
Parameter Optimization of Writing Batik Machine with Synthetic & Natural Fabric

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ABSTRACT

Batik is a cultural heritage that is a mainstay product in the textile sector. In 2019, the export volume of Indonesian batik from January to July reached 18,500 tons. On the other hand, batik production is currently experiencing a shortage of human resources. This is due to the long process of making written batik, so it takes time and high skills to learn it. This study aims to determine the efficiency of the written batik machine while optimizing parameters to work on a new contemporary patterned batik fabric with the theme of balance. Parameters analysed were wax temperature, fabric types, and nozzle size using the full factorial method and quality assessment approach through expert judgement. In this research, the analysis is separated between the *klowong* process and the *Isen* process. The batik that was designed was successfully made using a written batik machine. The optimal parameter obtained for the *klowong* and *isen* process on both mori and synthetic fabric is the wax's temperature of 115 °C and a nozzle size of 3 and nozzle size 2 for *isen* process. The comparisons made show that the *klowong* and *isen* stage batik machines are 10.5% faster, the cost is cheaper 11.5%, and wax use 33.7% more efficient than manual batik with a comparison of the quality of the workmanship that is able to equal or better than the results of manual batik.

Keywords:

Batik; CNC machine; Design of Experiment; expert judgement; ANOVA

ARTICLE INFO

Received March 11, 2023

Accepted April 8, 2023

Available online September 8, 2023

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1. Introduction

As a developing country, Indonesia carries out economic development to prosper and prosper its people. One of the factors is the level of income and trade of a country. Judging from the Purchasing Manager's Index, Indonesia ranks at 51.2, outperforming Thailand, Malaysia, and Singapore at the Southeast Asian level. Small and medium industries are also a strategic sector for each region to overcome this problem (Sari & Husaini, 2015). A growing small and medium industry is the batik industry. According a 2022 data from the Indonesian Ministry of Industry, there are currently approximately 101 centres and 47 thousand batik business units throughout Indonesia that are able to absorb 200 thousand workers. This is evidenced by the increase in the value of batik exports in 2020. Batik is a cultural heritage that is a mainstay product in the textile sector. In 2019, the export volume of Indonesian batik from January to July reached 18,500 tons (Sekretariat Kabinet Republik Indonesia, 2019). On the other hand, batik production is currently experiencing a shortage of human resources. This is due to the long process of making written batik, as it takes time and skills to learn.

In Indonesia, batik is one of the hallmarks of the textile and apparel industry. According to the Centre for Handicrafts and Batik, batik is the work of the Indonesian people which is a combination of art and technology by the ancestors of the Indonesian people. According to the Centre for Handicrafts and Batik, Indonesia has several motifs related to local culture influenced by geographical location, the nature and lifestyle of the region, beliefs, and customs in a region, as well as the surrounding natural conditions including flora and fauna.

Batik is found in several west African countries such as Nigeria, Ghana, and Mali and several Asian countries such as India, Sri Lanka, Malaysia, Thailand, and Indonesia ([Wibisono et al., 2010](#)). Batik has become a product of Indonesia's traditional creative industry and has now been recognised by UNESCO as a Representative List of Intangible Cultural Heritage. Based on the working technique, batik types can be divided into *Batik Tulis*, *Batik Lukis* and *Batik Cap*. Written batik is a type of batik that is made conventionally using hands with canting tools to apply wax to batik patterns.

[Lisbijanto \(2013\)](#) explains that there are 3 types of batik according to the manufacturing technique, namely *Batik Tulis*, *Batik Lukis*, and *Batik Cap* which are made with human labour and have meaning in each motif. Batik motifs can be classified into classic and contemporary batik. The characteristics of contemporary and classic batik motifs have some differences. Classical motifs that are bound by *pakem* usually have complex motifs with many details and tight segments. According to [Utoro et al. \(1979\)](#), the meaning of contemporary is 'today' or 'the present'. Contemporary batik patterns are batik patterns that have undergone new development or innovation.

The quality of batik products is influenced by fabric raw materials, batik wax/wax, dyes, environmental conditions, and human resources ([Moerniwati, 2015](#)). Nowadays, the need for product variations has developed into design to order. The demand for customised products raises the need for a system that can speed up the production process to shorten the lead-time. Then the problem of batik regeneration because the younger generation prefers to work in factories. In addition, according to Indonesian media in 2019 only 3% understood the value of the batik process. Therefore, a solution is needed with the development of textile technology, one of which is the use of textile production support printer machines. This machine appears to improve the manufacturing system ([Wibisono et al., 2012](#)).

A textile printer machine that already exists today can be a batik CNC machine. Computerised Numerical Control (CNC) is a machine that enters a programme through software to control the movement of its tools. In addition, by using a batik CNC machine, the quality between batik products is better maintained, because it creates uniformity of quality and consistency in batik products. [Suh et al. \(2008\)](#) explained that CNC machine tools can be classified into two types, namely Cutting Machines that perform the process of removing material on the workpiece and Non-Cutting Machines that provide force or pressure on the workpiece to give it a certain shape. To maintain the quality of this batik product is maintained and optimal, it is necessary to use the right parameters. In the past few years, there have been many studies on printed and written batik. There is research related to canting and the type of wax for batik as in Suharto's research ([Suryanto et al., 2015](#)). In addition, there is also research on CNC machines as an alternative to producing written and printed batik as in Kusumawardani's research (2018). Based on research conducted by [Permana & Yayat \(2019\)](#), testing was carried out on the turning process of 6061 Aluminium.

Research on the use of a machine similar to the flame cutting machine at the UGM DTMI Production Process and Systems Laboratory to produce written batik using CNC-based machines has been successfully carried out by [Kusumawardani \(2018\)](#). Then similar research was developed and improved by research based on the Butimo hand-written batik machine. Research using the hand-written batik machine in Butimo has been successfully conducted previously by [Marsel \(2019\)](#), [Mikra \(2020\)](#), [Prasetya \(2020\)](#), [Larasati \(2020\)](#), and [Anugerah \(2021\)](#). Each researcher has differences in the parameters tested and the methods used.

Research conducted by [Kusumawardani \(2018\)](#), written batik made using CNC machines is superior after production and comparison. The research was conducted with the aim of comparing different feed rates for each process such as the *klowong* process, *nembok* technique, *cecek* process, and *nglatari*. By using a wax temperature of 95°C, an optimal feedrate was obtained. For *klowong* 1500 mm/min, *nembok* 1200 mm/min, *cecek* 5000 mm/min, and *nglatari* 1200 mm/min. After being assessed by 11 batik experts (experts), it was found that the use of batik machines was superior to conventional.

Further research by [Mikra \(2020\)](#). This study shows that the production time of written batik using a CNC machine averages 655 minutes. Meanwhile, conventional batik making by batik makers has an average time of 1355 minutes. Comparison of written batik production using a CNC machine is about 2.1 times faster than conventional batik. In [Larasati's research \(2020\)](#), the overall batik time using the machine is on average 29.97% faster than conventional batik. The calculation time starts from setup, *klowong* (10.15% faster), and *sawut* (45.27% faster). In [Anugerah's research \(2021\)](#), the researcher found a feedrate of 550 mm/min, wax type 2, and nozzle size 3 for the *klowong* process and a feedrate of 1500 mm/min, wax type 3, and nozzle size 2 for the *sawut* process. In terms of wax

usage, Machine Batik uses 10.08% more than conventional Batik due to the repetition of the feeding motion on the same segment.

Research conducted by [Kusumawardhani \(2018\)](#) and [Mikra \(2020\)](#) used the feedrate variable of the CNC Batik machine canting as the test factor. Meanwhile, research conducted by [Marsel \(2019\)](#), [Larasati \(2020\)](#), and [Prasetya \(2020\)](#) used a combination of two variables consisting of feedrate, wax type, wax temperature, and nozzle size. All of these studies used different batik motifs with the aim of comparing the quality of batik results using CNC machines and batik using human hands with expert judgment and ANOVA methods. Meanwhile, research conducted by [Anugerah \(2021\)](#) used the factors of feedrate, wax type, and nozzle size and used the Taguchi - GRA method to assess the quality of Batik. The research shows that the machine can make batik faster but with maintained batik quality.

From some of the literature reviews above, researchers can determine the position of this research. This research will focus on the production of *Batik Tulis* using CNC Batik machine. The difference between this research and previous research lies in the number of factors and the Design of Experiment approach used (Full Factorial). The purpose of this research is to find the optimal parameters to produce batik. In addition, this study will use a combination of open loop and closed loop patterns in batik pattern making. This pattern type is different from the [Anugerah \(2021\)](#) pattern which uses a closed loop pattern type. An open loop pattern is a pattern where the starting point and stopping point will not be in the same coordinate. While the closed loop pattern is a pattern where the starting point and stopping point will be in the same coordinates or the end point will be in the groove that has been travelled before. Then for the batik motif that will be used is a contemporary motif that differs in pattern and type of looping from previous research.

2. Literature Review

In this research, the objects to be observed consist of conventional batik making activities using hands & canting and batik making using CNC batik machine. According to [Hamzuri \(1985\)](#), the batik process consists of the preparation process and the batik process. In this study, to define the process, benchmarking was used. Benchmarking is a systematic search for the best methods, innovative ideas, or effective procedures ([Besterfield et al., 2012](#)). In detail, these stages consist of *ngirah*, *mola*, *klowong*, *ngiseni*, *nerusi*, *nembok*, colouring, *medel* & *bironi*, *nglorod*, and drying. This research focuses on the *klowong*, *ngiseni* and *nembok* processes, because they have a dominant percentage of working time in the batik process. The *klowong* process is the incision of wax following the main pattern that has been drawn on the fabric. The *ngiseni* process is the process of incising wax on the batik filling motif that has been made. This process uses small canting according to the type of *isen*. The *nembok* process is the process of incising wax on parts of the fabric that do not want to be coloured. The data needed in this research is a comparison between the conventional batik motif "Balance" and the batik process using CNC results. The benchmarking process is carried out on the process, time, and quality of the batik results from the two methods. The conventional process will be carried out by three craftsmen with more than or equal to 10 years of experience located in the Special Region of Yogyakarta. The comparison of batik time will be limited to the *Klowong* process, *Isen* process, and *nembok* process. The quality comparison will be conducted using the expert judgement method using a scaled questionnaire. In addition, a comparison will be made of the wax used by weighing the fabric, as well as a comparison of the thickness and translucency of the lines using Root Mean Square Deviation (RMSD) and Standard Deviation (SD) calculations.

2.1 Conventional hand-made batik

Conventional batik is used as a comparison for the results of batik using a machine. There are many tools and materials for batik writing using conventional methods. The batik process is done by hand by craftsmen using tools and materials such as: oil stove, small pan, small stove, small chair, canting, *gawangan*, mori fabric, liquid wax, and dye.

2.2 Machine-made batik

The object of this research is the production process of contemporary batik motifs using CNC batik machines on fabrics that are 250 cm long and 115 cm wide. CNC programming uses two types of modes, namely incremental and absolute types ([Krar & Gill, 1999](#)). The machine used in the research is a three-axis CNC for the needs of the batik process, where the machine is added with canting and batik wax heater. The process is carried out on a 250 cm x 115

cm Mori fabric with a drawing field measuring 240 cm x 100 cm to draw batik motifs. The entire machining process was carried out at Butimo Batik in Pajangan, Bantul, Yogyakarta Special Region. The tools used in this research are CNC Batik machine, fabric frame, CNC Batik machine canting nozzle, CNC Batik machine canting heater, infrared thermometer, stopwatch, stapler, camera, calliper, scales, assessment questionnaire sheet, CorelDraw X8, Inkscape, Artsoft Mach3, and Minitab software and Mitutoyo microscope. Then the materials used in this research are 250 cm x 115 cm mori fabric, 250 cm x 150 cm synthetic velvet fabric, batik wax, and batik dye.

There are several stages that are passed when conducting this research to determine the best parameters in batik making using a CNC batik machine.

2.2.1 Determination of Batik Motifs

The first step is the planning and motif selection stage. The batik process in this study uses a new creation contemporary batik motif designed by the researcher. The selection of this contemporary batik motif aims to follow the development of the latest batik motifs that tend to use modern pattern shapes. This batik motif is designed in such a way that the process will involve *klowong*, *nembok*, and *sawut* processes where the combination of these processes has never been done in previous studies. The entire motif design process was carried out using CorelDraw X8 vector design software.

2.2.2 Data Collection of Conventional Written Batik

Written batik was made as many as three fabrics with the size of each fabric that was given a motif of 2.4 m x 1.10 m on a fabric measuring 2.5 m x 1.15 m by three different craftsmen in Lendah District, Kulon Progo Regency, Yogyakarta Special Region. The selection of batik artisans was done by selecting three artisans who fulfil the minimum requirements of more than ten years of batik experience and have worked in the batik industry for more than ten years, to determine batik artisans who are experts and experienced.

2.2.3 Vector-Based Batik Design

The design of batik motifs was made using CorelDraw X8 software. The drawn motifs include *klowong* lines that form the outermost line, *sawut* lines, and *tembokan* that fill the batik motif. The batik motifs that have been drawn by batik artisans before this step will be captured in high quality. The photo that has been taken will then be inputted and resized to 250 cm x 100 cm and placed on the canvas. The image is formed with a three-point curve. Save the image in .svg format, then convert the format into G-Code. The G-Code formation is done with the help of Inkscape software. The finished vector will be exported into G-code which will be inputted into the batik CNC machine. The motif creation is divided into two layers, where the bottom layer is *klowong*, then above it is filling, and above it is *nembok*.

2.2.4 Simulation with CAMotics Software

After the g-code file is saved, the file is simulated into the CAMotics software to see the estimated production time and see whether the gcode is wrong in the rendering process. In CAMotics, there are estimation time features to estimate time and tracing to follow patterns.

2.2.5 Determination of Experiment Design

The parameters that will be optimised in making *batik tulis* using a CNC batik machine are wax temperature, fabric type, and nozzle size. These parameters are determined because they affect the final quality of the batik, such as line width and wax penetration. The experiment is conducted using 2 types of fabric, two types of wax and two variations of nozzle size, where each combination will be replicated three times, making a total of 24 parts.

The canting sizes used are size one (hole diameter 1-1.25 mm) & two (hole diameter 1.25-1.5 mm) for *isen* and three (hole diameter 1.5-1.75 mm) & two for *klowong*. The Design of Experiment method used is the full factorial method with 3 factors and 2 levels with replication three times to increase accuracy. Then the results were measured for the penetration and continuity of line thickness by applying the concepts of Root Mean Square Error and Standard Deviation.

2.2.6 Measurement of Line Thickness Dimension

The results of the experimental run that have been printed then measured the thickness of the line using a digital calliper with an accuracy of 0.01 mm. Measurements were made on the top and bottom surfaces of the fabric. The response taken is the value of the permeability of the wax represented by the Root Mean Square Deviation (RMSD)

value and the continuity of the line thickness represented by the Standard Deviation (SD) value. The measurement of *klowong* and *isen* line dimensions will be done at 10 points.

2.2.7 Determination of Optimal Parameters

The parameters that will be optimised in making hand-drawn batik using a CNC batik machine are fabric type, nozzle size, and wax temperature. The determination of these parameters is done because these three parameters affect the final quality of batik, such as the width of the lines and the translucency of the wax. The determination is done with Full Factorial DOE analysis. Determination of DOE using 2 types of fabric, 3 nozzle sizes, and 2 variations of wax temperature, where each combination will be replicated three times, so there are 48 parts in total. Then the results of the DOE run will be measured the thickness of the line with a digital calliper, the results will be averaged and analysed using SPSS. In SPSS, it is tested in ANOVA to determine the significance of certain factors on the research response.

2.2.8 Batik Writing Production Process Using CNC Batik Machine

The batik making process is carried out at Butimo Batik, Pajangan, Bantul, Yogyakarta Special Region. The production of hand-written batik uses a batik CNC machine type FTS-4332. CNC machine control is carried out with the help of Artsoft Mach3 software including G-Code file input and optimal parameter settings. In the written batik production process, the time of batik production is measured for each type of *klowongan*, *sawut*, and *nembok* batik.

2.2.9 Data Collection on the Quality of the Result

In this step, the quality assessment of three conventional batik machines and three CNC batik machines is carried out using the expert judgment method in the form of a questionnaire to 3 experts with the criteria of at least 10 years of experience in the field of hand-written batik. The Expert Judgement method is a process whereby an expert provides data as a response to a technical problem (Meyer & Booker, 2001). The attributes in the questionnaire are batik quality criteria according to the Indonesian National Standard (SNI). After obtaining an assessment from the three experts, further analysis was carried out to compare the quality of batik making between conventional and CNC batik machines.

3. Results

The making of new contemporary batik motifs is divided into several types of batik, namely: *klowong*, *isen*, and *tembok*. Each craftsman works on one mori fabric. *Klowong* is made first to facilitate the making of the wall because the outer boundaries of the wall are clearly visible from the *klowong* wax. Figure 1 shows the visualisation of the process.



Figure 1. Results of conventional batik making

When making conventional batik, the time required to complete the batik was recorded. The calculated time includes the *klowong*, *isen*, and *tembokan* stages as shown in Appendix 1. In determining the optimal parameters, the full factorial design method was used in the Design of Experiment of this research. The factors tested are wax temperature, fabric type, and nozzle size where each factor has 2 levels. Each combination will be replicated 3 times. The DOE combinations were applied to the *klowong* and *isen* stages as shown in Appendix 2.

- *Klowongan* Trial

In the *klowong* type of batik, experiments were conducted with wax temperature starting from 105 °C and nozzle size 2. The experiment was carried out by increasing the temperature and changing the nozzle size on fabric 1 until a thickness and line thickness close to conventional batik were obtained. The results of the DOE and its replications can be seen in Appendix 3. From each DOE replication, measurements of the width of the lines in each pattern on the front side and back side of the motif were taken using a digital calliper that has a relatively high accuracy of 0.01 mm (Appendix 4).

- *Isen* Trial

In the *isen* batik type, experiments were conducted with wax temperature starting from 105 °C and nozzle size 1. The experiment was carried out by increasing the temperature and changing the nozzle size on fabric 1 until the thickness and translucency of the lines were obtained that were close to conventional batik. The results of the DOE and its replications can be seen in Appendix 5. From each DOE replication, the width of the lines in each pattern on the front side and back side of the motif was measured (Appendix 4) using a digital calliper.

3.1 Data Normality Test

The data tested in appendix 7 is the average line thickness from each of the 48 experiments. From the graphical results that can be seen from Appendix 10 and Appendix 14, it can be seen that all data are normally distributed. The significance value in the Shapiro Wilk test is more than 0.05. Therefore, it can be interpreted that the model fails to reject H0. This means that the data that has been collected can be used in this study and proceed to the next stage.

3.2 Data Homogeneity Test

The results of the calculation of the homogeneity test of variance can be seen in Appendix 11 and Appendix 15. From the results of the graph, the data fulfils the requirements of the homogeneity test where the p value is smaller than 0.05 which can be interpreted that the data does not have homogeneity. This means that the test time group data for each process that has been collected does not have homogeneity of variance with each other and can be used in this study and proceed to the next stage.

3.3 Significance Test

Through simultaneous analysis using Two-Way ANOVA, the results can be seen in Appendix 12 and Appendix 16. For the data of "Wax Temperature", "Nozzle Size", "Fabric Type" as well as the combination between factors that have significance less than 0.05. Thus, there are significant differences. Therefore, it can proceed to the Post Hoc test to find out which level has significance from other levels,

3.4 Post Hoc Test

Further tests were conducted using the Bonferroni method. Appendix 8 shows the location of significant differences in batik quality values in different pairs of wax temperature, nozzle size and fabric type. The calculation results can be seen in Appendix 13 and Appendix 10. From the data in Appendix 8, it can be interpreted that each temperature variation, nozzle size variation, and fabric type variation against each other in both *klowong* and *isen* are significantly different, because we have p-value less than 0.05.

3.5 Result with CNC Machine

Written batik with a new contemporary motif was produced as many as 6 fabrics (3 mori and 3 velvet fabrics) each measuring 2.5 x 1.15 m and 2.5 x 1.5 m using a CNC machine in Butimo, Bantul, Yogyakarta. The parameters used in producing batik based on the results of the experiment using Full Factorial Design are wax temperature 115°C & nozzle size number 3 for *klowong* on fabric 1 and fabric 2. Then wax temperature 115°C & nozzle size number 2 for *isen* on fabric 1 and fabric 2. All work on the machine used a feed rate of 1000 mm/minute.



Figure 2. CNC machining of fabric 1 (mori)

In batik using the machine, the batik time data is obtained as in Appendix 9. The overall batik time for machine work has an average of 316 minutes. Then for the results of batik using mori fabric seen in Figure 2 and the results of batik on velvet fabric seen in Figure 3.



Figure 3. CNC machining of fabric 2 (synthetic velvet)

The *klowong* and *isen-isen* produced through Full Factorial Design are assessed based on seven batik quality criteria, namely, wax bleed (A1), line neatness (A2), line continuity (A3), line thickness continuity (A4), pattern angle quality (A5), line deviation (A6), and art value (A7). Based on these criteria, the scores of *klowong* and *isen-isen* experiments can be seen in Appendix 12.

From the results of the expert assessment (Table 5), the total average value of machine-assisted batik on mori fabrics (Fabrics 1, 2, and 3) was higher than conventional batik (1', 2', and 3') and on synthetic velvet fabrics (Fabrics 4, 5, and 6). This is because in the conventional mori fabric, the batik is too rushed so that the results produced are not too neat. Then for the synthetic velvet fabric, the value is not as high as the machine-made mori fabric, which could be due to some droplets of wax that appear due to a dirty nozzle. In addition, synthetic velvet fabric is not as heat-resistant as polyester. This makes it difficult to remove wax stains when drips occur.

4. Discussions

4.1 Comparison of conventional and machine batik making

After observing the two methods, conventional and machine, a comparison is made on the time during batik making and the quality of the final batik. In addition, the production cost as well as the weight between the two methods will be compared.

4.1.1 Completion Time

The analysis of time aims to determine the capability of the machine to be an alternative to batik making. The analysis will be carried out by comparing the time of walling, *klowong*, and *isen* on batik made conventionally and by using a machine. The waste of time that can occur in CNC machining is in the non-feeding motion which is usually done when moving between one segment and another.

Table 1. Completion Time

| Process | Time (minute) | | | | | | Difference (minute) | Percentage |
|----------------------------|---------------|----------|----------|----------|----------|----------|------------------------|------------|
| | Conventional | | | Machine | | | | |
| | Fabric 1 | Fabric 2 | Fabric 3 | Fabric 1 | Fabric 2 | Fabric 3 | | |
| <i>Klowong</i> | 143.00 | 148.00 | 142.00 | 121.00 | 128.00 | 123.00 | | |
| <i>Isen</i> | 118.00 | 112.00 | 99.00 | 105.00 | 104.00 | 105.00 | | |
| <i>Nembok</i> | 28.00 | 30.00 | 25.00 | 80.00 | 93.00 | 90.00 | | |
| Total Time | 289.00 | 290.00 | 266.00 | 306.00 | 325.00 | 318.00 | | |
| Average total | 281.67 | 281.67 | 281.67 | 316.33 | 316.33 | 316.33 | | |
| Avg time of <i>klowong</i> | | 143.00 | | | 121.00 | | 22.00 | 15.38% |
| Avg time of <i>Isen</i> | | 109.67 | | | 105.00 | | 4.67 | 4.26% |
| Avg time of <i>Nembok</i> | | 27.67 | | | 80.00 | | 52.33 | 189.16% |

A comparison of the batik process time between the two methods is presented in Table 1. The time taken by the machining process for the *klowong* and *isen* processes separately is faster than the conventional process by 121 minutes and 105 minutes, respectively. Overall, the batik process time using the CNC Batik machine is 22 minutes faster for the *klowong* process and 4.67 minutes for the *isen* process or about 22% and 4.2% of the conventional process time. However, the *tembakan* process takes much longer, around 80 minutes or almost 190% longer than the conventional process.

This percentage is relatively small when compared to the percentage obtained in previous studies, namely 39%, 18%, 51.66%, and 29.97%, but it is still superior to previous studies, namely, 9%, and in the [Marsel's research \(2019\)](#) where the percentage touched -49% ([Anugerah, 2021](#); [Mikra, 2020](#); [Larasati, 2020](#)). The difference in the value of the time advantage obtained is estimated to occur because the motifs designed are not as complex as the motifs used in previous studies so that conventional Batik craftsmen can easily memorise and familiarise themselves with existing patterns.

4.1.2 Weight of Batik Wax

The wax used in both conventional and CNC machines is calculated by finding the difference in the mass of the fabric that has been made into batik minus the mass of the plain fabric. The weight of the plain fabric for each fabric is 543 grams. The following Table 2 shows the comparison of the wax used in conventional and CNC machines. From the calculation of the weight of the wax in Table 2, it is found that batik using a machine provides savings of 33.75%.

Table 2. Wax Weight Comparison

| Fabric | Wax Mass (gram) | |
|----------|-----------------|---------|
| | Conventional | Machine |
| Fabric 1 | 116,95 | 72,54 |
| Fabric 2 | 137,72 | 80,81 |
| Fabric 3 | 84,37 | 71,24 |
| Average | 113,01 | 74,86 |

4.1.3 Production Cost

In making Batik, there are various kinds of costs incurred, both direct and indirect costs. In this study, the cost components are divided into three types, namely, material costs (consisting of wax and fabric), labour costs (consisting of operators for machines and batik makers and sketchers for conventional), Overhead costs consist of costs that are not directly related but support the course of production (Kerosene and electricity). The production price of a written batik will have an impact on the sale of written batik products. This is related to price competition in the market.

Table 3. Production costs using conventional.

| No | Cost | Description | Amount | Unit | Unit Cost | Total Cost |
|----------------------|-------------|--|--------|-------|-------------|--------------|
| Material Cost | | | | | | |
| 1 | Wax | Each fabric requires 113 grams of wax | 113.01 | gram | Rp88.49 | Rp10,000.00 |
| 2 | Fabric Mori | 250 x 115 cm prime mori fabric | 1 | piece | Rp20,000.00 | Rp20,000.00 |
| Labour Cost | | | | | | |
| 3 | Batik Maker | Cost of 1 batik maker to finish 1 fabric | 4.69 | hour | Rp23,431.95 | Rp110,000.00 |
| 4 | Sketcher | There is 1 Sketcher | 1 | piece | Rp15,000.00 | Rp15,000.00 |
| Overhead Cost | | | | | | |
| 5 | Karosene | 1 bag of kerosene for 1 fabric | 1 | bag | | Rp7,000.00 |
| TOTAL COST | | | | | | Rp162,000.00 |

Table 4. Production costs using machine.

| No | Cost | Description | Amount | Unit | Unit Cost | Total Cost |
|----------------------|-------------|--|--------|-------|-------------|-------------|
| Material Cost | | | | | | |
| 1 | Wax | Each fabric requires 75 grams of wax | 74.86 | gram | Rp35.00 | Rp2,620.22 |
| 2 | Fabric Mori | 250 x 115 cm prime mori fabric | 1 | piece | Rp20,000.00 | Rp20,000.00 |
| Labour Cost | | | | | | |
| 3 | Operator | Regional Minimum Wage Bantul 2022 Rp 1,916,848.00 | 5.27 | Hour | Rp9,982.54 | Rp54,918.98 |
| 4 | Sketch | Regional Minimum Wage Bantul 2022 Rp 1,916,848.00 | 4 | Hour | Rp9,982.54 | Rp41,666.67 |
| Overhead Cost | | | | | | |
| 5 | Electricity | the machine requires 5.5 kwh | 5.27 | Hour | Rp1,444.70 | Rp7,616.78 |
| Depreciation | | | | | | |
| 6 | Machine | machine depreciation 25000 per day (8 hours working day) | 5.27 | hour | Rp3,125.00 | Rp16,468.75 |

TOTAL COST

Rp143,291.39

In doing this calculation, the author takes the point of view as the owner of a batik handicraft industry where he has hand and machine batik workers and operators. So that in this cost calculation does not pay attention to the value of depreciation, maintenance, etc. From Table 3 and Table 4, it is found that the cost of making new contemporary batik motifs as in this study is 11.55% more efficient. Cheaper production prices make the market more competitive.

4.1.4 Quality Comparison

The quality assessment of hand-written batik is carried out by direct expert judgment method in the form of a questionnaire containing the quality attributes of Indonesian National Standard batik. The quality assessment was carried out by experts from the Indonesian Batik Lovers Association (PPBI) Sekar Jagad Yogyakarta and experts from the Centre for Handicrafts and Batik of the Ministry of Industry. The six written batiks were randomised and not annotated with conventional batik or CNC machines to avoid bias in the assessment. Appendix 8 shows the average quality assessment of each attribute of conventional and CNC machine-made batik.

Table 5. Summary of Expert judgement

| No | Quality Attributes | Score | | | | | | | | | |
|----|--------------------------------|--------------------|-------|-------|--------------------|-------|-------|-------|-------|-------|--|
| | | Conventional Batik | | | Machine-made Batik | | | | | | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | Wax Breakout | 4.67 | 2.00 | 3.67 | 5.00 | 5.00 | 4.00 | 2.33 | 4.00 | 3.00 | |
| 2 | Line Neatness | 4.00 | 2.00 | 3.67 | 5.00 | 4.00 | 3.67 | 2.67 | 3.33 | 4.00 | |
| 3 | Line Continuity | 4.00 | 2.33 | 3.67 | 3.67 | 4.33 | 4.00 | 2.00 | 3.33 | 4.00 | |
| 4 | Line Thickness Continuity | 3.00 | 3.00 | 3.67 | 4.00 | 3.67 | 4.00 | 2.33 | 3.67 | 3.33 | |
| 5 | Pattern Angle Quality | 3.33 | 3.67 | 3.00 | 3.00 | 4.33 | 4.33 | 2.67 | 3.33 | 3.67 | |
| 6 | The quality of <i>Tembokan</i> | 2.33 | 4.00 | 3.67 | 2.33 | 4.00 | 3.33 | 2.33 | 4.00 | 3.67 | |
| 7 | The Quality of <i>Isen</i> | 2.00 | 3.00 | 3.00 | 2.33 | 3.67 | 3.00 | 2.00 | 4.00 | 3.33 | |
| 8 | Line Deviation | 2.67 | 2.00 | 3.67 | 2.00 | 3.33 | 3.00 | 2.33 | 3.33 | 3.33 | |
| 9 | Overall Assessment | 3.00 | 2.67 | 3.33 | 3.00 | 4.00 | 4.00 | 2.67 | 4.00 | 3.67 | |
| 10 | Art Value | 2.67 | 4.00 | 3.33 | 3.00 | 4.00 | 3.67 | 2.00 | 4.00 | 3.67 | |
| | Score per Fabric | 31.67 | 28.67 | 34.67 | 33.33 | 40.33 | 37.00 | 23.33 | 37.00 | 35.67 | |
| | Average Score per Fabric | 3.17 | 2.87 | 3.47 | 3.33 | 4.03 | 3.70 | 2.33 | 3.70 | 3.57 | |
| | Total Average | | 3.17 | | | 3.69 | | 3.20 | | | |

Then the significance test of the average value per fabric between conventional batik and CNC machines was carried out using One Way Anova with Minitab 18 software. The batik assessment data was first tested for normality using the Shapiro Wilk Test. The results of the normality test resulted in a P-value for each batik that is more than 0.05 which means it fails to reject H₀ as shown in Appendix 20, so the conclusion obtained is that the batik assessment data is normally distributed. The One-Way Anova test results as shown in Appendix 20 show a P-value of 0.124 for conventional against machine and 0.369 for mori fabric machine against synthetic velvet fabric machine which means it has a value of more than 0.05 which means it fails to reject H₀, so there is no significant difference between the assessment of conventional batik and CNC batik machine.

4.2 Comparison of batik between fabric types

In this research, one parameter of fabric type is used. The fabric types used are natural fibre (Mori fabric) and synthetic fibre/polyester (synthetic velvet fabric). The price of the fabric used is selected which has the same price of Rp 20,000 per 1 metre length. To quantify the two types of fabric using the fabric fibre density parameter. This fabric fibre density measurement uses a Mitutoyo Microscope located at the UGM DTMI Procession Laboratory. From the vision using the microscope, it was found that the number of fibres in the mori fabric was more tenuous than the number of fibres in the synthetic velvet fabric (Figure 4).

Table 6. Comparison of Wax Mass between Fabrics

| Fabric | Wax Mass (gram) | |
|----------|----------------------|-------|
| | Conventional Machine | |
| Fabric 1 | 116.95 | 72.54 |
| Fabric 2 | 137.72 | 80.81 |
| Fabric 3 | 84.37 | 71.24 |
| Average | 113.01 | 74.86 |

In the cross-sectional images of velvet and mori fabrics, the microscope shows a screen size of 3.2 x 4.2 mm. Then for the mori fabric, a total of 23 vertical fibres and 8 horizontal fibres are visible on the screen. So that in 1 cm² area has 72 vertical fibres and 19 horizontal fibres. Furthermore, for synthetic velvet fabric, using the same tool with the same magnification, the number of fibres in it cannot be counted. This happened because the distance between the fibres was too tight, making it difficult for light to penetrate. Then an increase in magnification was made to try to count the fibres, but still could not be counted. This is because the structure of this synthetic velvet fabric is layered, causing the microscope light to not be able to help the fibres to be seen. In addition, the final results obtained after the dyeing process (Appendix 19), show that the colour on the mori fabric is more pervasive than the velvet fabric, making the colour more even and sharp. This is due to the difference in fabric fibre density and the different characteristics of the constituent fibres.

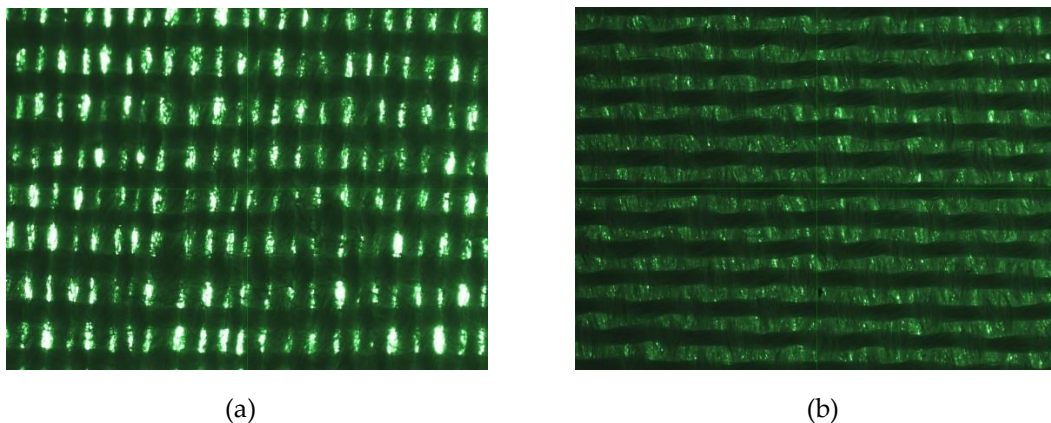


Figure 4. (a) Mori Fabric Fibres; (b) Velvet Fabric Fibres

In machine-assisted batik on both the mori and synthetic velvet fabrics, the amount of wax used on each fabric was calculated. The results were obtained as in Table 6. The table shows that the use of wax on both mori and synthetic velvet fabrics has relatively the same amount. Although it has a difference value of 1.27%, one of which is caused by the presence of droplets when working using a machine. The occurrence of these droplets occurs due to dirt that clogs the nozzle, so that the stopper on the nozzle cannot close perfectly.

5. Conclusion

Based on the results of the research that has been carried out, it can be concluded that a contemporary patterned batik with the theme "Balance" was successfully made using a CNC Batik machine. The whole process includes designing *klowongan* motifs and *isen* motifs and walls. The sequence of work has been adjusted to the conventional batik process by benchmarking. The motif design and G-code generation were done digitally using CorelDraw X8 and Inkscape software. Direct machining is then controlled using specialised CNC control software called Artsoft Mach3. The optimal parameters used to produce batik for mori fabrics are 115 °C wax temperature & nozzle size 3 for the *klowong* process and 115 °C wax temperature & nozzle size 2 for the *isen* process. Then for the velvet synthetic fabric type, the wax temperature is 115 °C & nozzle size 3 for the *klowong* process and the wax temperature is 115 °C & nozzle size 2 for the *isen* process. These results were then successfully validated by expert judgement which is not significantly different when compared to conventional Batik.

The fastest conventional batik production time is 266 minutes done by hand-written batik craftsmen with \pm 30 years of experience and the longest is 290 minutes done by hand-written batik craftsmen with \pm 20 years of experience. The average production time of conventional hand-written batik is 281.67 minutes. The time of making batik using the machine as a whole, from setup, *klowong* on average 15.38%, *isen* on average 4.26% faster than conventional batik making. However, for the wall process, it is 189% longer than conventional batik making.

The measurement results show that Machine Batik has a wax penetration and thick line continuity that is not much different from conventional Batik. In terms of wax usage, conventional Batik uses 33.75% more wax than Machine Batik. Machine batik requires lower production costs compared to conventional batik. The production cost of batik fabric using a machine is IDR 143,291.39, while conventional batik is IDR 162,000.00.

The comparison of batik using mori fabric (natural fibre and low density) against synthetic velvet fabric (polyester fibre and high density) produced different results. In Appendix 13 with the same treatment in both dyeing and batik, the final results are different. Making batik using synthetic and natural fabrics has an insignificant difference in the use of wax. This can be seen from the amount of wax use that is 1% adrift. One of the causes is the presence of wax droplets during the non-feeding movement.

Suggestions for further research based on the researcher's experience, it is important to pay attention to the tension and flatness of the fabric when installing the mori fabric on the wooden frame, because this greatly affects the final quality of the batik. Then the need to clean the nozzle, wax equipment, and canting, so that the wax liquid flows smoothly, so that the continuity of the resulting lines can be good. The need for further research aimed at looking at the interaction between variables such as feedrate, type of wax and wax temperature, against other media. Further research is needed to reduce the non-feeding movement in the process of batik making with CNC Batik machines. Non-feeding movement is a non-value-added movement that can be shortened so that the machining time can be faster. A better method is needed to quantify the fibre density of the fabric. So that the results of the analysis become more accurate.

Acknowledgments. I would like to thank all the employees and owners of Batik Butimo for the opportunity to conduct research using its tools and materials. I would also like to thank all the employees of Balai Batik and PPBI Sekar Jagad who have helped in conducting expert judgment on the results of this research.

Declaration of Conflicting Interests. The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendix

Appendix 1

Table 7. Time Conventional batik making

| Process | Time (minute) | | |
|----------------|---------------|--------------|--------------|
| | Craftsmen 1 | Craftsmen 2 | Craftsmen 3 |
| <i>Klowong</i> | 143 | 148 | 142 |
| <i>Isen</i> | 118 | 112 | 99 |
| <i>Nembok</i> | 28 | 30 | 25 |
| Total | 289 | 290 | 266 |
| Average | 96.33 | 96.67 | 88.67 |

Appendix 2

Table 8. *Klowong* DOE Combination

| Experiment | Wax Temp (°C) | Size of Nozzle | Fabric Type |
|------------|---------------|----------------|-------------|
| 1 | 105 | 2 | 1 |
| 2 | 105 | 3 | 2 |
| 3 | 105 | 2 | 2 |
| 4 | 105 | 3 | 1 |
| 5 | 115 | 2 | 1 |
| 6 | 115 | 3 | 2 |
| 7 | 115 | 2 | 2 |
| 8 | 115 | 3 | 1 |

Table 9. *Isen* DOE Combination

| Experiment | Wax Temp (°C) | Size of Nozzle | Fabric Type |
|------------|---------------|----------------|-------------|
| 1 | 105 | 1 | 1 |
| 2 | 105 | 2 | 2 |
| 3 | 105 | 1 | 2 |
| 4 | 105 | 2 | 1 |
| 5 | 115 | 1 | 1 |

| | | | |
|---|-----|---|---|
| 6 | 115 | 2 | 2 |
| 7 | 115 | 1 | 2 |
| 8 | 115 | 2 | 1 |

Appendix 3

Table 10. Result of *Klowong* Process

























| Exp | Parameter Combination Wax Tempt/ Nozzle size/ Fabric Type | Experiment Result | | |
|-----|--|---|--|---|
| | | Replication 1 | Replication 2 | Replication 3 |
| 1 | 105/ 2/ 1 |  |  |  |
| 2 | 105/ 3/ 2 |  |  |  |
| 3 | 105 /2 /2 |  |  |  |

Table 11. Result of *Klowong* (Continued)

| Exp | Parameter Combination | Experiment Result | | |
|-----|---|---|--|---|
| | Wax Tempt/ Nozzle size/ Fabric Type | Replication 1 | Replication 2 | Replication 3 |
| 4 | 105/ 3/ 1 |  |  |  |
| 5 | 115/ 2/ 1 |  |  |  |
| 6 | 115/ 3/ 2 |  |  |  |
| 7 | 115/ 2/ 2 |  |  |  |
| 8 | 115/ 3/ 1 |  |  |  |

Appendix 4

Table 12. *Klowong* Front- and Back-Line Thickness Results

| Exp | Measurement | Replication Front Side (mm) | | | Replication Back Side (mm) | | |
|-----|-------------|-----------------------------|------|------|----------------------------|------|------|
| | | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | 1 | 1.38 | 1.4 | 1.4 | 1.29 | 1.2 | 1.19 |
| | 2 | 1.37 | 1.41 | 1.41 | 1.46 | 1.21 | 1.28 |
| | 3 | 1.35 | 1.39 | 1.4 | 1.33 | 1.26 | 1.27 |
| 2 | 1 | 1.66 | 1.43 | 1.56 | 0.9 | 1.37 | 1.2 |
| | 2 | 1.65 | 1.52 | 1.57 | 1.3 | 1.3 | 1.28 |
| | 3 | 1.56 | 1.53 | 1.55 | 1.07 | 1.35 | 1.34 |
| 3 | 1 | 1.45 | 1.35 | 1.49 | 1.35 | 1.2 | 1.39 |
| | 2 | 1.39 | 1.33 | 1.3 | 1.22 | 1.19 | 1.22 |
| | 3 | 1.4 | 1.44 | 1.37 | 1.2 | 1.15 | 1.21 |
| 4 | 1 | 1.7 | 1.63 | 1.64 | 1.62 | 1.29 | 1.5 |
| | 2 | 1.78 | 1.67 | 1.69 | 1.53 | 1.3 | 1.52 |
| | 3 | 1.6 | 1.61 | 1.6 | 1.54 | 1.24 | 1.45 |
| 5 | 1 | 1.49 | 1.53 | 1.52 | 1.62 | 1.34 | 1.4 |
| | 2 | 1.7 | 1.6 | 1.59 | 1.64 | 1.59 | 1.45 |
| | 3 | 1.59 | 1.63 | 1.6 | 1.65 | 1.7 | 1.47 |
| 6 | 1 | 1.79 | 1.61 | 1.65 | 1.52 | 1.5 | 1.55 |
| | 2 | 1.9 | 1.71 | 1.67 | 1.35 | 1.49 | 1.58 |
| | 3 | 1.7 | 1.7 | 1.68 | 1.34 | 1.59 | 1.6 |
| 7 | 1 | 1.48 | 1.56 | 1.6 | 1.21 | 1.4 | 1.44 |
| | 2 | 1.45 | 1.49 | 1.5 | 1.27 | 1.44 | 1.4 |
| | 3 | 1.49 | 1.57 | 1.51 | 1.2 | 1.41 | 1.39 |
| 8 | 1 | 1.8 | 1.7 | 1.6 | 1.82 | 1.72 | 1.58 |
| | 2 | 1.73 | 1.8 | 1.7 | 1.53 | 1.6 | 1.67 |
| | 3 | 1.87 | 1.9 | 1.75 | 1.48 | 1.74 | 1.73 |

Appendix 5

Table 13. Result of *Isen*
























| Exp | Parameter Combination | Experiment Result | | |
|-----|---|---|--|---|
| | | Replication 1 | Replication 2 | Replication 3 |
| 1 | Wax Temp/ Nozzle size/ Fabric Type 105/ 1/ 1 |  |  |  |
| 2 | 105/ 2/ 2 |  |  |  |
| 3 | 105 /1/ 2 |  |  |  |
| 4 | 105/ 2/ 1 |  |  |  |

Table 14. Result of *Isen* (continued)

| Exp | Parameter Combination | Experiment Result | | |
|-----|--|---|--|---|
| | Wax Temp/ Nozzle size/ Fabric Type | Replication 1 | Replication 2 | Replication 3 |
| 5 | 115/ 1/ 1 |  |  |  |
| 6 | 115/ 2/ 2 |  |  |  |
| 7 | 115/ 1/ 2 |  |  |  |
| 8 | 115/ 2/ 1 |  |  |  |

Appendix 6

Table 15. *Klowong* Front- and Back-Line Thickness Results

| Exp | Measurement | Replication Front Side (mm) | | | Replication Back Side (mm) | | |
|-----|-------------|-----------------------------|------|------|----------------------------|------|------|
| | | 1 | 2 | 3 | 1 | 1 | 2 |
| 1 | 1 | 0.94 | 0.8 | 0.9 | 0.75 | 0.8 | 0.77 |
| | 2 | 0.87 | 0.79 | 0.89 | 0.73 | 0.79 | 0.76 |
| | 3 | 0.85 | 0.85 | 0.91 | 0.64 | 0.78 | 0.78 |
| 2 | 1 | 1.44 | 1.43 | 1.45 | 1.4 | 1.14 | 1.08 |
| | 2 | 1.4 | 1.39 | 1.44 | 1.11 | 1.09 | 1.08 |
| | 3 | 1.45 | 1.42 | 1.4 | 1.12 | 1.11 | 1.11 |
| 3 | 1 | 1.29 | 1.12 | 1.17 | 0.94 | 1.02 | 1 |
| | 2 | 1.22 | 1.23 | 1.22 | 1 | 0.95 | 1.06 |
| | 3 | 1.1 | 1.18 | 1.24 | 1.02 | 1.09 | 1.07 |
| 4 | 1 | 1.6 | 1.52 | 1.56 | 1.4 | 1.48 | 1.45 |
| | 2 | 1.42 | 1.55 | 1.55 | 1.35 | 1.47 | 1.42 |
| | 3 | 1.5 | 1.53 | 1.57 | 1.34 | 1.49 | 1.4 |
| 5 | 1 | 1.21 | 1.23 | 1.24 | 1.15 | 1.24 | 1.2 |
| | 2 | 1.23 | 1.22 | 1.21 | 1.12 | 1.01 | 1.18 |
| | 3 | 1.1 | 1.2 | 1.22 | 1.11 | 1.06 | 1.19 |
| 6 | 1 | 1.6 | 1.5 | 1.64 | 1.26 | 1.19 | 1.51 |
| | 2 | 1.65 | 1.51 | 1.6 | 1.1 | 1.5 | 1.45 |
| | 3 | 1.62 | 1.55 | 1.5 | 1.28 | 1.55 | 1.5 |
| 7 | 1 | 1.2 | 1.3 | 1.23 | 1.16 | 1.2 | 1.15 |
| | 2 | 1.22 | 1.32 | 1.22 | 1.12 | 1.22 | 1.28 |
| | 3 | 1.23 | 1.31 | 1.29 | 1.14 | 1.25 | 1.21 |
| 8 | 1 | 1.52 | 1.47 | 1.77 | 1.51 | 1.45 | 1.44 |
| | 2 | 1.74 | 1.55 | 1.62 | 1.64 | 1.57 | 1.46 |
| | 3 | 1.79 | 1.57 | 1.65 | 1.6 | 1.44 | 1.49 |

Appendix 7

Table 16. Average Line Thickness of *Klowong* Process

| Exp | Nozzle Size | Fabric Type | Wax Temp (°C) | Replication Front Side (mm) | | | Replication Back Side (mm) | | |
|-----|-------------|-------------|---------------|-----------------------------|------|------|----------------------------|------|------|
| | | | | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | 2 | 1 | 105 | 1.37 | 1.40 | 1.40 | 1.36 | 1.22 | 1.25 |
| 2 | 3 | 1 | 105 | 1.69 | 1.64 | 1.64 | 1.56 | 1.28 | 1.49 |
| 3 | 2 | 2 | 105 | 1.41 | 1.37 | 1.39 | 1.26 | 1.17 | 1.27 |
| 4 | 3 | 2 | 105 | 1.62 | 1.49 | 1.56 | 1.09 | 1.31 | 1.27 |
| 5 | 2 | 1 | 115 | 1.59 | 1.59 | 1.57 | 1.64 | 1.54 | 1.44 |
| 6 | 3 | 1 | 115 | 1.80 | 1.80 | 1.68 | 1.61 | 1.69 | 1.66 |
| 7 | 2 | 2 | 115 | 1.47 | 1.54 | 1.54 | 1.23 | 1.42 | 1.41 |
| 8 | 3 | 2 | 115 | 1.80 | 1.67 | 1.67 | 1.40 | 1.53 | 1.58 |

Table 17. Average Line Thickness of *Klowong* Process

| Exp | Nozzle Size | Fabric Type | Wax Temp (°C) | Replication Front Side (mm) | | | Replication Back Side (mm) | | |
|-----|-------------|-------------|---------------|-----------------------------|------|------|----------------------------|------|------|
| | | | | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | 1 | 1 | 105 | 0.89 | 0.81 | 0.90 | 0.71 | 0.79 | 0.77 |
| 2 | 2 | 1 | 105 | 1.51 | 1.53 | 1.56 | 1.36 | 1.48 | 1.42 |
| 3 | 1 | 2 | 105 | 1.20 | 1.18 | 1.21 | 0.99 | 1.02 | 1.04 |
| 4 | 2 | 2 | 105 | 1.43 | 1.41 | 1.43 | 1.21 | 1.11 | 1.09 |
| 5 | 1 | 1 | 115 | 1.18 | 1.22 | 1.22 | 1.13 | 1.10 | 1.19 |
| 6 | 2 | 1 | 115 | 1.68 | 1.53 | 1.68 | 1.58 | 1.49 | 1.46 |
| 7 | 1 | 2 | 115 | 1.22 | 1.31 | 1.25 | 1.14 | 1.22 | 1.21 |
| 8 | 2 | 2 | 115 | 1.62 | 1.52 | 1.58 | 1.19 | 1.41 | 1.49 |

Appendix 8

Table 18. Post Hoc Test Result

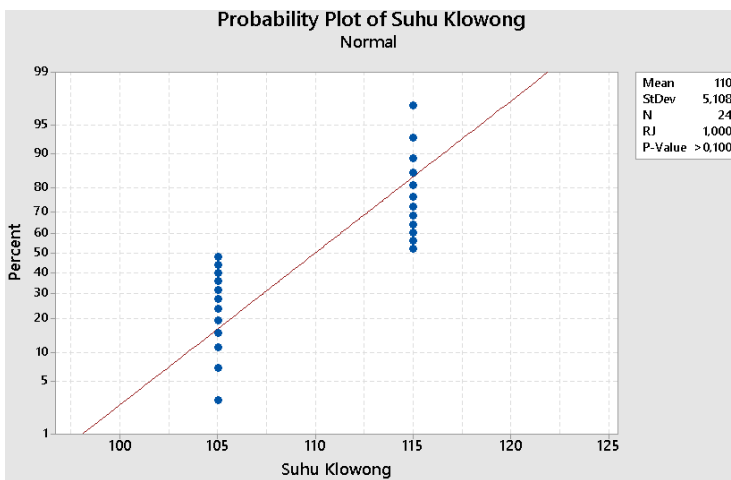
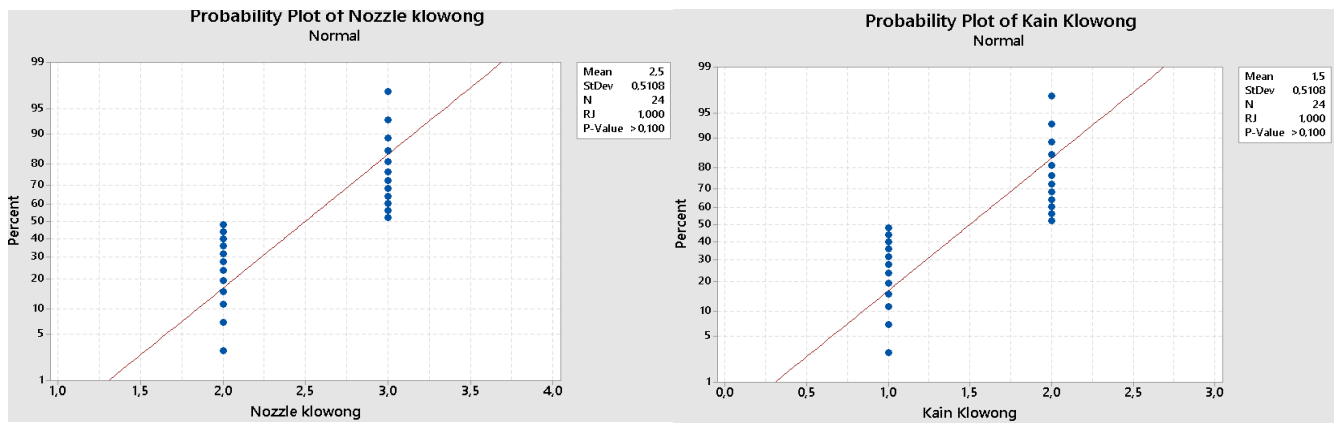
| Exp | Factor | P-value | Mean Difference |
|----------------|-------------------------|---------|-----------------|
| <i>Isen</i> | Temp 105 °C Temp 115 °C | 0.000 | -0.1622 |
| | Temp 115 °C Temp 105 °C | 0.000 | 0.1622 |
| | Nozzle 1 Nozzle 2 | 0.000 | -0.4089 |
| | Nozzle 2 Nozzle 1 | 0.000 | 0.4089 |
| | Fabric 1 Fabric 2 | 0.010 | -0.0539 |
| | Fabric 2 Fabric 1 | 0.010 | 0.0539 |
| <i>Klowong</i> | Temp 105 °C Temp 115 °C | 0.000 | -0.1439 |
| | Temp 115 °C Temp 105 °C | 0.000 | 0.1439 |
| | Nozzle 2 Nozzle 3 | 0.000 | -0.2022 |
| | Nozzle 3 Nozzle 2 | 0.000 | 0.2022 |
| | Fabric 1 Fabric 2 | 0.013 | 0.0533 |
| | Fabric 2 Fabric 1 | 0.013 | -0.0533 |

Appendix 9

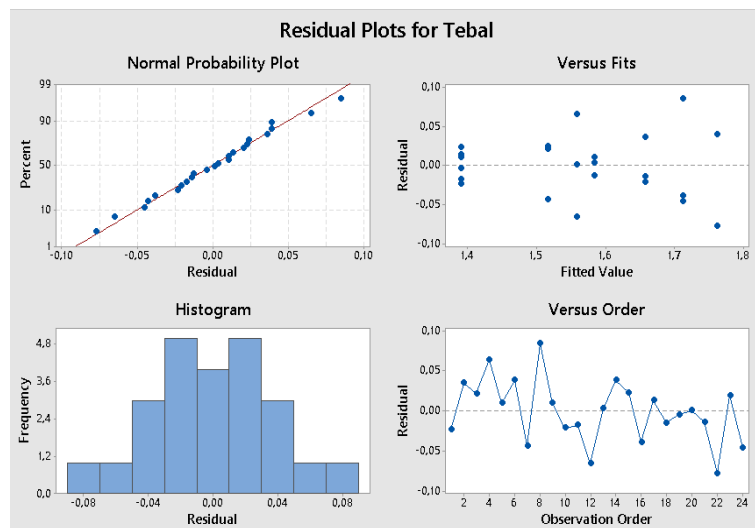
Table 19. Completion Time of Mesin CNC

| Process | Time (minute) | | |
|----------------|---------------|---------------|------------|
| | Machine 1 | Machine 2 | Machine 3 |
| <i>Klowong</i> | 121 | 128 | 123 |
| <i>Isen</i> | 105 | 104 | 105 |
| <i>Nembok</i> | 80 | 93 | 90 |
| Total | 306 | 325 | 318 |
| Average | 102 | 108.33 | 106 |

Appendix 10 Test of Normality DOE Klowong Process



| Term | Effect | Coef | SE Coef | T-Value | P-Value | VIF |
|----------|----------|----------|---------|---------|---------|------|
| Constant | | 1,57139 | 0,00954 | 164,77 | 0,000 | |
| A | 0,20222 | 0,10111 | 0,00954 | 10,60 | 0,000 | 1,00 |
| B | -0,05333 | -0,02667 | 0,00954 | -2,80 | 0,013 | 1,00 |
| C | 0,14389 | 0,07194 | 0,00954 | 7,54 | 0,000 | 1,00 |
| A*B | -0,02056 | -0,01028 | 0,00954 | -1,08 | 0,297 | 1,00 |
| A*C | -0,01556 | -0,00778 | 0,00954 | -0,82 | 0,427 | 1,00 |
| B*C | -0,00444 | -0,00222 | 0,00954 | -0,23 | 0,819 | 1,00 |
| A*B*C | 0,02944 | 0,01472 | 0,00954 | 1,54 | 0,142 | 1,00 |



Appendix 11 Test of Homogeneity *Klowong* Process

Test

Null hypothesis $H_0: \sigma_1 / \sigma_2 = 1$
 Alternative hypothesis $H_1: \sigma_1 / \sigma_2 \neq 1$
 Significance level $\alpha = 0,05$

| Test | | | | |
|--------|-----------|-----|-----|---------|
| Method | Statistic | DF1 | DF2 | P-Value |
| Bonett | 90,22 | 1 | | 0,000 |
| Levene | 626,94 | 1 | 46 | 0,000 |

Test

Null hypothesis $H_0: \sigma_1 / \sigma_2 = 1$
 Alternative hypothesis $H_1: \sigma_1 / \sigma_2 \neq 1$
 Significance level $\alpha = 0,05$

| Test | | | | |
|--------|-----------|-----|-----|---------|
| Method | Statistic | DF1 | DF2 | P-Value |
| Bonett | 90,22 | 1 | | 0,000 |
| Levene | 626,94 | 1 | 46 | 0,000 |

Test

Null hypothesis $H_0: \sigma_1 / \sigma_2 = 1$
 Alternative hypothesis $H_1: \sigma_1 / \sigma_2 \neq 1$
 Significance level $\alpha = 0,05$

| Test | | | | |
|--------|-----------|-----|-----|---------|
| Method | Statistic | DF1 | DF2 | P-Value |
| Bonett | 537,02 | 1 | | 0,000 |
| Levene | 99342,55 | 1 | 46 | 0,000 |

Appendix 12 Test of Significance & ANOVA Two Way *Klowong* Process

Tests of Between-Subjects Effects

Dependent Variable: TebakK

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|-------------------------|-------------------------|----|-------------|-----------|------|
| Corrected Model | .396 ^a | 7 | .057 | 25.218 | .000 |
| Intercept | 59.220 | 1 | 59.220 | 26369.017 | .000 |
| NozzleK | .244 | 1 | .244 | 108.653 | .000 |
| KainK | .017 | 1 | .017 | 7.599 | .014 |
| SuhuK | .126 | 1 | .126 | 56.171 | .000 |
| NozzleK * KainK | .002 | 1 | .002 | 1.069 | .317 |
| NozzleK * SuhuK | .001 | 1 | .001 | .601 | .449 |
| KainK * SuhuK | 6.667E-5 | 1 | 6.667E-5 | .030 | .865 |
| NozzleK * KainK * SuhuK | .005 | 1 | .005 | 2.404 | .141 |
| Error | .036 | 16 | .002 | | |
| Total | 59.653 | 24 | | | |
| Corrected Total | .432 | 23 | | | |

a. R Squared = .917 (Adjusted R Squared = .881)

Analysis of Variance

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|--|----|----------|----------|---------|---------|
| Nozzle klowong | 1 | 0,245363 | 0,245363 | 112,40 | 0,000 |
| Kain Klowong | 1 | 0,017067 | 0,017067 | 7,82 | 0,013 |
| Suhu Klowong | 1 | 0,124224 | 0,124224 | 56,91 | 0,000 |
| Nozzle klowong*Kain Klowong | 1 | 0,002535 | 0,002535 | 1,16 | 0,297 |
| Nozzle klowong*Suhu Klowong | 1 | 0,001452 | 0,001452 | 0,67 | 0,427 |
| Kain Klowong*Suhu Klowong | 1 | 0,000119 | 0,000119 | 0,05 | 0,819 |
| Nozzle klowong*Kain Klowong*Suhu Klowong | 1 | 0,005202 | 0,005202 | 2,38 | 0,142 |
| Error | 16 | 0,034926 | 0,002183 | | |
| Total | 23 | 0,430887 | | | |

Appendix 13 Test of Post Hoc *Klowong* Process

Grouping Information Using the Bonferroni Method and 95% Confidence

| Nozzle | klowong | N | Mean | Grouping |
|--------|---------|----|---------|----------|
| | 3 | 12 | 1,67250 | A |
| | 2 | 12 | 1,47028 | B |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Nozzle klowong | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|------------------------------|---------------------|------------------|---------------------|---------|------------------|
| 3 - 2 | 0,2022 | 0,0191 | (0,1618; 0,2427) | 10,60 | 0,000 |

Individual confidence level = 95,00%

Grouping Information Using the Bonferroni Method and 95% Confidence

| Kain | Klowong | N | Mean | Grouping |
|------|---------|----|---------|----------|
| | 1 | 12 | 1,59806 | A |
| | 2 | 12 | 1,54472 | B |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Kain Klowong Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|-----------------------------------|---------------------|------------------|---------------------|---------|------------------|
| 2 - 1 | -0,0533 | 0,0191 | (-0,0938; -0,0129) | -2,80 | 0,013 |

Individual confidence level = 95,00%

Grouping Information Using the Bonferroni Method and 95% Confidence

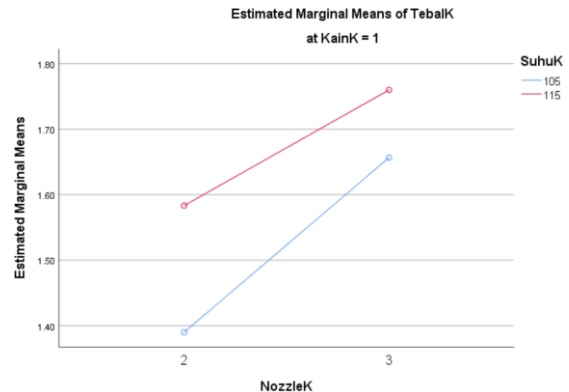
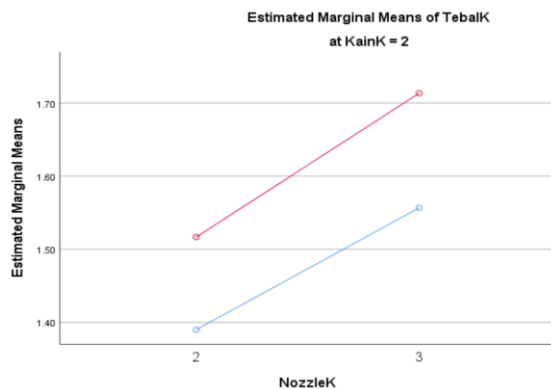
| Suhu | Klowong | N | Mean | Grouping |
|------|---------|---------|------|----------|
| 115 | 12 | 1,64333 | A | |
| 105 | 12 | 1,49944 | B | |

Means that do not share a letter are significantly different.

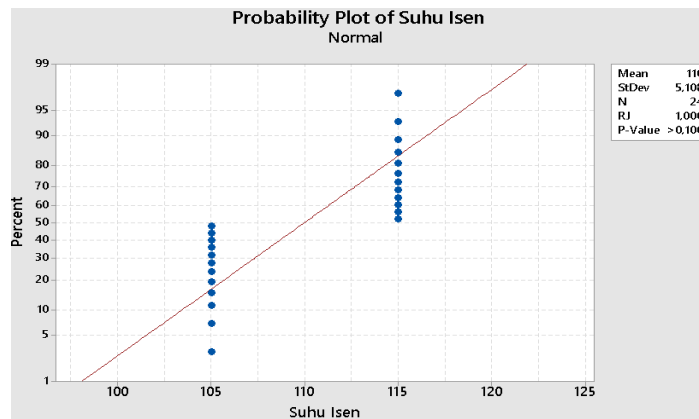
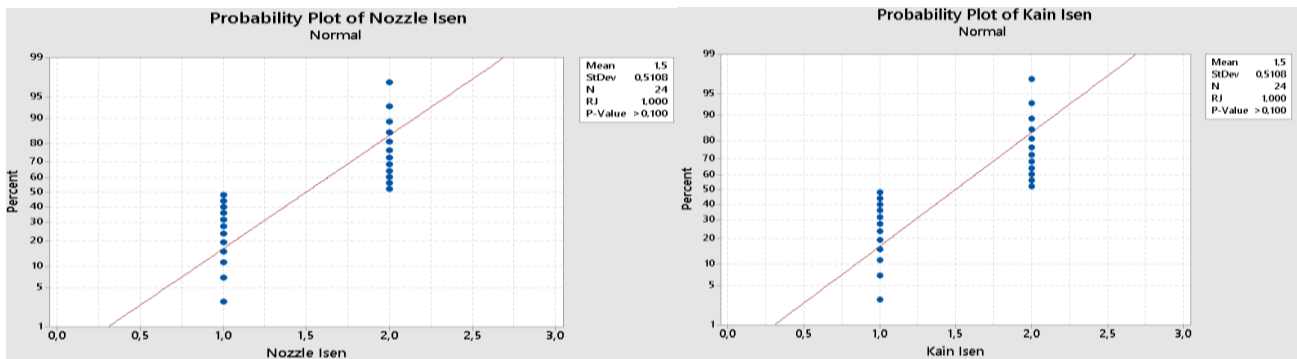
Bonferroni Simultaneous Tests for Differences of Means

| Difference of Suhu Klowong Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|-----------------------------------|---------------------|------------------|---------------------|---------|------------------|
| 115 - 105 | 0,1439 | 0,0191 | (0,1035; 0,1843) | 7,54 | 0,000 |

Individual confidence level = 95,00%



Appendix 14 Test of Normality DOE Isen Process



Tests of Normality

| | Suhul | Kolmogorov-Smirnov ^a | | | Shapiro-Wilk | | |
|--------|-------|---------------------------------|----|------|--------------|----|------|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Teball | 105 | .219 | 12 | .117 | .883 | 12 | .096 |
| | 115 | .215 | 12 | .131 | .843 | 12 | .030 |

a. Lilliefors Significance Correction

Tests of Normality

| | Kainl | Kolmogorov-Smirnov ^a | | | Shapiro-Wilk | | |
|--------|-------|---------------------------------|----|-------|--------------|----|------|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Teball | 1 | .237 | 12 | .061 | .885 | 12 | .101 |
| | 2 | .183 | 12 | .200* | .905 | 12 | .186 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of Normality

| | Nozzel | Kolmogorov-Smirnov ^a | | | Shapiro-Wilk | | |
|--------|--------|---------------------------------|----|-------|--------------|----|------|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Teball | 1 | .363 | 12 | .000 | .764 | 12 | .004 |
| | 2 | .138 | 12 | .200* | .935 | 12 | .430 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix 15 Test of Homogeneity *Isen* Process

| Test | | | | | Test | | | | | Test | | | | |
|------------------------|-----------|-----------------------------------|-----|---------|------------------------|-----------|-----------------------------------|-----|---------|------------------------|-----------|-----------------------------------|-----|---------|
| Null hypothesis | | $H_0: \alpha_1 / \sigma_2 = 1$ | | | Null hypothesis | | $H_0: \alpha_1 / \sigma_2 = 1$ | | | Null hypothesis | | $H_0: \alpha_1 / \sigma_2 = 1$ | | |
| Alternative hypothesis | | $H_1: \alpha_1 / \sigma_2 \neq 1$ | | | Alternative hypothesis | | $H_1: \alpha_1 / \sigma_2 \neq 1$ | | | Alternative hypothesis | | $H_1: \alpha_1 / \sigma_2 \neq 1$ | | |
| Significance level | | $\alpha = 0,05$ | | | Significance level | | $\alpha = 0,05$ | | | Significance level | | $\alpha = 0,05$ | | |
| Test | | | | | Test | | | | | Test | | | | |
| Method | Statistic | DF1 | DF2 | P-Value | Method | Statistic | DF1 | DF2 | P-Value | Method | Statistic | DF1 | DF2 | P-Value |
| Bonett | 38,66 | 1 | | 0,000 | Bonett | 38,66 | 1 | | 0,000 | Bonett | 379,21 | 1 | | 0,000 |
| Levene | 119,10 | 1 | 46 | 0,000 | Levene | 119,10 | 1 | 46 | 0,000 | Levene | 31355,44 | 1 | 46 | 0,000 |

Appendix 16 Test of Significance & ANOVA Two Way *Isen* Process

Tests of Between-Subjects Effects

Dependent Variable: Teball

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|------------------------|-------------------------|----|-------------|-----------|------|
| Corrected Model | 1.355 ^a | 7 | .194 | 96.154 | .000 |
| Intercept | 42.854 | 1 | 42.854 | 21293.683 | .000 |
| Nozzle | .996 | 1 | .996 | 495.075 | .000 |
| Kainl | .018 | 1 | .018 | 8.747 | .009 |
| Suhul | .158 | 1 | .158 | 78.727 | .000 |
| Nozzle * Kainl | .113 | 1 | .113 | 56.366 | .000 |
| Nozzle * Suhul | .009 | 1 | .009 | 4.573 | .048 |
| Kainl * Suhul | .019 | 1 | .019 | 9.294 | .008 |
| Nozzle * Kainl * Suhul | .041 | 1 | .041 | 20.292 | .000 |
| Error | .032 | 16 | .002 | | |
| Total | 44.240 | 24 | | | |
| Corrected Total | 1.387 | 23 | | | |

a. R Squared = .977 (Adjusted R Squared = .967)

Analysis of Variance

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---------------------------------|----|---------|---------|---------|---------|
| Nozzle Isen | 1 | 1,00314 | 1,00314 | 487,25 | 0,000 |
| Kain Isen | 1 | 0,01742 | 0,01742 | 8,46 | 0,010 |
| Suhu Isen | 1 | 0,15790 | 0,15790 | 76,69 | 0,000 |
| Nozzle Isen*Kain Isen | 1 | 0,11207 | 0,11207 | 54,43 | 0,000 |
| Nozzle Isen*Suhu Isen | 1 | 0,00882 | 0,00882 | 4,28 | 0,055 |
| Kain Isen*Suhu Isen | 1 | 0,01927 | 0,01927 | 9,36 | 0,007 |
| Nozzle Isen*Kain Isen*Suhu Isen | 1 | 0,04111 | 0,04111 | 19,97 | 0,000 |
| Error | 16 | 0,03294 | 0,00206 | | |
| Total | 23 | 1,39266 | | | |

Appendix 17 Test of Post Hoc *Isen* Process

Grouping Information Using the Bonferroni Method and 95% Confidence

| Nozzle | | | |
|--------|----|---------|----------|
| Isen | N | Mean | Grouping |
| 2 | 12 | 1,54083 | A |
| 1 | 12 | 1,13194 | B |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Nozzle Isen Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|----------------------------------|---------------------|------------------|---------------------|---------|------------------|
| 2 - 1 | 0,4089 | 0,0185 | (0,3696; 0,4482) | 22,07 | 0,000 |

Individual confidence level = 95,00%

Grouping Information Using the Bonferroni Method and 95% Confidence

| Kain | | | |
|------|----|---------|----------|
| Isen | N | Mean | Grouping |
| 2 | 12 | 1,36333 | A |
| 1 | 12 | 1,30944 | B |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Kain Isen Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|--------------------------------|---------------------|------------------|---------------------|---------|------------------|
| 2 - 1 | 0,0539 | 0,0185 | (0,0146; 0,0932) | 2,91 | 0,010 |

Individual confidence level = 95,00%

Grouping Information Using the Bonferroni Method and 95% Confidence

| Suhu | | | |
|------|----|---------|----------|
| Isen | N | Mean | Grouping |
| 115 | 12 | 1,41750 | A |
| 105 | 12 | 1,25528 | B |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Suhu Isen Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|--------------------------------|---------------------|------------------|---------------------|---------|------------------|
| 115 - 105 | 0,1622 | 0,0185 | (0,1230; 0,2015) | 8,76 | 0,000 |

Individual confidence level = 95,00%

Grouping Information Using the Bonferroni Method and 95% Confidence

| Nozzle Isen*Kain | | | |
|---------------------|---|---------|----------|
| Isen | N | Mean | Grouping |
| 2 1 | 6 | 1,58222 | A |
| 2 2 | 6 | 1,49944 | B |
| 1 2 | 6 | 1,22722 | C |
| 1 1 | 6 | 1,03667 | D |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Nozzle Isen*Kain Isen Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|--|---------------------|------------------|---------------------|---------|------------------|
| (1 2) - (1 1) | 0,1906 | 0,0262 | (0,1117; 0,2694) | 7,27 | 0,000 |
| (2 1) - (1 1) | 0,5456 | 0,0262 | (0,4667; 0,6244) | 20,83 | 0,000 |
| (2 2) - (1 1) | 0,4628 | 0,0262 | (0,3840; 0,5416) | 17,67 | 0,000 |
| (2 1) - (1 2) | 0,3550 | 0,0262 | (0,2762; 0,4338) | 13,55 | 0,000 |
| (2 2) - (1 2) | 0,2722 | 0,0262 | (0,1934; 0,3510) | 10,39 | 0,000 |
| (2 2) - (2 1) | -0,0828 | 0,0262 | (-0,1616; -0,0040) | -3,16 | 0,036 |

Individual confidence level = 99,17%

Grouping Information Using the Bonferroni Method and 95% Confidence

| Kain Isen*Suhu | | | |
|-------------------|---|---------|----------|
| Isen | N | Mean | Grouping |
| 1 115 | 6 | 1,41889 | A |
| 2 115 | 6 | 1,41611 | A |
| 2 105 | 6 | 1,31056 | B |
| 1 105 | 6 | 1,20000 | C |

Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Kain Isen*Suhu Isen Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T-Value | Adjusted P-Value |
|--|---------------------|------------------|---------------------|---------|------------------|
| (1 115) - (1 105) | 0,2189 | 0,0262 | (0,1401; 0,2977) | 8,36 | 0,000 |
| (2 105) - (1 105) | 0,1106 | 0,0262 | (0,0317; 0,1894) | 4,22 | 0,004 |
| (2 115) - (1 105) | 0,2161 | 0,0262 | (0,1373; 0,2949) | 8,25 | 0,000 |
| (2 105) - (1 115) | -0,1083 | 0,0262 | (-0,1871; -0,0295) | -4,14 | 0,005 |
| (2 115) - (1 115) | -0,0028 | 0,0262 | (-0,0816; 0,0760) | -0,11 | 1,000 |
| (2 115) - (2 105) | 0,1056 | 0,0262 | (0,0267; 0,1844) | 4,03 | 0,006 |

Individual confidence level = 99,17%

Grouping Information Using the Bonferroni Method and 95% Confidence

| Nozzle Isen*Kain Isen*Suhu | | | |
|----------------------------------|---|---------|----------|
| Isen | N | Mean | Grouping |
| 2 1 115 | 3 | 1,63111 | A |
| 2 2 115 | 3 | 1,57444 | A |
| 2 1 105 | 3 | 1,53333 | A B |
| 2 2 105 | 3 | 1,42444 | B |
| 1 2 115 | 3 | 1,25778 | C |
| 1 1 115 | 3 | 1,20667 | C |
| 1 2 105 | 3 | 1,19667 | C |
| 1 1 105 | 3 | 0,86667 | D |

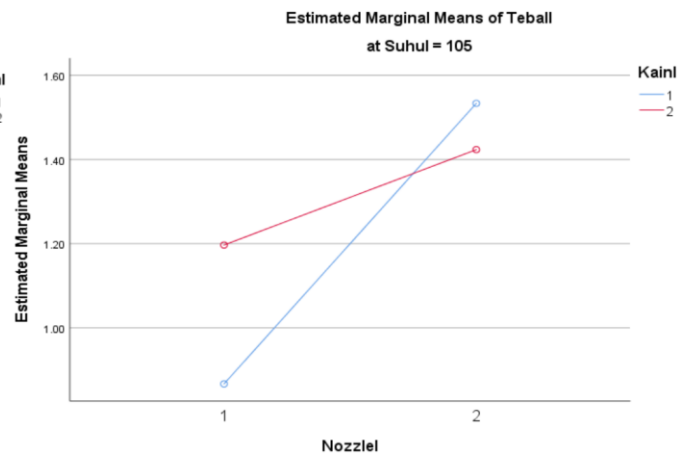
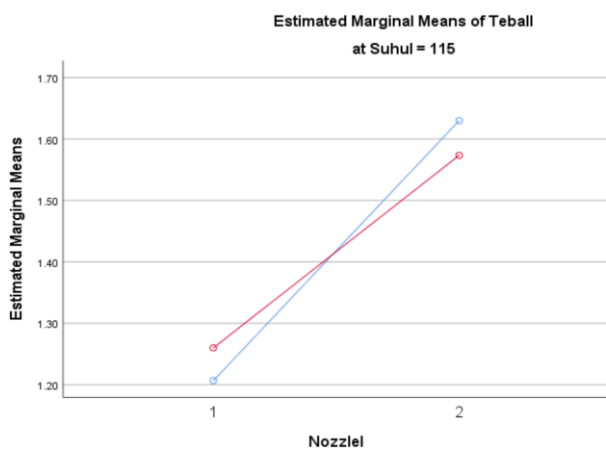
Means that do not share a letter are significantly different.

Bonferroni Simultaneous Tests for Differences of Means

| Difference of Nozzle Isen*Kain Isen*Suhu Isen Levels | Difference of Means | SE of Difference | Simultaneous 95% CI | T- Value | Adjusted P-Value |
|--|------------------------|---------------------|---------------------------|-------------|---------------------|
| (1 1 115) - (1 1 105) | 0.3400 | 0.0370 | (0.2014; 0.4786) | 9.18 | 0.000 |
| (1 2 105) - (1 1 105) | 0.3300 | 0.0370 | (0.1914; 0.4686) | 8.91 | 0.000 |
| (1 2 115) - (1 1 105) | 0.3911 | 0.0370 | (0.2526; 0.5297) | 10.56 | 0.000 |
| (2 1 105) - (1 1 105) | 0.6667 | 0.0370 | (0.5281; 0.8052) | 17.99 | 0.000 |
| (2 1 115) - (1 1 105) | 0.7644 | 0.0370 | (0.6259; 0.9030) | 20.63 | 0.000 |
| (2 2 105) - (1 1 105) | 0.5578 | 0.0370 | (0.4192; 0.6963) | 15.06 | 0.000 |
| (2 2 115) - (1 1 105) | 0.7078 | 0.0370 | (0.5692; 0.8463) | 19.10 | 0.000 |
| (1 2 105) - (1 1 115) | -0.0100 | 0.0370 | (-0.1486; 0.1286) | -0.27 | 1.000 |
| (1 2 115) - (1 1 115) | 0.0511 | 0.0370 | (-0.0874; 0.1897) | 1.38 | 1.000 |
| (2 1 105) - (1 1 115) | 0.3267 | 0.0370 | (0.1881; 0.4652) | 8.82 | 0.000 |
| (2 1 115) - (1 1 115) | 0.4244 | 0.0370 | (0.2859; 0.5630) | 11.46 | 0.000 |
| (2 2 105) - (1 1 115) | 0.2178 | 0.0370 | (0.0792; 0.3563) | 5.88 | 0.001 |
| (2 2 115) - (1 1 115) | 0.3678 | 0.0370 | (0.2292; 0.5063) | 9.93 | 0.000 |
| (1 2 115) - (1 2 105) | 0.0611 | 0.0370 | (-0.0774; 0.1997) | 1.65 | 1.000 |
| (2 1 105) - (1 2 105) | 0.3367 | 0.0370 | (0.1981; 0.4752) | 9.09 | 0.000 |
| (2 1 115) - (1 2 105) | 0.4344 | 0.0370 | (0.2959; 0.5730) | 11.73 | 0.000 |
| (2 2 105) - (1 2 105) | 0.2278 | 0.0370 | (0.0892; 0.3663) | 6.15 | 0.000 |
| (2 2 115) - (1 2 105) | 0.3778 | 0.0370 | (0.2392; 0.5163) | 10.20 | 0.000 |
| (2 1 105) - (1 2 115) | 0.2756 | 0.0370 | (0.1370; 0.4141) | 7.44 | 0.000 |
| (2 1 115) - (1 2 115) | 0.3733 | 0.0370 | (0.2348; 0.5119) | 10.08 | 0.000 |

| | | | | | |
|-----------------------|---------|--------|--------------------|-------|-------|
| (2 2 105) - (1 2 115) | 0.1667 | 0.0370 | (0.0281; 0.3052) | 4.50 | 0.010 |
| (2 2 115) - (1 2 115) | 0.3167 | 0.0370 | (0.1781; 0.4552) | 8.55 | 0.000 |
| (2 1 115) - (2 1 105) | 0.0978 | 0.0370 | (-0.0408; 0.2363) | 2.64 | 0.500 |
| (2 2 105) - (2 1 105) | -0.1089 | 0.0370 | (-0.2474; 0.0297) | -2.94 | 0.270 |
| (2 2 115) - (2 1 105) | 0.0411 | 0.0370 | (-0.0974; 0.1797) | 1.11 | 1.000 |
| (2 2 105) - (2 1 115) | -0.2067 | 0.0370 | (-0.3452; -0.0681) | -5.58 | 0.001 |
| (2 2 115) - (2 1 115) | -0.0567 | 0.0370 | (-0.1952; 0.0819) | -1.53 | 1.000 |
| (2 2 115) - (2 2 105) | 0.1500 | 0.0370 | (0.0114; 0.2886) | 4.05 | 0.026 |

Individual confidence level = 99.82%



Appendix 18 Value of RMSD and SD of DOE

1. Value of RMSD and SD

| Fabric | Rep | Thick Line Continuity /SD (mm) | | Wax Permeability / RMSD (mm) | |
|--------------------------|-----|--------------------------------|-------------|------------------------------|-------------|
| | | <i>Klowong</i> | <i>Isen</i> | <i>Klowong</i> | <i>Isen</i> |
| Mori with handmade Batik | 1 | 0.16 | 0.10 | 0.22 | 0.11 |
| | 2 | 0.12 | 0.10 | 0.17 | 0.19 |
| | 3 | 0.13 | 0.12 | 0.19 | 0.06 |
| Average | | 0.14 | 0.11 | 0.19 | 0.12 |
| Mori with Machine Batik | 1 | 0.18 | 0.08 | 0.25 | 0.14 |
| | 2 | 0.12 | 0.13 | 0.17 | 0.14 |
| | 3 | 0.11 | 0.05 | 0.15 | 0.18 |
| Average | | 0.13 | 0.09 | 0.19 | 0.15 |

| | | | | | |
|----------------------|---|------|------|------|------|
| Synthetic | 1 | 0.14 | 0.12 | 0.19 | 0.16 |
| Fabric with Batik | 2 | 0.11 | 0.08 | 0.16 | 0.11 |
| Machine | 3 | 0.13 | 0.13 | 0.18 | 0.18 |
| Average | | 0.13 | 0.11 | 0.18 | 0.15 |

2. Standard Deviation of DoE

| Experiment of <i>Klowong</i> | Replication | | | Average |
|---------------------------------|-------------|------|------|---------|
| | 1 | 2 | 3 | |
| 1 | 0.00 | 0.12 | 0.11 | 0.08 |
| 2 | 0.38 | 0.13 | 0.20 | 0.24 |
| 3 | 0.11 | 0.14 | 0.08 | 0.11 |
| 4 | 0.09 | 0.25 | 0.11 | 0.15 |
| 5 | 0.03 | 0.03 | 0.09 | 0.05 |
| 6 | 0.28 | 0.10 | 0.06 | 0.15 |
| 7 | 0.17 | 0.09 | 0.09 | 0.12 |
| 8 | 0.13 | 0.08 | 0.02 | 0.08 |

| Experiment of <i>Isen</i> | Replication | | | Average |
|------------------------------|-------------|------|------|---------|
| | 1 | 2 | 3 | |
| 1 | 0.13 | 0.02 | 0.09 | 0.08 |
| 2 | 0.16 | 0.21 | 0.24 | 0.20 |
| 3 | 0.15 | 0.11 | 0.12 | 0.13 |
| 4 | 0.10 | 0.04 | 0.10 | 0.08 |
| 5 | 0.04 | 0.08 | 0.02 | 0.05 |
| 6 | 0.31 | 0.08 | 0.07 | 0.15 |
| 7 | 0.05 | 0.06 | 0.02 | 0.05 |
| 8 | 0.07 | 0.03 | 0.15 | 0.08 |

3. Nilai RMSD DoE

| Experiment of <i>Klowong</i> | Replication | | | Average |
|---------------------------------|-------------|------|------|---------|
| | 1 | 2 | 3 | |
| 1 | 0.00 | 0.03 | 0.02 | 0.02 |
| 2 | 0.28 | 0.04 | 0.08 | 0.13 |
| 3 | 0.02 | 0.04 | 0.01 | 0.03 |
| 4 | 0.02 | 0.13 | 0.02 | 0.06 |

| | | | | |
|---|------|------|------|------|
| 5 | 0.00 | 0.00 | 0.02 | 0.01 |
| 6 | 0.15 | 0.02 | 0.01 | 0.06 |
| 7 | 0.06 | 0.02 | 0.02 | 0.03 |
| 8 | 0.04 | 0.01 | 0.00 | 0.02 |

| Experiment of <i>Isen</i> | Replication | | | Average |
|------------------------------|-------------|------|------|---------|
| | 1 | 2 | 3 | |
| 1 | 0.03 | 0.00 | 0.02 | 0.02 |
| 2 | 0.05 | 0.09 | 0.12 | 0.08 |
| 3 | 0.05 | 0.02 | 0.03 | 0.03 |
| 4 | 0.02 | 0.00 | 0.02 | 0.01 |
| 5 | 0.00 | 0.01 | 0.00 | 0.01 |
| 6 | 0.19 | 0.01 | 0.01 | 0.07 |
| 7 | 0.01 | 0.01 | 0.00 | 0.00 |
| 8 | 0.01 | 0.00 | 0.05 | 0.02 |

Appendix 19 Batik Colouring Result

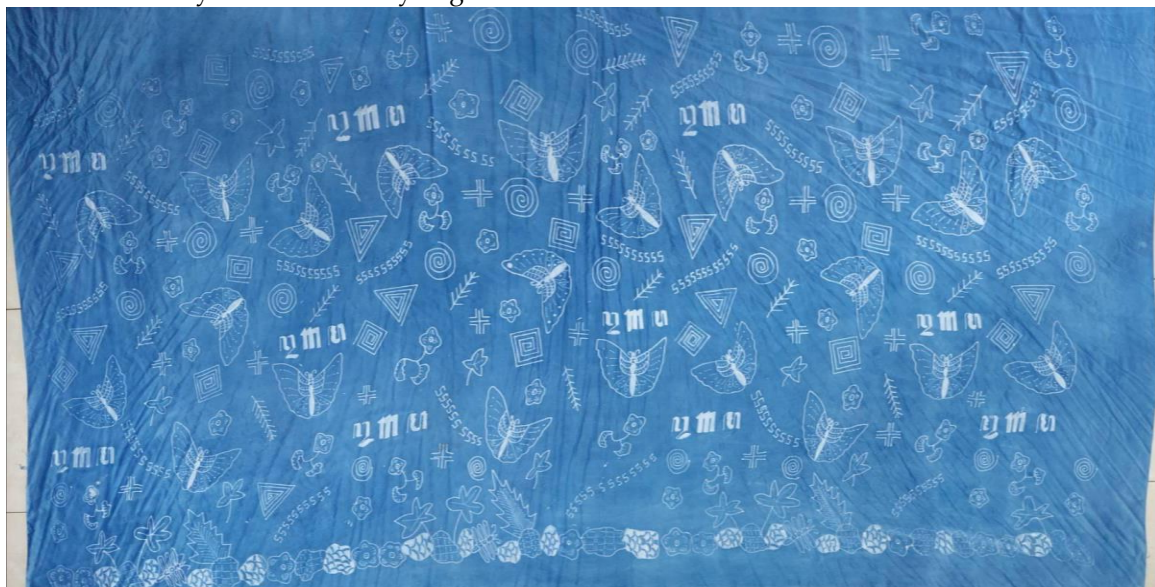
1. Conventional handmade Mori Fabric Dyeing



2. Machine-made Mori Fabric Dyeing

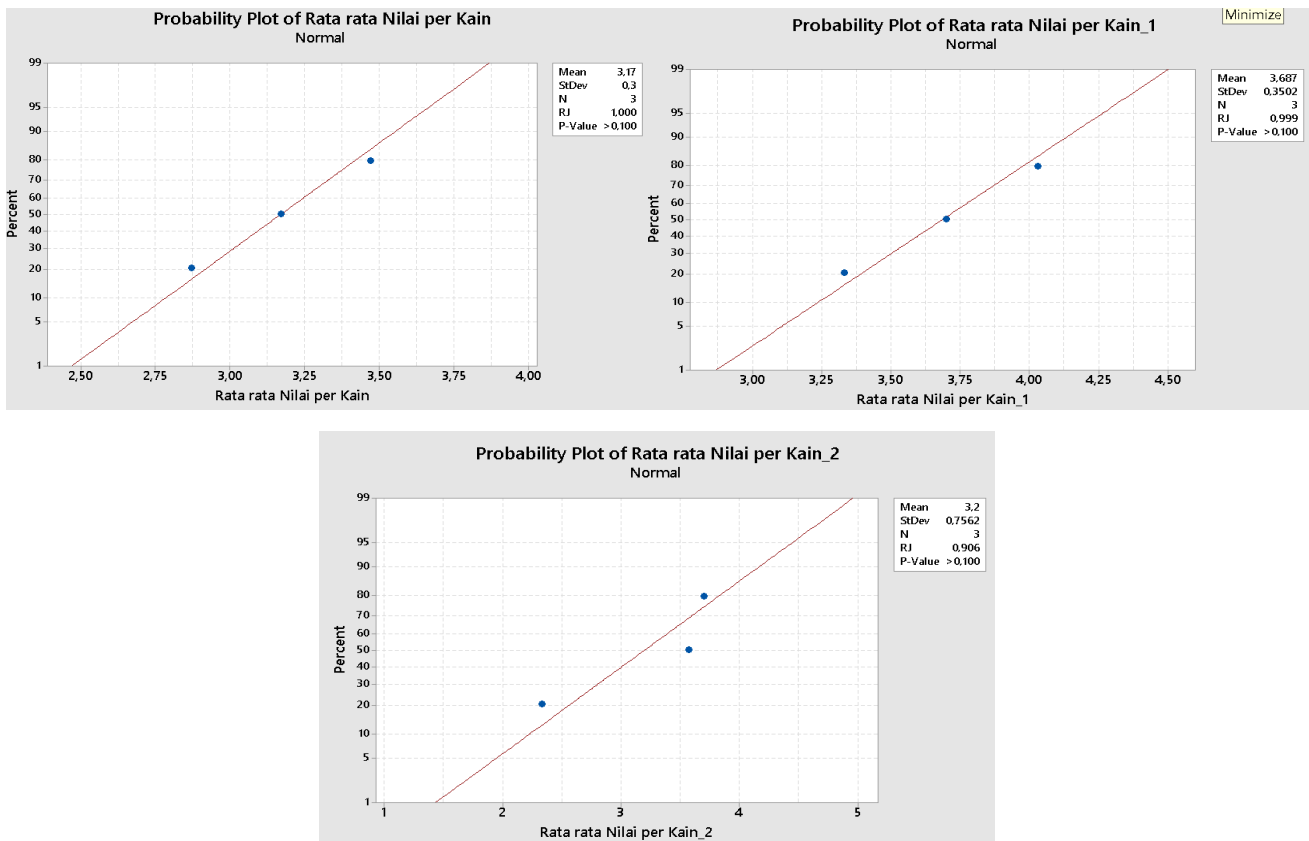


3. Machine-made Synthetic Fabric Dyeing



Appendix 20 Statistic Overall Result

1. Normality Test



2. Significance Conventional Handmade Result Test

Analysis of Variance

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|--------|----|--------|--------|---------|---------|
| Factor | 1 | 0,4004 | 0,4004 | 3,77 | 0,124 |
| Error | 4 | 0,4253 | 0,1063 | | |
| Total | 5 | 0,8257 | | | |

3. Significance Machine-made Result Test

Analysis of Variance

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|--------|----|--------|--------|---------|---------|
| Factor | 1 | 0,3553 | 0,3553 | 1,02 | 0,369 |
| Error | 4 | 1,3891 | 0,3473 | | |
| Total | 5 | 1,7443 | | | |

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To Cite This Article: Daffa'ulhaq, M.N., & Sudiarmo, A. (2023). Parameter Optimization of Writing Batik Machine with Synthetic & Natural Fabric, *Journal of Industrial Engineering and Education*, 1(2), 1-35.