in this study is the Motion and Time Study method, which is useful for evaluating the production movements of stamped batik by classifying and identifying efficiency in these movements. In addition to identifying movements, this method also determines the standard time for a process so that production time can be standardized. The study results show that the cycle time for stamped batik production is 135.30 minutes, with the longest average processing time being the drying process, which takes an average of 121.25 minutes. The normal time for stamped batik production, considering the rating factor, is 168.17 minutes. The standard time for stamped batik production is 240.48 minutes. Based on the Therblig map for the right and left hands, the dominant movements of the right hand are using and holding, with respective durations of 184 seconds and 122 seconds per batik fabric production cycle. The proposed improvement for the using activity is to redesign the dimensions of the stamping tool, while for the holding activity, the improvement involves rearranging the layout of the stamping ink. The left hand is more frequently used for holding and idling activities, with durations of 149 seconds and 139 seconds, respectively. The proposed improvement for the holding activity is to provide a dedicated place to store and support the fabric dye. The improvement for the idling activity is that during the stamping process, the left hand can hold a ruler, eliminating the need for manual alignment and ensuring more precise stamping results.The implication of this study is that by applying the Motion and Time Study method, the processing time for stamped batik production can be identified, along with inefficient movements that can be minimized.

Keywords: Motion and Time Study, Stamped Batik, Efficiency, Hand Mapping, Therblig

A. INTRODUCTION

Pekalongan is a batik city that is known worldwide. Batik craftsmen are spread almost throughout the Pekalongan region. One of the areas in Pekalongan that has become a batik center is the Buaran sub-district because most of its people work in the batik industry and there are many household-scale batik producers, making the area the largest batik producer in the Pekalongan regency and city [1]. Most of the batik production process still relies on human labor from start to finish. In this digital era, with the development of marketplaces, consumers can easily choose batik according to their preferences. This presents both an opportunity and a threat for batik entrepreneurs, as competition among batik producers becomes intense. Thus, in order for producers to survive the existing competition, they must continuously improve their production processes to create high-quality products at affordable prices. Based on field surveys of batik producers, many tasks are performed repetitively, such as cutting mori fabric, stamping batik, and other activities. This causes the time for a process to become longer.

Therefore, these movements must be minimized by making them more effective and efficient, as well as engineering the placement of items to shorten production time [2]. If the production time is faster, the output will increase, which means productivity will rise. Factors that influence productivity can be broadly categorized into two aspects: technical factors, which include the work environment, technology, and equipment used, and human factors. In addition to the many repetitive movements, there are also inefficiencies found in the batik production process, such as the inefficient transportation of mori cloth due to uncertain demand and excessive mori cloth stock, as well as product defects like misaligned patterns. If these issues are not addressed, production costs will tend to increase, and the quality of the batik cloth will decline. This will certainly be detrimental to the producers, as price and quality are key benchmarks for a product [3]. Figure 1 shows one of the processes in the production of stamped batik.

Figure 1. the processes in the production of stamped batik.

Source : data processing

To improve productivity, it is necessary to identify human activities, especially related to the movements performed, considering that humans are the main element in the batik production process. Therefore, the Motion and Time study method is appropriate for evaluating the movements performed by workers during the production process and determining standard time, so that the work system implemented is truly accurate in addition to determining standard time. Motion and Time Study can be useful for developing better systems and work methods, thereby reducing costs, standardizing systems and work methods, and training workers to implement better methods [4]. The application of motion and time study in the batik production process is useful for identifying movements and evaluating production time, and it can also function to improve workflow so that it runs efficiently [5].

B. LITERATURE

B1. Time Study

Time Study is a method used to measure the time required to complete a task with optimal efficiency. This approach aims to increase productivity and reduce time wastage in the work process [6]. Time study was first introduced by Frederick Winslow Taylor, and this method continues to evolve with advancements in technology and research methodologies. The main objective of Time Study is to determine the standard time required to perform a specific task. This standard time is used to improve work efficiency, workforce planning, and production cost determination [7]. In addition, the benefits of Time Study include the identification of time-wasting areas, the development of more efficient workflows, and the improvement of work output quality [8]. The Time Study methodology involves direct observation of work processes, time measurement using tools such as stopwatches, and data analysis to determine standard times [9]. This approach can be carried out using time sampling techniques, work cycle time measurement, and the use of software for more accurate analysis [10]. An effective time study also requires a deep understanding of the work process and worker involvement in the measurement process. To improve the accuracy and acceptance of the results [11]. Several factors that influence the results of a Time Study include:

1. Individual variation: Differences in ability, experience, and speed of workers.
2. Task complexity: The more complex the task, the more difficult it is to determine an accurate standard time.
3. Use of technology: Modern technology can help improve the accuracy of time measurement [12].

Some challenges often faced in the implementation of Time Study include resistance from workers, measurement errors, and difficulty in determining standard times for non-routine tasks. To overcome these challenges, a participatory approach and the use of advanced technology are needed to support the time measurement process. Time Study is an important tool in modern operational management, providing a strong foundation for decision-making related to efficiency and productivity. By understanding the concepts, benefits, and challenges involved, the implementation of Time Study can be carried out effectively to achieve organizational goals. Time study is an analytical method used to measure the time required to complete a task or a series of tasks within a specific context. This method is often applied in various fields, including healthcare, education, and industry, to improve efficiency and productivity. In the context of healthcare services, time studies can help in understanding workflows and identifying areas that need improvement. Application of Time Studies in Healthcare One relevant application of time study is in the context of pathology laboratories. Cinar [13] shows that time study techniques can used to improve productivity in the pathology laboratory by analyzing the time spent on various clinical activities. The research revealed that doctors spend less than half of their time in the clinic, indicating the potential to improve efficiency through better time management. Additionally, time studies are also used to evaluate workflow efficiency in surgical procedures, as demonstrated by Shetty [14], who assessed the impact of digital workflows on time and resource efficiency in cataract surgery. In the context of healthcare, time studies are also used to analyze the tasks performed by healthcare workers. For example, Snowdon et al.[15] conducted a time study to measure the time spent by healthcare assistants in completing patient-related tasks. This research follows the Suggested Time And Motion Procedures (STAMP) guidelines, which are the standard in the design and reporting of time studies. Similarly, Chebolu-Subramanian et al. [16] emphasize the importance of time studies in understanding the workflow of mental health workers in rural areas, which can help in designing more effective interventions. Time studies can also be applied in the context of education and training. Baker et al. [17] reported on a time study conducted to understand the workflow of nurses in providing education to patients in hospitals. This study shows that The collection of quantitative data through continuous observation can help identify process efficiencies and necessary improvements. Thus, time studies not only serve to measure time but also to provide valuable insights into resource management and process improvement. Overall, time studies are a very useful tool in various contexts for analyzing and improving efficiency. By applying the appropriate methodology and following recognized guidelines, such as STAMP, researchers can produce valid and reliable data to support better decision-making in time and resource management.

B2. Motion Study

Motion Study is a work analysis technique aimed at identifying and eliminating inefficient movements in the work process. This method is used to improve productivity, efficiency, and workplace safety by studying movement patterns in specific tasks. This technique was developed by Frank B. Gilbreth, who is known as a pioneer in this field, with a primary focus on improving operational effectiveness through the simplification of human movements. The application of Motion Study in the workplace can help minimize wasted movements, thereby speeding up the completion time of tasks without compromising the quality of the results. Motion Study can be used as a systematic approach to improve work processes through the observation and analysis of work movements [8]. In practice, Motion Study involves several steps, including direct observation of work activities, video recording, and analysis using work process maps. The use of aids such as video can provide in-depth insights into specific movements that can be eliminated or simplified [9]. The importance of standardized motion analysis to generate precise improvement recommendations. The use of Motion Study not only focuses on efficiency but also includes ergonomic aspects [18]. Proper motion analysis can enhance work comfort and reduce the risk of injuries due to repetitive physical activities. Implementation Motion Study often has a positive impact on employee job satisfaction, as work processes become smoother and more organized [10]. Motion Study can be used as part of strategic planning in human resource management. Through the identification of unnecessary steps, companies can reallocate time and resources to more productive activities. Overall, Motion Study is a very effective tool in operational management [19]. By utilizing this technique, organizations can achieve better work efficiency, enhance workplace safety, and reduce waste [2]. Motion study plays an important role in improving efficiency in various fields, including biomechanics, robotics, and fluid dynamics. The relationship between motion study and efficiency can be understood through several key aspects: optimization of movement patterns, the influence of external factors on movement efficiency, and the application of motion analysis in various practical scenarios. The relationship between motion study and efficiency is the Optimization of Motion Patterns and Efficiency. Optimizing movement patterns is a fundamental factor in improving efficiency. Studies on fish swimming movements show that fin angles and specific movement trajectories can significantly enhance propulsion efficiency. Research by Kugai et al. [20] indicates that the movement of the caudal fin modeled as an arctangent wave can optimize propulsion efficiency by aligning the fin angle with the water entry angle. Furthermore, research by Demirer et al. [21] found that the movement of the elastic propulsor's trailing edge is passive and follows the movement of the leading edge, which contributes to minimizing flow pressure differences and enhancing hydrodynamic performance. These findings indicate that understanding and optimizing movement can enhance efficiency in biological and mechanical systems. The Influence of External Factors on Movement Efficiency External factors such as environmental conditions and system design can affect motion efficiency. Liu et al. [22] studied the dynamics of self-propelled robotic systems with viscoelastic joints and found that hysteresis and friction affect the stiffness and damping characteristics of the system, which are crucial for optimizing the motion trajectory. Additionally, the study by Alben [23] on gliding motion with isotropic friction shows that certain undulatory motion patterns result in minimal net displacement, emphasizing the importance of careful motion design to achieve optimal efficiency. The Application of Motion Study in Improving Efficiency Motion analysis also has practical applications in various fields such as medicine and robotics. For example, the application of motion correction techniques in MRI has significantly reduced the number of non-diagnostic studies, thereby improving the efficiency of the diagnostic process [24]. Additionally, Singh's [25] research on surgical suturing skills highlights the importance of rotational motion analysis in efficiently quantifying skills, which ultimately enhances training and performance outcomes in the surgical field. As for evaluating the movements, the basic therblig movements are used, namely:

1. Search
2. Select
3. Grasp
4. Reach
5. Move
6. Hold
7. Release
8. Position
9. Pre position
10. Inspect
11. Assemble
12. Diassemble
13. Use

14. Unavoidable delay
15. Avoidable delay
16. Plan
17. Rest to overcome delay

B3. The Relationship Between Time And Motion Study And Productivity

The relationship between time and motion study techniques and productivity is well-established in various industrial contexts. Motion and time studies are systematic approaches that analyze the efficiency of work processes by observing and measuring the time taken to perform tasks and the motions involved. These studies aim to identify inefficiencies and optimize workflows, ultimately leading to enhanced productivity. Time study techniques involve the meticulous observation of workers performing specific tasks, often using a stopwatch to record the time taken for each activity. This method allows for the identification of bottlenecks and unnecessary delays in the production process. For instance, Cinar's research highlights the successful application of these techniques in pathology laboratories, where they led to significant improvements in productivity by optimizing task execution and reducing wasted time [13]. Similarly, Akarslan emphasizes that work study techniques, including time studies, are crucial for evaluating production activities, thereby directly impacting productivity by minimizing non-value-added operations and streamlining processes [26]. Motion study techniques complement time studies by focusing on the physical movements involved in task execution. By analyzing these movements, organizations can redesign workflows to eliminate unnecessary motions, thereby enhancing efficiency. For example, Noamna et al. utilized the Methods Time Measurement (MTM-2) technique to analyze human motions in a manufacturing context, demonstrating that optimizing these motions can lead to improved production standards and reduced cycle time [27]. Furthermore, Kumar's study on assembly line balancing in the textile sector illustrates how time and motion analysis can identify and eliminate redundant activities, ensuring a seamless workflow and minimizing idle time [28]. The integration of motion and time study techniques is particularly effective in lean manufacturing environments, where the goal is to maximize value while minimizing waste. Research by Nnanna and Arua emphasizes that productivity improvement can be achieved by adopting work-study techniques that focus on reducing inefficiencies and optimizing processes [29]. This aligns with findings from other studies that advocate for the use of lean tools to enhance productivity through systematic waste reduction [30].

C. RESEARCH METHOD

This research was conducted on the batik cap owned by Mr. Abdullah in Watusalam Village, Buaran District, Pekalongan Regency. with direct observation of the cap batik-making process starting from the burning of coconut shells as the main material for making cap batik. The tools used in the research are as follows:

1. Stopwatch
2. Camera

3. Handycam
4. Observation Sheet

A stopwatch is used to measure the time for each activity in the making of batik cap. Meanwhile, the camera and handycam are used for documentation and creating videos of the batik cap-making process, which will subsequently be used for motion analysis. In data collection, each activity is repeated 10 times, which will later be analyzed for data sufficiency and data uniformity. The stages of the research can be seen in Figure 2:

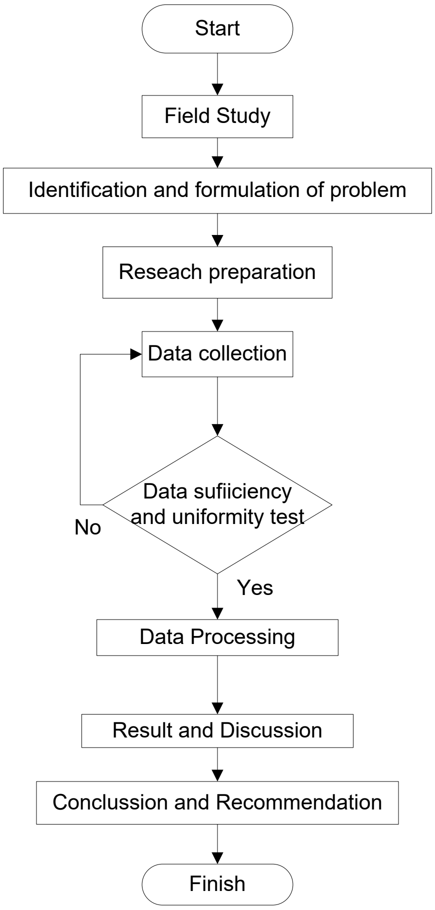

Figure 2. Flowchart
Source : Data Processing

1. Research Preparation

Research preparation is carried out before data collection so that the data obtained can be focused and yield optimal results. The research preparation includes the selection of samples,workers, and which workstations will be studied.

2. Data Collection

The next stage is data collection. The data to be collected includes the time taken for each production process, production capacity, and recordings of the production process using a camera. This recording will later be analyzed to determine which movements are efficient and which are not.

3. Data Processing

For data processing using the Motion and Time Study method, the first measurement conducted is the cycle time measurement. Cycle time is the time taken to complete the detailed activities performed. In measuring cycle time, it must meet the adequacy and uniformity tests so that the calculation results can be optimal. After passing these tests, the average is then calculated, followed by finding the adjustment factor for each operator, which will yield the normal time. Then, after the normal time is found, the allowance factor is determined so that the standard time (base) for the batik-making process can be obtained. Next, observations are made on the operator's movements obtained from camera recordings, which are then identified using the Therblig motion principles to determine which movements are effective and which are not. The next step is to eliminate the ineffective movements. From these results, proposals will be obtained for improving worker movements and also the production cycle time.

D. RESULT AND DISCUSSION

D.1. Result

The measurement of process time was conducted with a stopwatch for each batik-making process, and the observational data can be seen in Table 1.

Table 1. Time for each process of making stamped batik

No	Process	No. Replication (minutes)										Average
		1	2	3	4	5	6	7	8	9	10	
1	Stamping	3,13	3,26	3,29	3,15	3,28	3,31	3,06	3,1	3,09	3,22	3,19
2	Pencoletan	1,08	1,01	1,04	1,1	1,24	1,03	1,26	1,12	1,1	1,12	1,11
3	Kenyos	0,5	0,4	0,42	0,47	0,5	0,42	0,45	0,44	0,42	0,46	0,45
4	Dyeing	1,33	1,26	1,27	1,19	1,14	1,3	1,2	1,26	1,27	1,29	1,25
5	Boiling	3,1	3,11	3,14	3,12	3,13	3,14	3,2	3,15	3,19	3,12	3,14
6	Washing	4,51	4,49	4,54	4,48	4,52	4,55	4,53	4,52	4,5	4,47	4,51
7	Drying	120,2	119	120,3	120,24	120,2	121	122	125	120,55	124	121,25

Source : Data Processing

The following is a comparison of the time taken for each process in the production of cap batik, which can be seen in Figure 2.

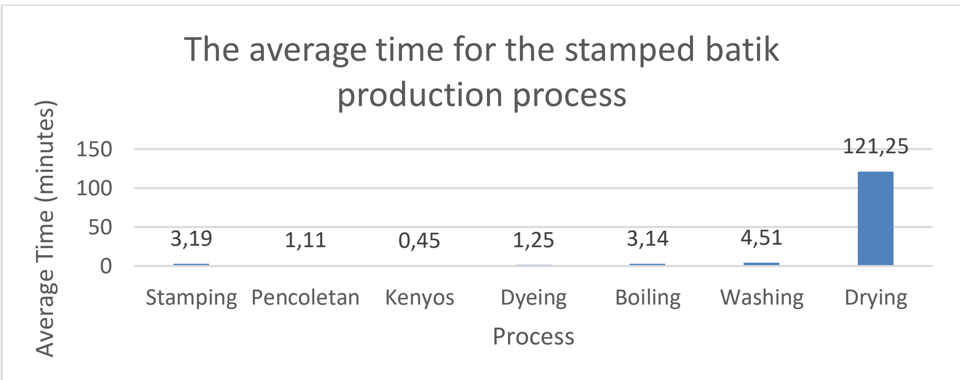

Figure 2. The average time for the stamped batik production process

Source : Data Processing

Based on Table 1, the longest process is the drying process, which has an average of 121.25 minutes, and the total cycle time for the entire process is 135.30 minutes. After obtaining the production process data, a test for data sufficiency and uniformity was conducted. able 2 is the result of the data data sufficiency test:

Table 2. The result of the data sufficiency test

No	Process	N	N[1]	Description
1	Stamping	10	1,2	sufficient
2	Pencoletan	10	6,19	sufficient
3	Kenyos	10	8,57	sufficient
4	Dyeing	10	3,03	sufficient
5	Boiling	10	0,04	sufficient
6	Washing	10	0,15	sufficient
7	Drying	10	0,34	sufficient

Source : Data Processing

It can be seen in Table 2 that all data have passed the data adequacy test. Next, a test of data uniformity was conducted. The results of the data uniformity test can be seen in Table 3.

Table 3. The results of the data uniformity test

No	Process	Description
1	Stamping	Homogeneus
2	Pencoletan	Homogeneus
3	Kenyos	Homogeneus
4	Dyeing	Homogeneus
5	Boiling	Homogeneus
6	Washing	Homogeneus
7	Drying	Homogeneus

Source : Data Processing

Based on Table 3, it can be concluded that the data is uniform. The calculation of normal and standard time is carried out after the data meets adequacy and uniformity. The calculation of normal time is done by multiplying the average cycle time from the observation data with the rating factor. In this study, the assessment factor is used with the Westing House method, which evaluates four factors: skill, effort, working conditions, and consistency. The evaluation factor score is 1.24. So, after determining that the cycle time for the cap batik production process is 135.30 minutes, then :

Normal Time = 135,30 x 1,24

Normal Time = 168,17 minutes

From the calculations, the normal time for the stamped batik-making process is obtained, which is 168.17 minutes. Next is to calculate the standard time or basic time. To calculate the standard time, data on allowances determined based on Table 4 is required.

Table 4. Assessment of Allowance

Need for Allowance	Assessment of Allowance	Keterangan
Allowance for personal need	2%	Male Worker
Allowance for eliminating fatique	18%	determined
Allowance unavoidable obstacles	10%	determined
Total Allowance	30%	

Source : Data Processing

Therefore, from the allowance calculation, the standard time is obtained.

Standard Time = 168,17 x $\frac{100}{100-30}$

Standard Time = 168,17 x 1,43 = 240,48 minutes

Based on that calculation, the making of stamped batik takes 240.48 minutes. Based on the observations made during the cap batik production process by watching the entire production process video, therblig data for the right and left hands were obtained, as shown in tables 5 and 6.

Table 5. Right-Hand Map of Therbligs

Right-Hand Map			
Therblig Name	Symbol	Total Time (s)	Total Moving
Grasp	G	122	10
Reach	RE	24	7
Move	M	34	13
Idle		8	2
Melepas	RL	9	9
Hold	H	0	0
Search	SH	0	0
Rest	R	0	0
Position	P	32	11
Assemble	A	0	0
Use	U	184	28
Select	ST	0	0
Plan	PN	0	0

Source : Data Processing

From Table 5, it can be seen that the dominant movements of the right hand are using and holding, with times of 184 seconds and 122 seconds respectively in one batik cloth production. Workers more often use their right hand because it is the most dominant hand. The activity of using is the most frequently performed by workers, namely using the batik stamp tool, the batik stamp tool filled with ink is then pressed onto the mori cloth, the stamping is only done twice because the ink will run out and then be refilled.

Table 6. Left-Hand Map of Therbligs

Left-Hand Map			
Therblig Name	Symbol	Total Time (s)	Total Moving
Grasp	G	149	26
Reach	RE	3	2
Move	M	80	4
Idle		139	19
Melepas	RL	4	4
Hold	H	11	2
Search	SH	8	3
Rest	R	0	0
Position	P	0	0
Assemble	A	0	0
Use	U	25	1

Select	ST	0	0
Plan	PN	0	0

Source : Data Processing

From table 6, it can be seen that the left hand is more often used for holding and idling activities, namely for 149 seconds and 139 seconds respectively for one batik fabric production process. The holding activity is most frequently performed during the dyeing process (dyeing fabric with a brush), where it is used to hold the batik dye, while the right hand is used to hold the brush and dye the fabric.

D.2. Discussion

In the results of the time study measurement, the average time per production process was determined, and it was found that the longest time in the process was the batik drying process, which took 121.25 minutes. This is because the drying process is still done in a conventional way, namely sun drying. During the rainy season, the drying process will certainly take longer, resulting in a longer lead time for the production process. The proposal for this improvement process is to consider using a batik drying machine, which is estimated to make the drying process 50% faster, or 1 hour, unaffected by weather changes [31]. In the right-hand movement, it is known that the process that most often uses the right hand is the batik stamping process. The proposed improvement for this activity is to redesign the dimensions of the stamping tool. The stamp tool is made longer so that one stamp covers a larger area, thereby reducing the frequency of using the stamp tool. Additionally, it can also use appropriate technology, namely with the help of more modern tools such as CNC to increase the productivity of the stamping process [32]. The activity that workers most frequently perform is holding the batik stamp tool, because the location of the dye for the batik stamp and the mori cloth to be stamped are not close together, requiring workers to turn their bodies to fill the stamp tool with the batik dye. The improvement that can be made is to arrange the layout of the stamp ink so that it is close to the fabric to be stamped, so that workers do not need to turn their bodies to reach the stamp ink. Layout arrangement is also useful for streamlining the production process by eliminating unnecessary movements and unused raw materials [33]. In the observation of the left-hand map results, it was found that the left hand is still frequently used for holding dye or fabric dye ink. To reduce the activity of holding, tools or places can be provided to place and support the fabric dye. The activity of the left hand is also considered not yet optimal, as it can be seen that the left hand is often idle. The left hand is often idle during the stamping process because the right hand is used to stamp the batik cloth, leaving the left hand idle. The improvement in this activity is that during the stamping process, the left hand can hold a ruler/template so that the right hand does not need to guide it, resulting in more precise stamps. The purpose of balancing the movements of the right and left hands is to achieve time efficiency, thereby reducing the production process time [34].

E. CONCLUSION

Based on the results of the cycle time study for the production of stamped batik, it is 135.30 minutes. With an average process time, the longest process is the drying/sunning of batik with an average time of 121.25 minutes. The normal time for making stamped batik, considering the rating factor, is 168.17 minutes. The standard time for making stamped batik is 240.48 minutes. therefore, based on the research objectives, the total time to complete the batik production process, considering several factors, is 168.17 minutes. Meanwhile, the motion analysis conducted with video using right and left hand maps found that the dominant movements of the right hand were using and holding, with times of 184 seconds and 122 seconds respectively in one production cycle of batik fabric. The dominant activity of using is the use of the stamp tool, and in holding, it is holding the stamp tool. The proposed improvement for the using activity is to redesign the dimensions of the stamping tool, while for the holding activity, it is to arrange the layout of the ink pad to be closer to the fabric that will be stamped. The left hand is more often used for the holding and idle activities, which last 149 seconds and 139 seconds respectively. The holding activity is performed during the dyeing process with a brush (colet), which involves holding the dye ink. the proposed improvement for this activity is to provide a tool or place to hold and support the fabric dye. The left hand is often idle during the stamping process because the right hand is used to stamp the batik cloth. The improvement in this activity is that during the stamping process, the left hand can hold a ruler/template so that the right hand does not need to guide it, resulting in a more precise stamp. For the next phase of research, the development of batik drying equipment can be undertaken so that the drying process can be faster and not hindered by sunlight. In addition, the design of batik stamp tools and the arrangement of batik stamp facility layouts can still be further developed to optimize the production process. There are still many instances of waste occurring, so a lean manufacturing study is needed..

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