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Exploring computer-to-screen applications for innovating a conventional screen-printing practicum

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Short abstract

This research explored and developed computer-to-screen (CTS) applications for innovating a conventional screen-printing practicum utilizing a MIMAKI UJF-6042 on-demand piezo head flatbed printer to image a stencil directly onto the mesh of a prepared screen. A test target was applied to standardize the imaging process and gauge the coverage that would sufficiently block out and hold a stencil to create an image. The project's goal was to develop a CTS system that would produce screens for spot color printing, replacing the make-ready consumables, shortening preparation time, and maintaining the quality accepted in comparable conventional screen imaging systems. A longer-term goal was to implement this innovative CTS procedure into the existing curriculum on a conventional cylindrical printing project for a practicum using an Innovative Machines Cylindrical Screen Press. This proposed CTS process would replace the traditional lab work of students creating digital single spot-color designs that are processed through a digital workflow into a TIFF file for outputting on a Kodak Trendsetter. The film positives are imaged onto a 230-mesh polyester screen prepared with Capillex-20 capillary film emulsion. The final steps include washing the exposed image, drying, blocking out, and redrying the prepared screen before setting up the press and printing on cylindrical glassware. Installation of the new CTS process predicts a reduction in consumables, shortening the preparation time and preferable alleviating mishaps observed in the conventional process.

Keywords: computer-to-screen, inkjet-to-screen, screen-printing, inkjet technologies

1. Introduction

Stenciling and screen-printing methods have much in common. The earliest form of human artistic expression, stenciling covers the walls of European caves. Stenciling applications existed over 40 000 years ago when early humans created hand stencils using various techniques for applying pigments onto the cave walls. Early forms of screen-printing appeared between 960 to 1279 AD in China. The Song Dynasty developed screen-printing – a technique that used silk mesh and ink-blocking methods developed from earlier stenciling practices. Japan took hold of the idea to incorporate stenciling on silk mesh and advanced the process for many years. (Lengwiler, 2013), and (ooshirts, n.d.).

Fast forward to modern applications and technologies, several U.S. patent applications and state-of-the-art inkjet technologies employ computer-to-screen (CTS) imaging systems for the preparation of print screens, as well as producing an image on a printing screen (Baxter, et al., 2006; Bourne, et al., 2006). There are predominantly three dissimilar technologies for exposing an UV photo-sensitive coated mesh used as a stencil in screen printing with an UV light source (Gmuender, 2017). First, film exposing, either directly mounted on the stencil, or indirectly imaged by using a projector. Second, direct exposing using Digital-Micromirror-Devices (DMD) or a UV laser beam, also called CTS. Third, Direct-to-Screen (DTS) where first the image is printed on the stencil by an ink jet printer and then in a second process is exposed by a UV lamp (Gmuender, 2017).

- In the 2006-Bourne patent, a specific formulated emulsion is mixed with a cross-linking agent to create a self-curing image (Bourne, et al., 2006).
- In the case of the Baxter patent, a photo activated emulsion is applied to a printing screen. The emulsion is using a laser as direct imaging technique to create an image in that emulsion. (Baxter, et al., 2006).
- In 2008, Berner developed an exposure device to produce screen print stencils (Berner, 2008). Berner's exposure system had a light source, and a lens system in an exposure head that yielded digital signals connected with the exposure system. Several laser diodes on the exposure unit controlled by the signals are guided to a raster plate in the exposure head. The light output of the raster plate is transferred to a focusing lens system in the exposure head (Berner, 2008).
- Nearly a decade later, a patent by Van Ness (2015), developed a screen-printing device and methodology for exposing an emulsion coated screen to light comprises an array of ultraviolet light emitting diodes (UV-LEDs). This system created a positive impression of the artwork to be printed; a flat transparent plate disposed between the array of UV-LEDs and the positive impression; a screen coated with a light-curable emulsion; the positive impression disposed on the side of the screen having the emulsion (Van Ness, 2015).
- More recently a patent by Oleson (2017), a mechanical system in which pre-stretched emulsion coated screens, digitally prints thereon, and exposes them before further processing and use in a screen-printing machine. Some of these patents have shown commercial value, as in the, "i-Image ST™ CTS Imaging System: from the M&R Companies (2022).

2. Materials and methods

In developing a CTS application, this research used an inkjet printer to print a stencil directly onto the mesh (ScreenPrinting, 2022) in a hybrid screen printing process. This research tested the functions of UV curable primer in a MIMAKI UJF-6042 (Mimaki, n.d.) on-demand piezo head flatbed inkjet printer (Figure 1) to prepare print screens. The project's goal was to develop a CTS system that would replace the need for emulsion and film for transferring an image to a tensioned mesh screen. The objective was to produce single-spot color screens for cylindrical printing on an Innovative Machines LP 400E Cylindrical Screen Press (Figure 2). Students create a digital single spot-color design for this specific cylindrical printing project. Once students create their digital file within the constraints and the desired specifications of the project, their files are converted into a TIFF file through ESKO's "Packedge/Automation-Engine" applications in a digital workflow process for outputting Kodak DITR film on a Kodak Trendsetter NX-Mid. These film positives are next imaged on a prepared 230-mesh polyester aluminum screen with Capillex-20 capillary film emulsion. The final steps include washing out the exposed image, drying, blocking out, and redrying the prepared screen before setting up the cylindrical screen press and printing on glassware.

Figure 1: MIMAKI UJF-6042 (Mark I Series) on-demand piezo head flatbed inkjet printer

Figure 2: Innovative Machines LP 400E Cylindrical Screen Press

2.1 Conventional process

The conventional system for preparing screen-printing frames for cylindrical printing is roughly a three to four-hour process if completed without any errors. Students complete this assignment individually and are presently allotted two to four labs (2 hours, and 45-minutes each) depending on the number of students enrolled in the lab. These labs are administered as rotating modules to better utilize space and equipment. Several of the steps are crucial in the process and mistakes can be made. If an error is made, then the process must be repeated to complete the project. The preparation of screens for this conventional process includes:

1. Processing digital files into film (30–60 minutes)
   a. This film also serves as a proof for checking the image quality on the glassware.
2. Cleaning, degreasing, and drying the mesh completely (30–45 minutes)
3. Application of capillary film and redrying the mesh thoroughly (50–60 minutes)
4. Imaging prepared screens correctly (5 minutes). If incorrectly, back to step 2.
5. Washing-out imaged capillary film (3–5 minutes). If incorrectly, a damaged stencil, back to step 2.
6. Drying the mesh, blocking out open mesh, and re-drying the block-out (45–60 minutes).
7. Prior to mounting the screens on the press, students prepare .025 pounds (11.34 ml) of ink, and .005 pounds (2.27ml) of catalyst mixed and allowed to bond for 20 minutes prior to printing. While waiting on the ink, their screen is mounted on the Innovative Machines LP 400E Cylindrical Screen Press (Figure 2). Students are encouraged to obtain a standard pint size glass with smooth flat sides in its profile (Figure 3).
8. Post-printing, remove ink, wash-out and reclaim screen for next student in the rotation.

Consumables: Kodak DITR film, Capillex-20 capillary film emulsion, Quick-dry Block-out, RE190 Thinner, ICC877 Degradant, ICC861 Degreaser.

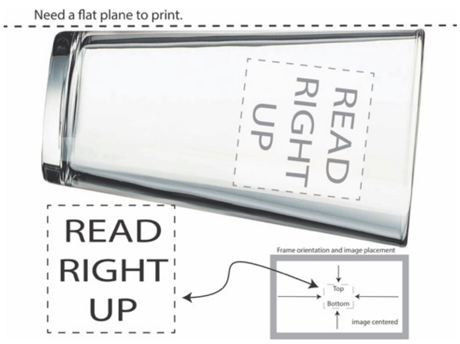


Figure 3: Standard pint size glass with smooth flat sides for printing

2.2 Hybrid inkjet stencil process

The proposed hybrid screen preparation process would include step 1, digital image preparation in the conventional system previously outlined, would eliminate steps 2 through 5 if the previous screen printer efficiently cleans the screen in their step 8. The new proposed hybrid inkjet stencil process includes:

1. Process digital files into single spot-color graphic as a TIF file. Upload to file server.
   a. Students are required to use this single spot-color graphic file to produce a proof on an alternate inkjet printer on transparent film prior to creating screen.
2. Load clean screen onto the platform of the MIMAKI printer (10 minutes)
3. Load prepared spot-color graphic into the printer's imaging software. (2–3 minutes)
4. Print two layers of primer @ 100 %, and a third layer of ink @ 100 %. (8–10 minutes)
5. Unload printed frame. Block-out the ink rest area mesh prior to cylindrical printing (20–30 minutes)
6. Preparation of ink… (30 minutes) (See Step 7 in Section 2.1)
7. Post-printing, remove ink, wash-out and reclaim screen for next student in the rotation

Consumables: UV Primer PR-200, UV ink LF140 White, Quick-dry Block-out, RE190 Thinner, ICC877Ink Degradant, ICC861 Degreaser.

2.3 Formulation and trials

The method and equipment for imaging a screen-printing screen utilized the capabilities of MIMAKI UJF-6042 on-demand piezo head flatbed printer to print a stencil on the exterior side of a print screen. The flat bed was able to adjust to the height of a standard 10" × 14" aluminum screen printing frame and self-adjusts the print heads so to print directly onto the various screen materials. Previous research on creating stencils for various mesh counts: 195, 230, and 420 found that a 230-mesh-count offered the best results in creating a durable and high coverage stencil (Blue, 2021). The test target (Figure 4) was developed to compare and seek to accomplish the capabilities of the capillary film. The priority was to test the inkjet-printed stencil's capacities to match the details achieved in capillary film as well as exceed the durability of a conventionally produce screen. Chemical properties of combination ink and added hardening catalyst require the use of caustic thinner and isopropyl alcohol for maintaining the fluidity of the ink and cleaning the stencil during longer printing applications. The inkjet-printed stencil needed to do as well as conventional systems.

The intent of this research was to print an adequate application of inkjet UV curable primer of a test target (Figure 4) to confirm the amount of coverage that would sufficiently block out the ink that passes through a screen. Based on previous research, and suggestions by the OEM to use primer instead of ink for creating the stencil. Primer provided better adhesion qualities for better results in creating an acceptable stencil (Blue, 2021). Previous trials involved testing a variety of applications of inks and primer on a range of mesh counts. Those initial formulations and process controls lead to the recommendation of applying two layers of primer to sufficiently create a stencil (Blue, 2021). Once the initial target was produced on the screen with two layers of primer, a third layer of white ink was printed onto the target stencil. This was done to counter the tackiness of the primer. This application of ink provided a smooth shell over the primer. The concern was the tackiness of the primer may affect the screen's contact with the glass substrate and attract unwanted ink deposits on the contact side of the screen. The prepared frame with print target stencil was setup on the cylindrical press, ink added, and trials commenced (Figure 5).

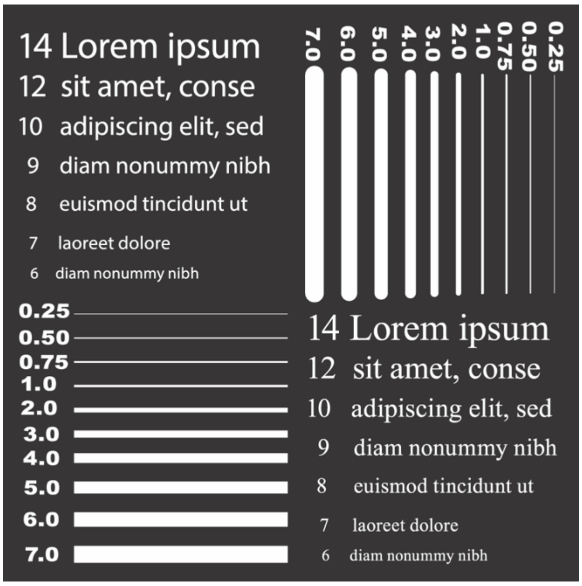


Figure 4: 3 × 3 inches (7.62 cm × 7.62 cm) test target for an inkjet-printed stencil for cylindrical printing

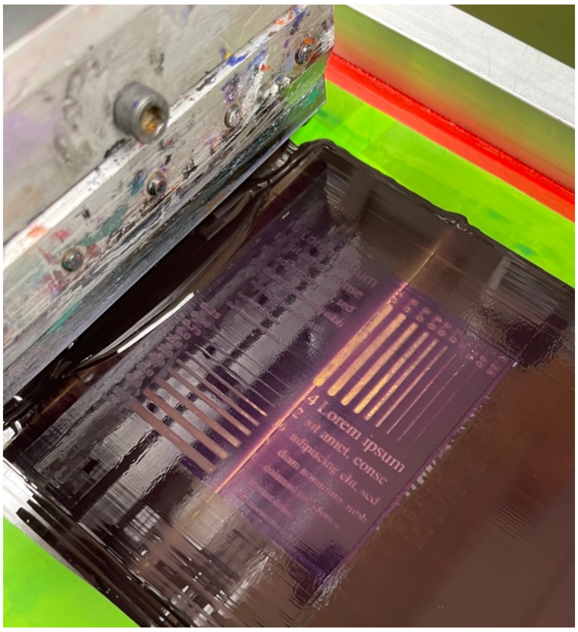
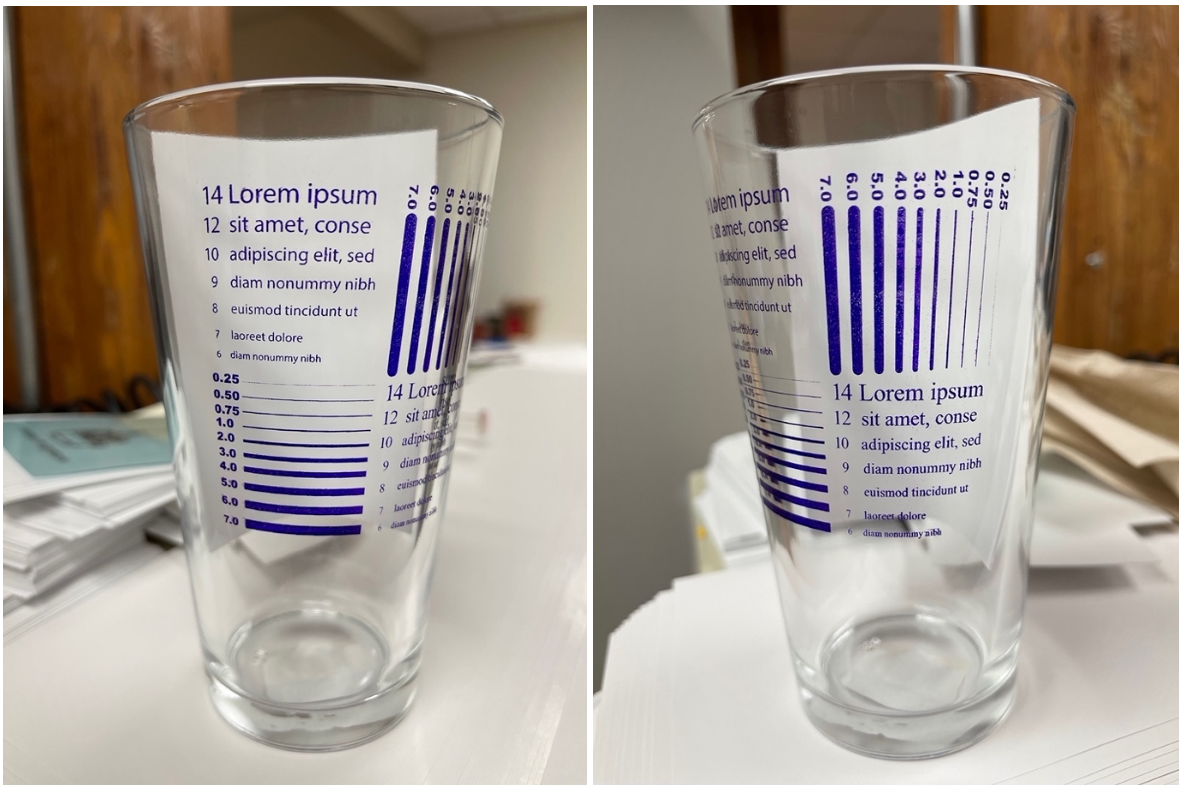


Figure 5: Printing the imaged stencil onto cylindrical substrate

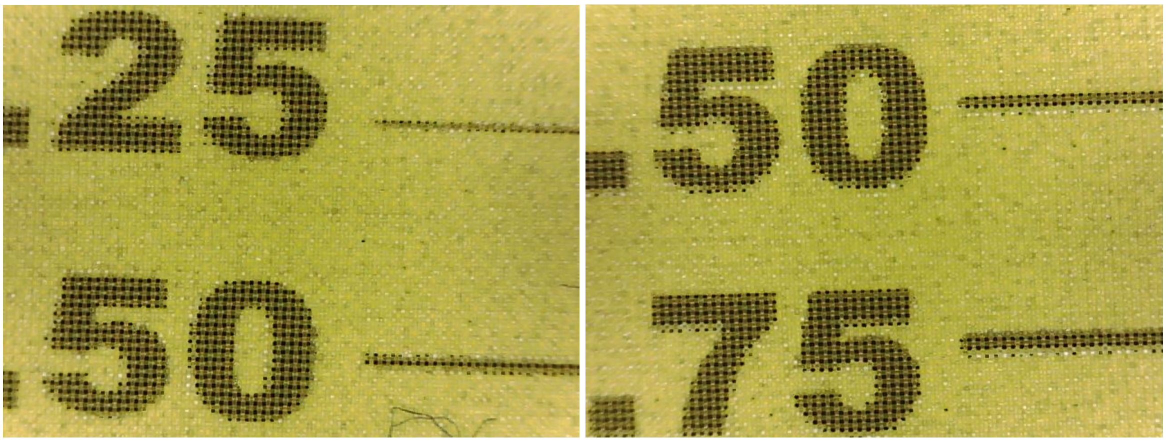
3. Results and observations

The Mimaki UJF-6042 (Mark 1 Series) printer used in the project is an older model with limited profiles available. This model has the capacity to produce 1 800 × 1 800 dpi. However, the default profile on this machine produced a resolution of 720 × 900 VD. The VD stands for "variable dot" and there are three sizes produced. The smallest is stated as 4 pL, and the other sizes are approximated as 8 pL and 12 pL. The average droplet size would be 8 pL. Considering the limited access to control the resolution of profiles, for future testing for this type of stencil creation, a standardized dot size would be optimal.

In Figures 6 and 7 the results demonstrate the capabilities of the inkjet-printed stencil. The 0.25-point line showed the least desirable results, however in the project in which students would be designing graphics, one of the constraints require students to limit any line art to 1.0-point. Regarding the font sizes, the stencil could reach a readable 6-point font for serif and sin-serif fonts. However, the project's design constraints for this project require any fonts used to be 12-point or larger. To ensure better visuals for the application of the primer, a Dino-lite™ Digital Microscope was used to take pictures of the primer/ink applications on the mesh. Figures 8 and 9 show the capabilities of the inkjet-printed stencil. Though the 0.25-point printed results were the least desirable, the outcomes exceeded the 1.0-point constraints.



Figures 6 and 7: Printed glassware from inkjet-printed target trials



Figures 8 and 9: Enlargements of .25-point, .50 point, and .75-point lines

3.1 Updated process

1. Inkjet applications of one layer of primer, and a second layer of white ink of the (3 × 3 inch) Line art [in reverse] onto the outer surface of the 10 × 15 aluminum screen. (7 minutes)
2. Block-out remainder of screen with conventional block-out solution and/or masking taped the image edges.

3. Setup for the Innovative Machines LP 400E Cylindrical Screen Press for standard screens and tapered pint glassware.
4. Prepare epoxy ink with catalyst for glassware (20 to 30-minute prep-time)
5. Load imaged screen, load glassware, make necessary adjustments.
6. Introduce ink onto screen, began printing paper samples, make adjustment, print glassware.

3.2 Stencil durability, screen reclaim, and cleanup observations

Some of the early concerns in developing this CTS application for innovating a conventional screen-printing practicum in the classroom for students is one, the durability of the printed stencil, and secondarily, how easily the inkjet printer primer and ink could be removed, and the screen reclaimed for further use. In Figures 10 "*squeegee side of the mesh*" and 11 "*print side of the mesh*" demonstrate the durability of the inkjet-printed stencil. The ink has been removed using RE190 Thinner and ICC-871 Ink Degradant to remove the ink leaving the stencil and the block out. At this point the stencil is intact and showed no ware or degradation. The ink and ink thinner were left on the screen post-printing for over an hour to test the stencil's durability to the chemicals used. In a laboratory classroom setting the screens are clean immediately after printing.

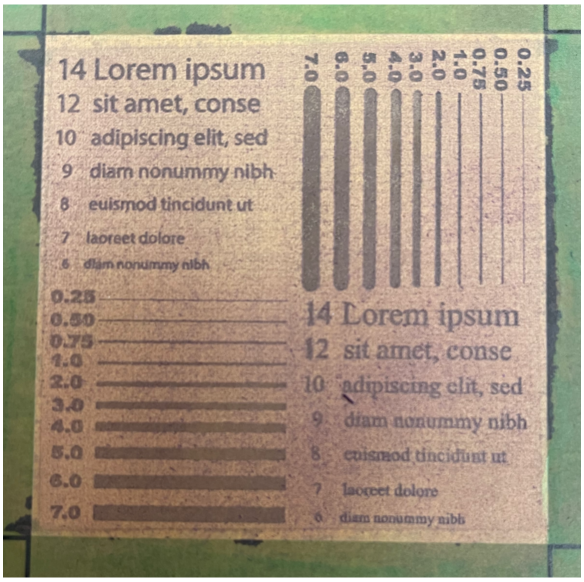


Figure 10: Squeegee side of the mesh

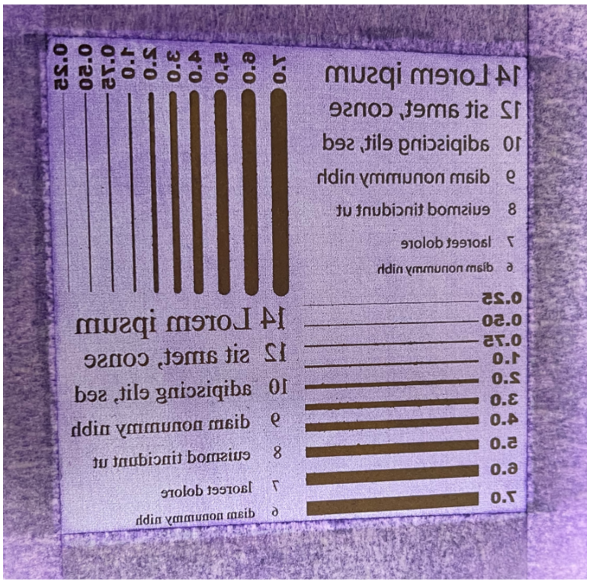


Figure 11: Print side of the mesh

In cleaning the screen's block-out, the green colored residue used for blocking out parts of the screen where there is no stencil, this was easily removed with water (Figures 12 and 13). At this point water without high pressure had little effect on the printed stencil. Some residue ink can be seen in the open spaces in the stencil. The next step will be to remove the printed stencil a high-pressure washer.

In cleaning the screen, there was some concern if the UV-cured inkjet-printed stencil would need specific products or processes to be removed from the mesh, however as noted in Figures 14 and 15, the stencil is easily removed by a pressure washer. In all previous research as in the case of this research, no chemical was needed to remove the stencil once the printing ink and block-out product were safely removed. The cleaning of the stencil took less than a minute to remove with no other chemicals, the residual ink cleaned up with some additional treatment. The finished clean screen, once dry is ready for re-use.

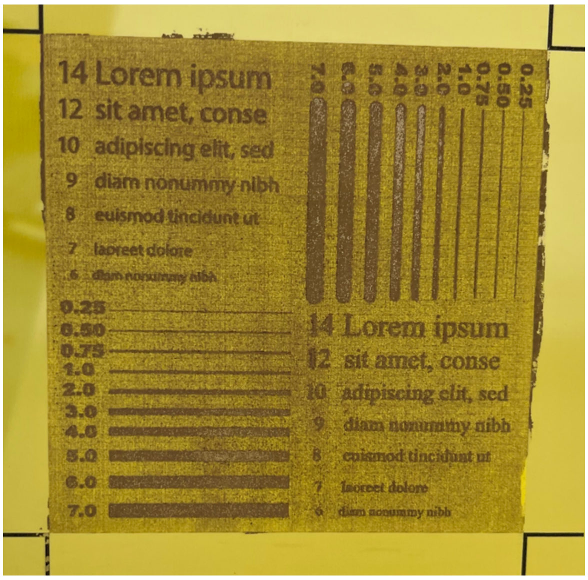


Figure 12: squeegee side of the mesh

Figure 13: print side of the mesh

Figure 14: Pressure washing 1

Figure 15: Pressure washing 2

4. Conclusion

The time spent preparing screens using the conventional system involved, 3 to 4 hours. The time spent on preparing screens in the CTS system took 1.5 to 2 hours. These achievements in utilizing a CTS process in a course practicum would shorten the preparation time, reduce costs in consumables, and alleviate possible mishaps in screen preparation. The CTS findings held up to the standards of conventional capillary film for single spot color reproduction. The shortened preparation time for processing screens provides opportunities for entertaining new design aspects beyond single-color applications to multiple spot color cylindrical printing, or several line-art graphics. These considerations allow greater experiences in learning and exposure to research.

Previous research in inkjet-printing stencils sought to develop CTS screens for four-color process printing (Blue, 2021). Attempts to create halftone and stochastic screens proved problematic yet a proof of concept was achieved. Returning to that work is a goal for future research in CTS technologies. Much of the knowledge obtained in developing those four-color projects assisted in making this CTS single-color project viable. The variable-dot characteristics of these on-demand piezo printers can produce exceptional photo-like images in high detail (Figure 16). However, the varying dot sizes produced should be taken into consideration when limited profiles are available. Profile development and considerations for this type of stencil creation on mesh and a standardized dot size would be optimum. The opportunity to have students explore and develop a CTS system for innovating a conventional screen-printing practicum through discovery has encouraged positive outcomes.

Figure 16: Primer cylindrical printing with inkjet produced stencils

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