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Calendering Machine Performance Analysis to Improve the Smoothness of Batik

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Abstract. *This research aims to analyze the performance of the batik ironing machine (calendering) towards ensuring optimal finishing due to the problems associated with the inability to measure the mechanical system of its roll which normally leads to the unevenness of the products. Finishing is an important process in batik production and this is commonly achieved through the calendering machine which is known as one of the mechanical refinements involving a rolling process conducted using high temperatures and pressures to produce fabric products with a flat, smooth, and shiny surface and also create a smooth, moire, and an embossed effect. It is, however, important to note that operators in the batik industry are currently being faced with the problems of finishing and this means there is a need for the appropriate tool for refinement of the fabric. Therefore, this observational study was conducted with the focus on identifying the main components and calculating the mechanical strength of the calendering machine in the batik industry. This involved using the solid work software and the results showed that the calendering machine generally consists of five rolls divided into three metal and two soft rolls. The metal roll has a smooth surface with a hole in the middle for heating which implies it functions as the ironing tool while the soft roll serves as a pressure booster during the ironing process. Moreover, the analysis of structural mechanics showed that the machine has the ability to iron 3.53 meters of fabric in 1 minute. It was also observed that it has six main parts which are the preparation, roller calendar, engine frame, transmission system, boiler engine, and special cooling. The machine was able to produce a batik fabric with a flat, smooth, and shiny surface, thereby, increasing its quality.*

Keywords: *fabric, batik, calendering machine*

I. INTRODUCTION

Batik is a pictorial fabric usually produced by writing or gluing liquid wax in the form of a canting or stamp using a specific tool (Hidayat, 2012). It is generally included in a small and medium industry (SME) and serves as the source of livelihood for some people in Indonesia (Nurainun et al., 2008). This SME was observed to be experiencing rapid growth before the monetary crisis of 1997 with several batik entrepreneurs observed to have enjoyed prosperity and productivity, especially in the 1980s when batik was an official attire required to be worn at every state or other official events (Siswiyanti et al., 2019). This led to its introduction on the global scale at the time, thereby, improving the image of the industry (Gilang, 2016).

The batik industry in Indonesia is currently growing rapidly and continuously with a high level of productivity (Lestari & Susandi, 2019). The smooth production process serves as the benchmark to determine the success of the industry in delivering good quality products to earn the trust and loyalty of its consumers (Yani, Ari Soeti & Azizah, 2019).

This is also in line with the findings of a previous study that the quality of these products can be proven based on the productivity and the effectiveness of the machines used for their production (Raihudaya, 2017). Meanwhile, it is necessary to conduct structured maintenance to achieve optimal machine effectiveness and involve every worker in the parts of the company

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to ensure a smooth and proper production process (Biegel, 1992).

The information on batikaluna.com showed that Central Java has a lot of motifs developed that vary according to the area of origin such as Pekalongan which is popular for the production of batiks. Some other areas considered to be popular for their batik motifs include Sragen.

Batik Aluna used as the object of this research is a batik production company located in Jantran RT 29 RW 05, Pilang Masaran – Sragen. It was established in 2005 with enough experience and readiness to innovate all kinds of batik motifs according to market needs. The reports from batikaluna.com showed that Sragen batik is dominated by flora and fauna patterns but sometimes combined with standard motifs. Moreover, its motifs currently tend to present a firm meaning by being more straightforward than the styles in Yogyakarta and Surakarta. The development of these motifs cannot be separated from the influence of the character of the Sragen community which is associated with the openness and outspokenness in expressing their hearts.

A new business is adjudged to be productive when its production processes are conducted efficiently and effectively or through the minimal use of resources to produce the most accurate results possible (Soebagiyo & Wahyudi, 2008). This indicates productivity can be increased through the enhancement of the efficiency and effectiveness of the business which can be achieved by 1) improving the skills of the employees and 2) updating production equipment (Budijono & Kurniawan, 2019).

(Utama et al., 2021) stated the production problems generally faced by Indonesian small and medium enterprises (SMEs) cannot be solved through the application of machines with the latest or advanced technology but by using the appropriate technology (TTG). This is mainly due to the fact that it requires relatively cheap investment costs and does not need a high knowledge base to master (Hasyim et al., 2018).

An intensive discussion with the batik industry shows that a partner company has proposed to assist in finding appropriate solutions to the problems being faced. These assumptions serve as the foundation of this research which is focused on collaborating to analyze the usefulness of the batik calendering machine at the finishing phase of the batik-making stage towards ensuring a better quality product and an efficient process. The calendering machine at Batik Aluna, Masaran-Sragen installed to assist in improving the batik fabric production process to improve quality and productivity was used in this study.

II. Research Method

This is an observational study conducted on the calendering machine in the Batik industry with the focus on identifying its main components and calculating its mechanical strength using solid work software. The research was conducted in two stages with the first being the location observation method supported by data collection and documentation at the Aluna Batik Factory, Village 2, Pilang, Masaran Sub-District, Sragen Regency, Central Java on Friday, December 24, 2021. This was used to obtain information on the dimensions, components and functions, workings,

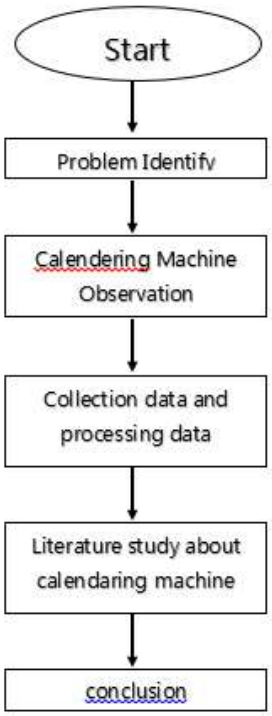


Figure 1. Research Methods

and maintenance of the calendering machine.

The second stage is data analysis using the information and documentation obtained from the first stage and a review of previous studies to determine the performance of the machine.

III. RESULT AND DISCUSSION

Understanding Calendering Machine

Understanding Calendering Machine: The calendering machine is used for the finishing process of fabric products to ensure they have a flat, smooth, and shiny surface. The process involves passing the fabric between the hot and rotating rollers to be pressed.

The machine generally has one pair of rollers (nip) or more with one designed to be softer than the other to be used for the thicker parts of the fabric. This soft roller is made of metal covered with fabric or thick paper to make the surface of the cloth flat. Moreover, the number of rollers on the calendering machine varies and is arranged in such a way to produce the desired effect of improving the fabrics. It is important to note that the refinement effect can be temporary or permanent depending on the types of the previous refinement process and fiber used in the processed fabric.

Calendering Effect

Some of the effects of the calendering process on different fabrics are stated as follows.

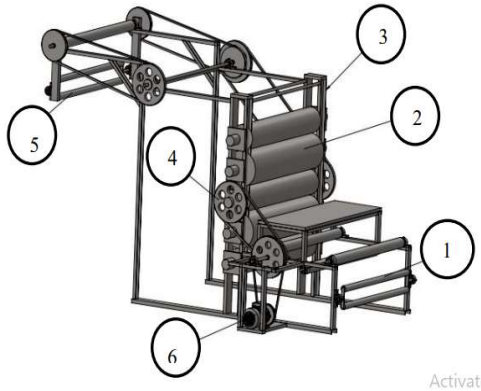
1. *Maat*: This is when the fabric surface is flat but not very shiny and the thread is not very flat. It is normally produced by passing the fabric through soft rollers only (Risa, 2018).
2. *Swizzing*: This is a flat and shiny fabric surface with flat threads normally produced by passing the fabric over all calendering rollers.
3. *Glazing*: This is a very smooth and shiny fabric surface obtained by first treating the fabric with resin before passing it through the calendar.
4. *Cire*: The word "cire" is a French word that means wax. It is normally obtained after the fabric has been processed with wax or other thermoplastic materials and later passed through a calendering machine to make the surface wet and shiny.
5. *Moire*: Moire is a French word that denotes water and it involves producing the fabric with a design showing a ripple on the surface of the water. This is normally obtained by passing two layers of rib-woven fabric simultaneously between calendering rollers under high pressure using 8-10 tons to make the upper rib motif press the lower layer and cause a different light reflection effect that looks like ripples on the surface of the water.
6. *Emboss*: This involves producing embossed motifs on the surface of the fabric as it is passed through hot metal rollers engraved with certain motifs. This can be permanent on fabrics made with thermoplastic fibers such as nylon, polyether, and acrylate. It is important to note that the embossed effect is usually

Table 1. Calendering Machine Type

No	Machine Type	Effect/Aim Machine
1	Schreiner or Simili	The silk effect or finish makes the fabric shine like silk. It is temporary and needs the addition of resin to be made permanent. This is usually conducted on natural cellulose fibers.
2	Embossing or Sculpture	This machine produces embossed motifs on the surface of the fabric. It is usually used for heat-sensitive synthetic fibers and is permanent.
3	Palmer	This makes the cloth dry with a flat surface (even though the item does not become flat), shiny, and have a full handle. It is commonly used for light fabrics, nylon fibers, or other synthetic fibers.
4	Calendering for Knitting Fabrics	This is normally used to flatten the surface of the fabric and adjust the diameter of the knitted fabric (which is usually tubular) to ensure easier handling in the confection process.

used for luxury clothes with high selling price (Diandra et al., n.d.).

There are different types of calendering machines based on the effect and purpose, and these include Schreiner or Simili, Embossing, and Palmer types as well as those designed to knit fabrics (Pujilestari, 2014).



1. Preparator
2. Calendering roll
3. Engine Frame
4. Transmission System
5. Cooler
6. Electric Drive Motor

Figure 2. Calendering Machine Design

The data obtained showed the calendering machine has 2,800 mm length, 2,500 mm width, and 280 mm height.

Calendering Machine Components: The components of the calendering machine include the following (see Fig. 2):

1. *Preparator* . The preparator is a small roll used to prepare the fabric before entering the calendering process. This roll preparator does not have steam flow because it only tidies up the fabric to ensure it does not wrinkle before calendering.
2. *Calendering roll*. Calendering roll is a machine component which is in the form of a roll with a hole to circulate TCU (Temperature Control Unit) water in order to stabilize its surface temperature according to the spec settings. It also tends to have a specially chromed surface to maintain flatness and smoothness. The functions of this component is stated as follows:
   - As the machine component to form a clearance or gap to produce product sheets with certain thickness according to production needs.
   - To even out the thickness of the product according to the spec settings.
   - Two calendering rolls squeezed together to form a gap to form a kneaded fabric with flexible properties.

   This machine has 5 rolls including 2 large rolls covered with fabric at 1,420 mm length, 2,500 mm width, and 350 mm diameter as well as 3 medium rolls made of a metal plate at 1,420 mm length, 250 mm width, and 250 mm diameter. The metal rollers found in calendering machines generally have a smooth surface with a hole in the center for heating. This has a smaller diameter than the soft roller.
3. *Engine Frame.* The calendering machine frame is made of angle iron assembled to support the calendering roll.
4. *Transmission System.* The transmission system used is a pulley and belt with a sprocket connected to a 5 HP 3.7 W AC motor.

   The engine RPMs are obtained as follows,

   D1= 1 inch, D2= 46 inches, N1= 1450

   Therefore, the RPM from the first transmission was:

   N2= $\frac{D1}{D2}.n1$; N2= $\frac{1}{46}.1450$; N2= 31,52 RPM

   This means the pulley and belt transmission produced 31.52 RPM. This is followed by the calculation of the RPM for the sprocket, N3.

   Where:

   T1= 14 teeth, T2= 98 teeth, N2= 31,52

   Therefore,

   N3= $\frac{T1}{T2}.n2$; N3= $\frac{14}{98}.31{,}52$; N3= 4,5 RPM

   This implies the rolls of the machine rotates at 4.5 RPM with a small roll circumference stated as follows:

   D= $\pi.d$

   D= 3,14 . 250 mm

   D= 785 mm or 0,785 m

   This shows the machine can iron as much as 0.785 m of batik fabric in 1 round.

   The length of the fabric ironed per minute is:

   P= RPM . D

   P= 4.5, 0.785

   P= 3.53 meters per minute

This shows that t can iron a fabric 3.53 meters long in one minute.

5. *Cooler.* The special cooler is a roll plate not steamed and placed on top to serve as the final part by cooling the batik fabric after the calendering process.
6. *Electric Drive Motor.* An electric motor is a companion drive on a motorcycle which has the ability to convert electrical power into mechanical power with high efficiency (Suryadi & Triyono, 2015) (Cahyo et al., 2020).
7. *Boiler Machine.* A boiler which is also known as the steam boiler is a closed vessel containing water to be heated and is also considered to be the heart of a factory (Irawan et al., 2018). It is the source of energy and steam to be used for heating in the process of ironing the batik fabric (Dianponti et al., n.d.).

The Calendering Machine Working Mechanism

The calendering machine has 5 rolls driven by a transmission system in the form of a pulley belt and sprocket. The drive is powered by a 3.7W AC engine connected to 220 Volt electricity. The working process is stated as follows:

1. The engine is powered by electricity to move the AC motor.
2. The driving motor is connected to the transmission system which makes the sprocket rotate at 4.5 RPM to drive one of the rolls.
3. The boiler is also turned on to produce thermal energy in the ironing process.
4. The fabric is fed through the preparator from below to ensure it reaches the previously rotating roller.
5. The fabric is connected through a large roller to ensure an emphasis on the ironing process towards producing a soft and wrinkle-free fabric.

The fabric is reconnected through the next rolls to repeat the ironing process to obtain perfect results.

Calendering Machine Maintenance

The mechanical technician needs to implement the following maintenance steps or care for the calendering roll:

1. Check the wear condition of the shaft for the rolls (Suhendar & Juanedi, 2010).
2. Supervise lubrication condition. Lubrication is the most important thing in machine maintenance to ensure the rotating or moving workpiece system works effectively and to avoid fatal damage to the working system (Novitasari, 2018). Therefore, it is important to:
   - Check the lubrication of the bearing unit.
   - Observe the oil circulating to the blushing calendering roll.
   - Ensure no oil leaks in circulation.
3. Checking the temperature of the calendering roll. The temperature is an important factor due to its importance to the quality of the product. It is important to reiterate that the thermal energy used in the calendering machine is obtained from the boiler machine through PVC pipes. Hence, the following procedures should be conducted:
   - Make sure the temperature listed on the controller panel is between the actual and values required to be set. For example, when the temperature of the calendering roll is set at 60, the same value also needs to be set as the actual.
   - Always clean the water strainer in the TCU because the temperature of the pickle circulating in the calendering roll is always stable according to the settings on the TCU controller.
   - Make sure there are no leaks in the TCU system in terms of water, steam, and wind to ensure continuous maintenance of the calendering roll temperature.
4. Check the belt age regularly. The transmission system in this machine uses pulleys and belts and this implies it is necessary to check the age of the belt regularly to ensure a proper transmission process.

Calendering Machine Advantages and Disadvantages

The advantages of the calendering process include are production of a uniform and precise sheet thickness distribution and improvement in the production process by producing high-quality products in large capacity. Disadvantage of the

calendering machine is requires a large capital in purchasing and installing the machine

IV. CONCLUSION

The Batik industry is a small and medium industry (SME) considered to be the source of livelihood for several people. However, the finishing phase of the production process needs to be explored deeply due to its importance to the quality of the fabric product. This led to the implementation of ironing or calendering machine in the textile industry including batik fabric manufacturing companies as the tool for fabric refinement.

This calendering machine is one of the mechanical refinements which works using the rolling process at high temperatures and pressures to produce a flat, smooth, and shiny surface for fabrics and also to create moire and embossed effects on them. The machine generally has five rolls divided into three metal and two soft rolls. The metal roll has a smooth surface with a hole at the middle for heating and is normally used for the ironing aspect while the soft roll acts as the pressure agent during the ironing process. This research was conducted through direct observation and the results showed that the machine consists of six main parts including the preparator, calendering roller, engine frame, transmission system, boiler engine, and special cooling.

The finishing process of the batik products is projected to be very important to customer satisfaction in the future. Therefore, these findings are expected to serve as the foundation to produce more constructive ideas to improve the finishing process towards ensuring the production of high-quality fabrics over time.

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