# 3D PRINTING STUDY FOR BATIK CANTING PATTERN DRAWING

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## ABSTRACT

*The new 3D printing technology has opened an opportunity for rapid prototyping, providing a relatively fast and cost-efficient product development. Previous research on the automation of Batik Lukis technology has shown that 3D printing technologies are applicable avenues for customising the automation of batik patterns and design. The printability of batik wax, which is dependent on the printhead mechanism to expel the wax, and the extrudability of paste-type filling, which is dependent on the rheology of the wax itself, are two major issues in paste printing. The first difficulty addressed in this project is the mechanism for ejecting the batik wax paste into a predetermined design. Although there are widely accessible CNC machines for this purpose, such as the Batik Klowong Machine, which are popular in the markets, particularly in Indonesia, this project attempts to use 3D printing to print batik wax by changing the printhead mechanism. Results shows that low extrusion steps of 8 extrusion steps per millimeter are potentially good extrusion speeds for viscous fluid like canting cold wax. Even though the wax line barrier produced by 8 extrusion steps has some increment in width of 1 to 2 mm, the line produced seems relatively more consistent than any other extrusion steps.*

**Keywords**: *3D Printing, Canting, Batik, Cold Wax, Batik Pattern.*



## 1.0 INTRODUCTION

Three-dimensional (3D) printing uses an additive manufacturing method, which is a technology for layer-by-layer deposition of computer-aided designed objects on a platform. An object is built in an additive technique by laying down successive layers of material until the object is complete. This technique starts with a digital design or 3D model of the object, which is then sliced into multiple horizontal cross-sections. Each of these slices corresponds to a layer of material that will be deposited during the building process. Each of these layers can be viewed as a cross-section of the object that has been thinly stacked [1-5]. This additive technique contrasts with traditional subtractive methods, where material is removed from a solid block to create a form. Additive manufacturing allows for


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greater design flexibility, reduced material waste, and the ability to create complex structures that might be difficult or impossible to achieve with conventional methods. These methods include generating novel materials for conventional 3D printing processes and developing technology and devices that utilize current materials, such as paste like materials in a 3D printing process. With specially designed paste extruders, advancements have been made in 3D printing materials that were previously restricted to plastic filaments printing, such as scaffolds for food, medicals, ceramics, and the handicraft industry [6-9]. With all the benefits, this technology makes mass customization, on-demand production, and personalized patterns possible.

The integration of 3D printing technology into the batik handicraft industry has become an inevitable development, driven by advancements in digital fabrication and the increasing need for innovation in traditional crafts. 3D printing offers unique opportunities for transforming the batik industry, particularly in terms of enhancing production methods, creating intricate patterns, and increasing design precision. This technology allows for more efficient and customizable production of batik tools, such as copper stamps (canting cap), which are essential for applying wax onto fabric in the batik-making process. By using 3D printing, artisans can experiment with complex, detailed motifs that would be difficult to achieve using traditional methods alone. Previous studies have highlighted how several Indonesian researchers and innovators have played a crucial role in advancing the batik industry through the adoption of modern technologies, including 3D printing. These contributions have had a significant impact on various aspects of the batik sector: a) Improving the Quality of Indonesian Batik: With 3D printing technology, artisans can produce more consistent and high-quality designs, reducing the likelihood of human error during the creation process. The precision of 3D-printed tools enables the creation of more intricate and uniform patterns, which enhances the overall aesthetic and quality of the finished batik fabric. Additionally, 3D printing offers new possibilities for design experimentation, allowing batik makers to push the boundaries of traditional patterns while maintaining cultural authenticity.b) Strengthening the Batik Economy: The use of 3D printing technology in batik production can streamline the manufacturing process, reducing labor costs and increasing efficiency. This enables batik businesses to scale up production and meet growing demand, both domestically and internationally. By incorporating 3D printing, the batik industry can also attract younger generations of artisans and entrepreneurs who are interested in blending tradition with technology, thus revitalizing the market and creating new economic opportunities.c) Improving Health and Safety in the Sector: Traditional batik-making involves the use of hot wax and chemical dyes, which can pose health risks to workers over time. By introducing 3D-printed tools and automated processes, the physical strain on artisans is reduced, and exposure to hazardous materials can be minimized. Researchers have explored ways to use 3D printing to design ergonomic tools and develop more sustainable production methods, ultimately contributing to safer working environments for batik makers.

Computer Numerical Control (CNC) machines have started being used in the batik industry because of the need to enhance batik production time to cope with the increasing demand and the lack of batik artisans. The Figure 1 below is the example of CNC batik Automatic Machine. This machine's batik waxing procedure is similar to hand-drawn batik, with a carving of batik wax on fabric. Depictions of wax patterns are done through the g-code command. Thus, the same concept applies to the 3D printer because it uses the same language and method since it consists of the X-axis and Y-axis sliders, each using a stepper motor drive. This project aims to customize a 3D printer print head to extrude the batik wax and evaluate the production time and batik quality.


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**Figure 1:** Batik CNC based machine [4]

The advantages of 3D printers in terms of accuracy and precision are remarkably transformative in the manufacturing process. These machines offer unparalleled precision, allowing for the creation of highly detailed and intricate designs that are difficult to achieve with traditional manufacturing methods. This high level of accuracy is particularly valuable in industries where the exactness of design and intricate patterns are crucial, such as in craftsmanship and traditional art forms. Canting is a traditional batik-making process that requires high skills and precision. It is a time consuming and conscientious process from drawing the pattern to applying hot wax following the pattern line [10-15]. The hot and liquid wax sometimes clogs the canting tip. Thus, it will affect canting wax consistency during the process. The existing batik automatic canting machines are expensive and complex because they reverse engineering from CNC machines. It will require special software to generate the design g-code to draw the pattern [15-18]. The stability and precision of 3D printer are suitable to produce batik products in fast and consistent production. However, there are several limitations on the 3D printer before it can be applied to the batik canting process. The extruder on a standard 3D printer is for processing plastic filament. In this research, a 3d printer extruder that is compatible with paste/liquid extrusion has been design to observe canting wax extrudability and output at different steps speed during the printing process on the different patterns.

## 2.0 METHODOLOGY

The field study was conducted at Aisar Batik in Peringat, Kota Bharu for data collection canting proses using traditional method (hand) in this project. The canting method was hand-drawn with hot-melted wax on a piece of linen cloth by an expert as shown in Figure 2.

**Figure 2:** Batik canting process by hand-drawn


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The wax flow rate of a liquid is how much fluid passes through an area at a particular time. Flow rate can be articulated in terms of velocity, cross-sectional area, time, and volume. The volumetric flow rate depends on the temperature and filament. In general, the higher the potential flow rate, the lower the material's viscosity will be. Most FDM 3D printing materials become less viscous as the printing temperature is raised. The cold wax viscosity is less than melting polylactic acid in this instance[18-19]. In 3D printing, flow rate could affect filament inaccuracy in width and layer thickness. The cold wax is less viscous and considered as non-Newtonian fluid, the fabric thickness is considered layer thickness. The volume flow rate is calculated as in equation (1), where Q = Flow rate, v = speed (mm/s), A = Cross-sectional vector area:

$$Q=vA \tag{1}$$

Layer thickness = 0.20mm (fabric thickness), Speed, $v$ = 58.33mm/s (printing speed)

The wax is melted on a stove and then poured into a canting tool, which will be used to draw the pattern on the fabric. The wax used to print the patterns is batik cold wax. High levels of wetness penetration are present in the cold wax, producing a good and persistent batik barrier line. In order to suit with the wax characteristic, a new printer head has been design for canting process. The parts were illustrated in CAD software, including the parameters of the parts as shown in Figure 3. By using a stepper motor to control the plunger movement. The threaded shaft is pushed through a screw nut. Thus, the batik wax will come out of the syringe. The extruder motor controls the feed rate; the maximum print speed is 200mm/s. The print speed for paste will depend on the rheology of batik wax.

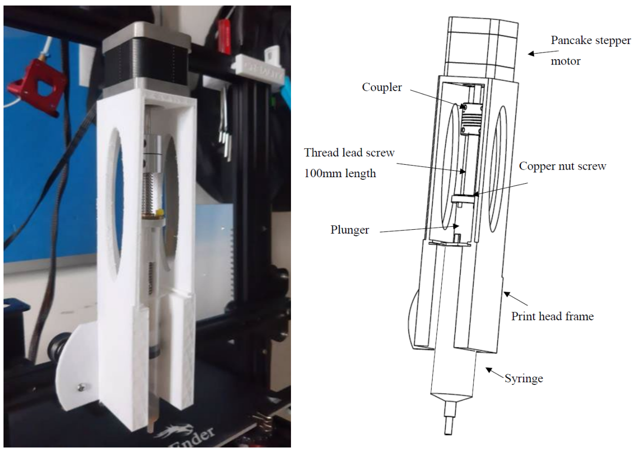


**Figure 3:** Canting printer head

In order to test the system , line pattern has been choose to evaluate the canting process for line consistency and repetition quality. The quality of the dots, line, shape and repetition to meet the good characterization of batik canting [19]. Thus, the repeated line pattern is suitable for meeting the requirement of canting characterization according to dimension as shown in Figure 4.


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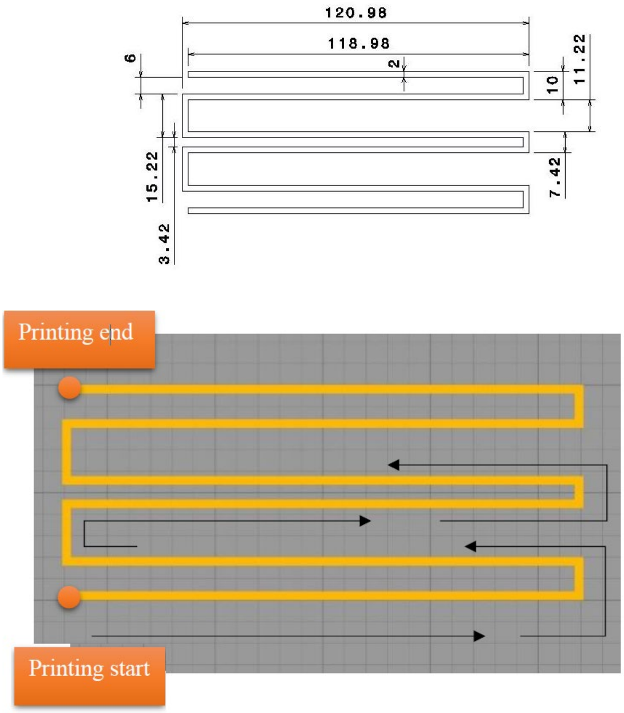


**Figure 4:** Line pattern with dimension (mm) [4]

## 3.0 RESULTS AND DISCUSSION

The experiments are executed with three different extruder steps (E-steps) at steps of 6 steps/mm, 8 steps/mm and 10 steps/mm. The E-steps setting determines how many steps are taken per unit of movement; in other words, E-step is the number of steps required by the extruder to extrude one millimetre of filament. In this project, the E-steps control the extrusion rate of the wax. By implementing syringe-based extrusion, the 3D printer head, which is designed to extrude melted plastic, is replaced with a syringe to contain canting wax. There is physical contact between the wax and the plunger in the stepper motor-driven piston system. Because the volume displacement is constant, this approach allows for better control of the extrusion rate. By imitating the canting's tip, the new head is attached perpendicular to the 3D printer bed on which a horizontal sheet of fabric was stretched. This mechanisation translates the batik pattern into the movement of its tip in x (horizontal, parallel with warp thread), y (vertical, parallel with weft thread), and z (up and down) coded numbers (G-code), resulting in the drawing of a line of wax following the pattern.

Figure 5a illustrates that during the initial phase of wax printing, the visibility and continuity of the wax line are compromised. The wax lines appear faint and incomplete, indicating that the flow of wax is inconsistent. This could be due to delayed wax extrusion, where the wax takes time to reach the optimal flow rate as it is dispensed through the nozzle. As a result, the early sections of the printed wax design lack clarity and definition, causing interruptions in the pattern or lines being formed. This delay in wax extrusion can impact the overall precision and quality of the design, requiring adjustments in the printing process to ensure continuous, well-defined lines from the outset. This arises because the initial printing process takes an extra restart distance of 5.00mm and the slow extrusion speed of 6 e-steps/mm. During the initial printing process, 5.00mm wax has retracted in the syringe, causing the delay of 6 steps/mm extrusion when printing begins. For 8e-steps/mm of extrusion, the visibility and consistency of the wax line are rather excellent than 6e-steps/mm, as shown in Figure 5b The initial printing process seems to be time well as the


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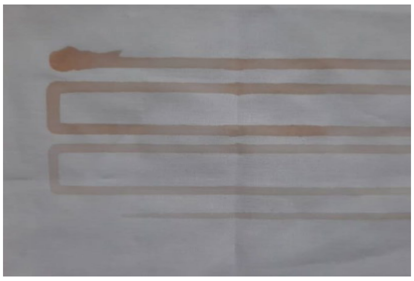
wax manages to be extruded and reach the build plate at the starting point of the pattern, leaving a relatively accurate trace of wax similar to the design. However, in the first printed line, the wax appears somewhat less visible and less consistent compared to the subsequent lines. This inconsistency may be attributed to a couple of factors. One possible reason is an uneven build plate level, which can cause variations in the distance between the nozzle and the printing surface. If the build plate is not perfectly leveled, it can lead to inadequate contact between the nozzle and the surface, resulting in insufficient wax deposition in certain areas. Another potential cause could be the retraction setting during the initial phase of the printing process. Specifically, the retraction of 5.00mm, which refers to the backward movement of the wax filament within the nozzle to prevent oozing, combined with the extra restart distance, may delay the resumption of wax extrusion when the printer begins laying down the first line. This slight delay can cause the initial section of the wax line to appear less pronounced or incomplete compared to the other lines where the flow of wax has stabilized. These factors may require careful adjustment to enhance the continuity and visibility of the wax lines from the very beginning of the printing process. Ensuring a smooth and uninterrupted flow of wax is crucial for achieving clean and precise patterns, especially in intricate designs typical of batik craftsmanship. The solutions to this problem are to level the bed evenly and reduce the retraction value as the 8 e-steps/mm can extrude the wax timely when the wax touches the build plate.

For the 10 e-steps/mm result, as shown in Figure 5c, the extrusion of canting wax seems to extrude excessively at lines 3,4,5 and 6. The inconsistent wax extrusion causes overly wax on the pattern, thus, causing wet wax to be abundant and spready. During the initial printing process, the visibility of wax is relatively poor and inconsistent with various widths produced. According to a previous journal, one drawback of this setup is the time it takes to start and halt the extrusion process, which might lead to imprecise printing [14-16]. The retraction speed of wax at the initial printing may cause the air to enter the syringe; thus, when extrusion happens, the wax will not timely reach the build plate accordingly to the tool path.



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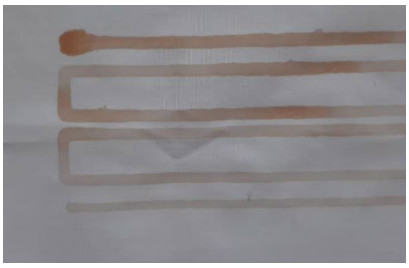

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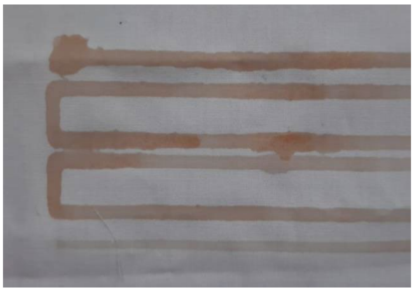

c

**Figure 5:** 3D printing canting pattern; (a)6e-steps/mm (b) 8e-steps/mm (c) 10e-steps/mm

The syringe nozzle plays a crucial role in regulating the flow of viscous wax during the 3D printing process. It acts as the gateway through which the wax is extruded onto the printing surface, and its design, in conjunction with the printer's settings, directly influences



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the accuracy and quality of the printed patterns. However, the retraction rate needs to be timely with the extrusion process. For 6e-steps/mm, the wax starts to extrude and touch the fabric at 22mm of the line pattern. Because of the slow extrusion of 6e-step/mm and retraction on initial printing causing, wax does not efficiently extrude accordingly. Based on the data in Figure 6, the volume flow rate of 6e-steps gradually increases as the plunger pushes the wax out of the syringe; based on the printing result above, on lines 3,4 and 5, the canting wax extruded smoothly, printing an excellent straight line without breaking. However, a noticeable issue arises at the end of the printing process where a wax blob forms as the extruder retracts. This occurs due to the release of trapped air within the syringe. As the extruder begins the retraction phase, meant to pull back the wax and halt extrusion, the trapped air is forced out, inadvertently pushing out a small amount of wax. This sudden expulsion of wax causes an unwanted accumulation, or blob, to form at the end of the printed pattern. This problem stems from the inability of the retraction mechanism to fully control both the wax and the air trapped within the syringe. As the air escapes, it forces the remaining wax to flow more aggressively than intended, resulting in the wax pooling in one area rather than tapering off smoothly. This blob formation disrupts the continuity and precision of the printed design, leaving an unsightly and thicker deposit of wax at the termination point of the pattern.

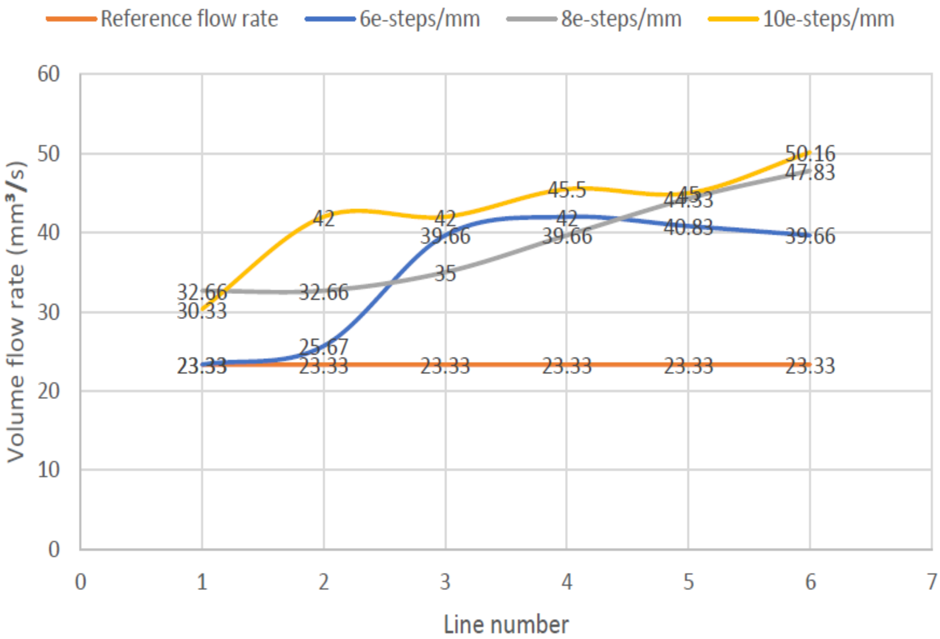


**Figure 6:** Volume flow rate at different line for each steps/mm setting

Table 1 shows the lines width measured for each extrusion setting. The width of lines made during 3D printing is relatively homogeneous due to extrusion at 6e-steps/mm. Line thickening during the printing process can be attributed to trapped air pressure within the syringe, which causes the wax to be expelled more forcefully and abruptly than anticipated. This sudden release of pressure, especially towards the end of the print, results in the wax being extruded in larger quantities than intended, leading to the thickening of the wax lines. The trapped air creates an inconsistent flow, disrupting the smooth, controlled deposition of wax required for precise pattern formation.

Moreover, maintaining consistent control over the wax temperature poses an additional challenge. Wax viscosity is highly temperature-dependent, meaning that even slight fluctuations in temperature can significantly impact the flow rate. If the wax becomes too hot, it may flow too quickly, causing instability in the lines and making it difficult to maintain uniform thickness throughout the pattern. Conversely, if the temperature drops


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too low, the wax may solidify prematurely, leading to incomplete or irregular lines.Nonetheless, the author mentioned the "nerusi" technique that uses the canting (make a line on the back of the fabric to revise the line where the wax was not perfectly penetrating the fabric) [6]. For 8e-steps/mm, the volume flow rate of wax extrudes increased over printing distance. The width of lines acquired from the printing result is relatively homogenous according to the previous journal, as the author's result with an excess line of 2-3mm[6]. The increment of volume flow rate in all lines seems to rise slowly and relatively consistent as the line produced in width on the line of the pattern has a little increment of 2 to 3mm. Thus, it can be decided that 8 e-steps/mm is potentially good extrusion speed for canting wax.

For 10e-steps/mm, there are some sudden increments in volume flow rate that occurs on line 2 and so on; the reason for the low flow rate on line 1 because of the retraction process that sucks up and retracts the wax by 10e-steps/mm, causing the wax delay to reach the build plate. The ununiform line produced by extrusion of the wax proves that 10e-steps/mm extrusion is too high for a slightly viscous wax. At the end of the printing process, even though reaching a coasting distance of 70.00mm at the end of the pattern, the wax still overflows, causing excessive wax blobs on the fabric when the extruder stops.

**Table 1:** Line width and volume flow rate for each step extrusion

| Line | Width (mm) | | | Volume flow rate ($mm^3/s$) | | |
|---|---|---|---|---|---|---|
| | 6e-steps | 8e-steps | 10e-steps | 6e-steps | 8e-steps | 10e-steps |
| 1 | 2.0 | 2.8 | 2.6 | 23.33 | 32.66 | 30.33 |
| 2 | 2.2 | 2.8 | 3.6 | 25.67 | 32.66 | 42.00 |
| 3 | 3.4 | 3.0 | 3.6 | 39.66 | 35.00 | 42.00 |
| 4 | 3.6 | 3.4 | 3.9 | 42.00 | 39.66 | 45.50 |
| 5 | 3.5 | 3.8 | 3.9 | 40.83 | 44.33 | 45.50 |
| 6 | 3.4 | 4.1 | 4.3 | 39.66 | 47.83 | 50.16 |

## 4.0 CONCLUSION

This project has been successfully completed with the development of a 3D print head specifically designed for canting wax, along with an assessment of the extrudability of the wax to create intricate batik patterns. The primary objective was to enable precise wax deposition using a 3D printing process, mimicking the traditional batik method while incorporating the benefits of modern technology. The low extrusion steps of 8 extrusion steps per millimeter has good extrusion speeds for viscous fluid like canting cold wax. The line produced relatively more consistent compared to other extrusion steps.

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## CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this paper.



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