# Print Quality of Laser-Engraved Clichés for Pad Printing

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## Abstract

Polymer and steel are widely used materials for making pad-printing clichés. Polymer clichés are typically produced in house using a photographic method involving exposure with film positives followed by development. There are many steps in the process, which affects consistent quality. The production of steel clichés is usually outsourced to professional etching houses because aggressive chemicals are used in the etching process. It is difficult to get straight-walled etching because pooling of the chemicals causes uneven edges and rough bottoms. Computer to plate (CTP) systems utilizing laser engraving to make clichés are available in the market today. They eliminate film and chemicals. They ensure direct image output and eliminate the myriad variables and time-consuming steps required in conventional methods. However, little research has been done yet to evaluate the print quality of laser-engraved clichés. In this study, a $CO_2$ laser cutter from Universal Laser Systems was used to engrave the image areas on polymer clichés. The laser system has a power of 150 watts and the laser beam has a spot size of 0.001 inch, which ensures fine detail reproduction. Image resolutions are determined by pulses per inch (ppi) in the lateral direction and dots per inch (dpi) in the downward direction. Highest available resolution was used, which was 1000 ppi by 1000 dpi. Laser power and engraving speed determines the depth of the ink wells. These two engraving parameters were varied to obtain optimum results. It was found that 100% speed with 11% power created an optimum etch depth. A vector image and images with large open areas that were screened with different settings were laser-engraved on clichés and printed on a pad printer Model Sealcup 60 from Trans Tech. The engraved sidewalls appeared to be straight and pooling of ink did not occur in the printing process, thus produced high print quality of line arts. Images with large open areas that were screened at a maximum angle of 45° with the doctoring direction and a high screen frequency of 200 lpi had the best


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print quality and highest print density. Differences between dot shapes were only observed when the screen frequency was low.

## Introduction

Pad printing is an indirect intaglio printing process based on recessed images. It uses an image carrier called *cliché*, which has image areas engraved on its surface. During the pad printing process, a proper pad is selected by shape and hardness and attached to a pad printing machine. Ink for pad printing is weighed and mixed with a prescribed amount of thinner. A closed ink cup is filled with the prepared ink and the cliché is placed onto the ink/cup assembly and then attached to the pad printing machine also. The machine swipes the ink filled cup over the cliché filling the recessed areas with ink. The pad is then lowered and pressed onto the cliché in a rolling motion that allows the ink to be lifted up and out of the cliché. The machine then positions the pad above the substrate to be printed and lowers the pad where the rolling motion is again repeated, this time releasing the ink onto the substrate surface. The pad is lifted away from the surface and the substrate is removed from the printing area (Kiddell and Swift, 2004).

Polymer and steel are widely used materials for making clichés. Polymer clichés are typically produced in house using a photographic method involving exposure with film positives followed by development. It begins with a positive image reproduced on a film. A polymer cliché is placed under the positive and then both are placed into a vacuum-sealed chamber and exposed for a specific amount of time. The positive image is then removed and a second positive image of halftone screen is applied and the cliché is exposed for a second time. The positive is removed and the cliché is washed to remove any excess emulsion or dust. The cliché is inspected carefully at this point to ensure that no random marks or dust are on the surface. Finally the cliché is baked to completely harden the remaining emulsion, leaving the image etched as a recessed area on the cliché (Swift and Kiddell, 2002). There are many steps in the process, which affects consistent quality. The production of steel clichés is usually outsourced to professional etching houses because aggressive chemicals are used in the etching process (Adner, 2005). It is difficult to get straight-walled etching because pooling of the chemicals causes uneven edges and rough bottoms.

Computer to plate (CTP) systems utilizing laser engraving to make clichés are available in the market today. They eliminate film and chemicals. They ensure direct image output and eliminate the myriad variables and time-consuming steps required in conventional methods (Adner, 2005). However, little research has been done yet to evaluate the print quality of laser-engraved clichés. In this study, a laser cutter at Ball State University was used to make polymer clichés and their print quality was evaluated.

## Experimental

A PLS6.150D Laser Cutter/Engraver from Universal Laser Systems was used to engrave the image areas on a cliché. The laser system uses a $CO_2$ laser and has a power of 150 watts. The high power density focusing options (HDPFO) 2.0" lens made it possible to narrow the focus of the laser to a spot size of 0.001 inch, which ensures fine detail reproduction.

Image resolutions are determined by pulses per inch in the lateral direction (x-axis) and dots per inch in the downward direction (y-axis). Maximum resolution of 1000 pulses per inch (x-axis) and 1000 dots per inch (y-axis) was used to ensure fine detail engraving.

Laser power and engraving speed determines the etch depth of the ink wells. The higher the power is and the slower the speed is, the deeper the etch will be. These two parameters were varied to obtain optimum engraving depth of 18–25 microns (Adner, 2005).

H2-Orange clichés from Trans Tech were used. They have a polymer layer for imaging with a steel back layer. They were attached to a magnetic plate during laser engraving process so they could remain flat throughout the process. They were then baked for 30 minutes at an oven temperature of 200ºF to harden the printing surface.

A vector image of Ball State University logo, shown in Figure 1, was first used for engraving.

***Figure 1.*** *Vector image used for engraving.*

For pad printing, images with large open areas need to be screened (Kaverman, 2004). There are two reasons. First, most large open areas in images need to be screened to support the doctor blade or ring, preventing it from dipping down into the etch and pulling the ink out from below the level of the top surface of the cliché. This ensures a consistent ink thickness to pick up with the pad, instead of one thick on the edges and thin in the middle. Second, the little hills in the screened images provide resistance to the flow of the ink when the pad compresses to pick up the image. In large open areas the pad can produce a wave action in the direction it is rolling during compression. The screen gives the ink something to hold on to in the bottom of the etch until it is picked up by the pad, so that a nice consistent ink thickness is achieved. In order to test images with large open areas, an image of a 0.5”x0.5” square was screened with different settings as shown in Table 1, and then engraved on clichés.

***Table 1.*** *Image Screen Settings*

| **Dot Size (%)** | **Screen Frequency (lpi)** | **Screen Angle (°)** | **Dot Shape** |
|---|---|---|---|
| 90 | 200<br>150<br>100 | 45<br>0 | Square<br>Diamond<br>Round |

A pad printer Model Sealcup 60 from Trans Tech was used for pad printing, as shown in Figure 1. It is a single color pad printer. Black Type G Ink from Trans Tech was mixed with a thinner to obtain desired viscosity. A cone-shaped pad was used. Printing was done on a 60# uncoated paper stock.


***Figure 2.*** *Pad printer used for printing.*

## Results and Discussion

The power and speed settings of the laser engraver needed to be fine-tuned to achieve an optimum etch depth of 18–25 microns. It was found that maximum speed was needed because any slower speed would engrave a too deep etch. Therefore, 100% speed was used for all the following cliché engraving.

Different power settings were used and the results are shown in Figure 3. It shows that laser power and etch depth have a very strong positive linear relationship, with a $R^2$ value of 0.9785. Increasing power increased etch depth. It was found that 11% power setting resulted in an etch depth of 21.2 microns; therefore, 11% power was selected for all the following cliché engraving.

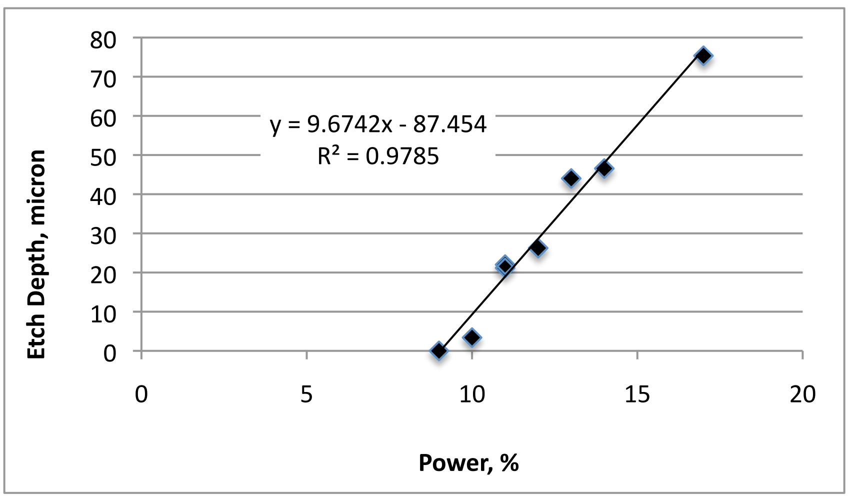



***Figure 3.*** *The relationship between laser power and etch depth.*

A laser engraved cliché is shown in Figure 4. Laser engraving created even edges and straight sidewalls, which were important for ensuring good print quality.

***Figure 4.*** *Laser engraved cliché.*

A printed vector image is shown in Figure 5. The overall print quality was good with uniform ink film thickness and optical density, and sharp edges.

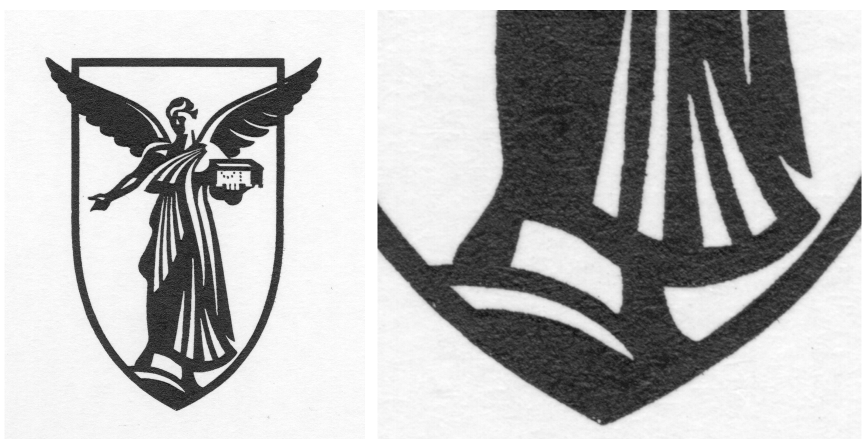
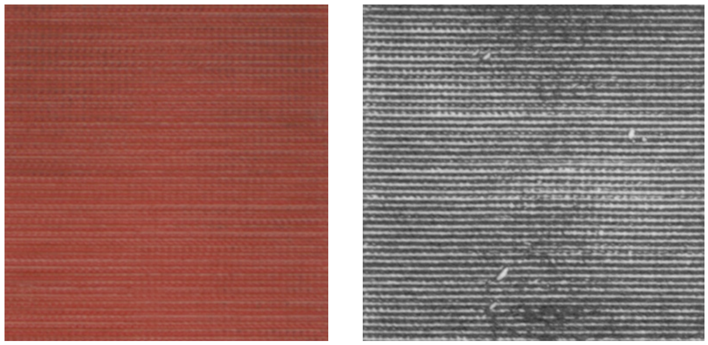
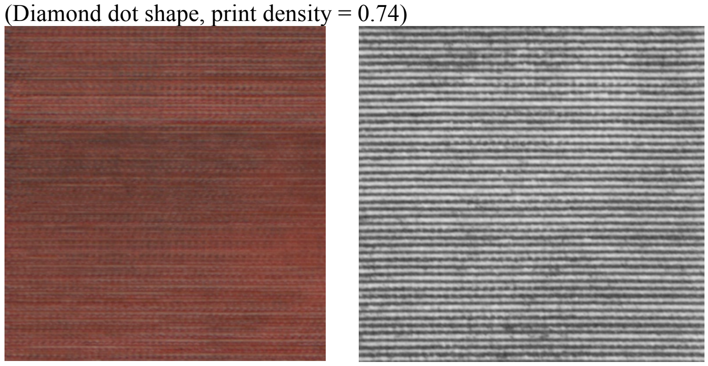


***Figure 5.*** *Pad printed vector image.*

As for screened images with large open areas, some of the engraved clichés and printed images are shown in Figure 6-8 for different screen settings. It was found that a cliché engraved with a screen angle of 0° printed a stripped image, as shown in Figure 6. The possible reason could be that the screen angle was parallel to the moving direction of the doctor ring so ink was pulled out from the ink wells during the inking process and there was not enough ink to cover the entire area.



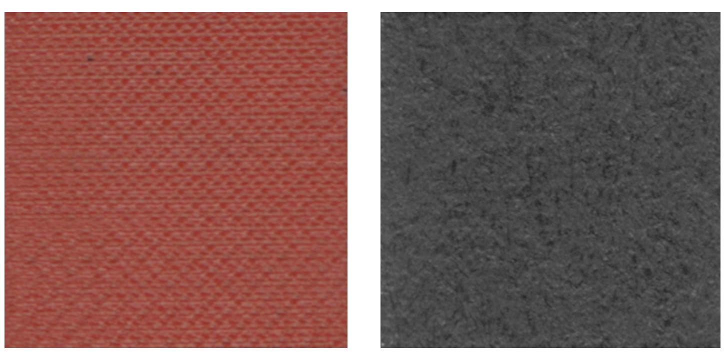
(Diamond dot shape, print density = 0.74)



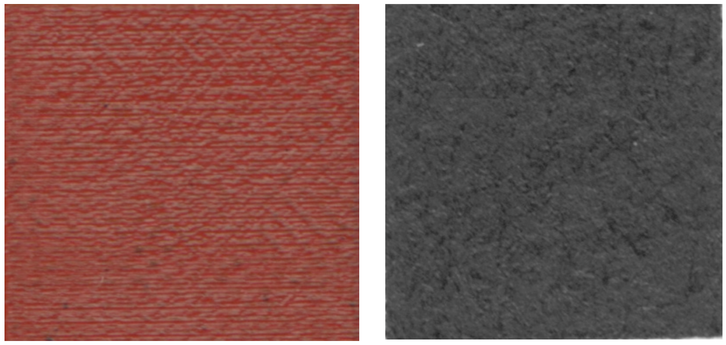
(Round dot shape, print density = 0.95)

***Figure 6.*** *Engraved clichés (left) and printed images (right) of an screened image with settings of 150 lpi and 0° angle.*

This problem didn't happen when the image was screened at a 45° angle, shown in Figure 7-8. The entire area was printed with consistent ink thickness.

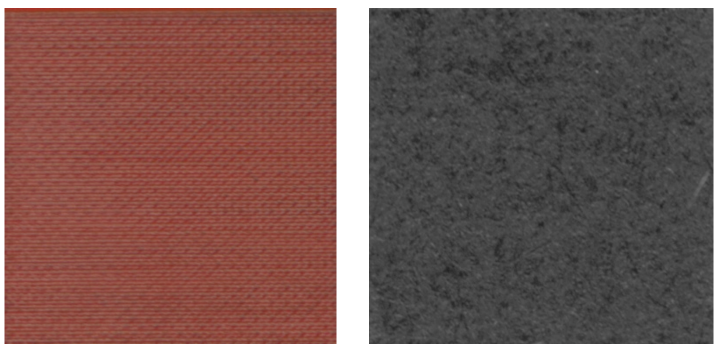


(Diamond dot shape, print density = 1.46)

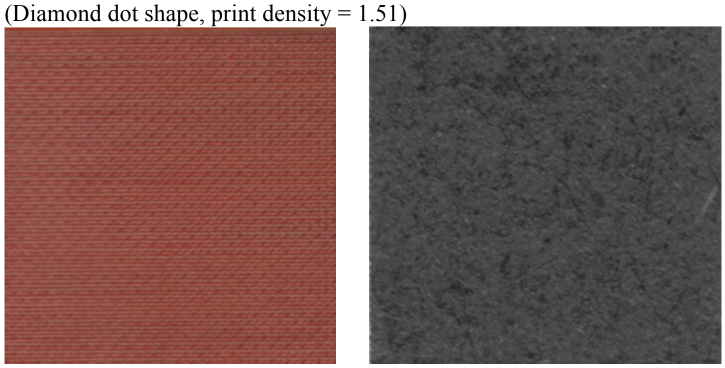


(Square dot shape, print density = 1.49)

***Figure 7.*** *Engraved clichés (left) and printed images (right) of an screened image with settings of 100 lpi and 45° angle.*



(Diamond dot shape, print density = 1.51)



(Square dot shape, print density = 1.51)

***Figure 8.*** *Engraved clichés (left) and printed images (right) of an screened image with settings of 200 lpi and 45° angle.*

Square dot shape resulted in a little higher print density with a low screen frequency of 100 lpi (Figure 7) and there was little difference between these two with a high screen frequency of 200 lpi (Figure 8). By comparing Figure 7 and 8, it was found that a higher screen frequency resulted a higher print density for both dot shapes. The ink wells were larger with a lower screen frequency; therefore, more ink would be left inside the wells without being transferred to the pad. Smaller ink wells would allow more, although not all, ink being picked up by the pad.

## Conclusions

Laser engraving output a digital file directly to a cliché, eliminating the transfer of an image to film and then to a cliché, thus considerable time was conserved. The sidewalls appeared to be straight and pooling of ink did not occur in the pad printing process, which produced high print quality of line arts.

Images with large open areas that were screened at a maximum angle of 45° with the doctoring direction and a high screen frequency of 200 lpi had the best print quality and highest print density. Differences between dot shapes were only observed when the screen frequency was low.

Consistency of etch depth over time is important and will be studied in the future. Images that combine fine details and large open areas will also be used and large open areas will be screened first before laser engraving.

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