RYETAGA

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chapter

2018

RyeTAGA

technical association of the graphic arts

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RYETAGA

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contents

A LETTER FROM THE ADVISOR

This year we have an excellent team and it is amazing to see the members work together to publish the journal and prepare for the conference.

As your time as a student at Ryerson comes to an end, you will remember these challenging times as the powerful and rewarding experiences that they are. Go out there and make the industry connections that will span your career and remember to consider every opportunity that opens its door to you. You have demonstrated outstanding teamwork, dedication, and autonomy, which will take you very far in your careers.

Warm regards,
Trung

about me

RyeTAGA has been instrumental to kick-starting my career in print. As a student member with RyeTAGA under my belt, I have been so lucky to have received many job offers and working opportunities upon graduation. It really is a microcosm of what it is like to work in industry. From marketing to production, I gained experience working cross-functionally with internal and external stakeholders to build the RyeTAGA brand as we prepared for the annual conference. I know that this experience will be invaluable to all the current and future members and know that it will benefit their own careers as it did mine.

A LETTER FROM THE CO-PRESIDENTS

Dear TAGA,

It comes with great pleasure that we are able to showcase to you our 2017/2018 Student Publication Journal. This journal is the distillation of a year of hard work and dedication from some of the most exceptionally talented students we know in the Graphic Communications Management program at Ryerson University. From the reports within the journal to the carefully chosen materials to the securing of sponsorship representative of both the versatility and power of the Canadian printing industry, the Presidential team cannot be prouder of the work done by our fellow students. We hope you enjoy reading the content within just as much as RyeTAGA enjoyed rallying the talents, skills, and aspirations for the future of our team to curate this project from start to finish. We truly cannot be prouder of the offering we bring to the 2018 Annual Technical Conference, here in beautiful and historic Baltimore.

A year for the RyeTAGA team is not one without challenge, but it is the overcoming of these challenges and the sense of duty to represent our school, fellow students, and the instructors who have inspired us that make it all worthwhile. We would like to extend our most sincere thanks to those who have aided in bringing the 2017/2018 RyeTAGA journal to life. To our team, our sponsors, our friends, and our families - this project would not be possible without the unending dedication and support from all of you. Whether it is a donation of materials, funds, or the rarest commodity of all, time, this journal is built by you, for you.

Graphic Communications Management here at Ryerson University is a broad program, with a depth of content we have found in few places before or since. We strive in our time here to learn all that we can about this diverse and exciting industry, and the TAGA Student Chapter initiative is perhaps our most treasured opportunity to put theory into practice. We are incredibly fortunate to count ourselves among the immense talent and skill of the other student chapters and look forward to another incredible conference, where it is confirmed over and over that the seeds we plant with each other today, will bear the sweetest of fruit tomorrow.

Sincerely,
Antek Krystecki & Jeremy Pagé,
Co-Presidents, RyeTAGA

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Zappar is a clever little app that can see and recognize images and objects in the world around us. With Zappar you can turn almost anything into a TV channel, a video game or even one of those social networking sites. Zappar adds a new visual dimension to the world for you to explore. Zapcodes can appear on just about anything; delivering video, audio, 3D animation, photos, games, links and a whole bundle of mind-blowing fun to your mobile device. How do you know what to zap? Wonder no more. Whenever you see a Zapcode like this you know there's exciting hidden content to discover.

1

rub resistance of conductive inks

- Alisha Campitelli
- Jamie Holman
- Jewel Bolasco

SCOPE

The purpose of this project is to gain insight about conductive inkjet printing and to perform a detailed analysis in order to understand the tolerance that a printed product has for harsh handling, all while maintaining its functionality. The rub resistance of water-based conductive ink, when printed on five unique substrate samples, will be tested and compared. This report will provide an in-depth analysis of the practical uses and limitations of the process. Furthermore, the findings of this test will aid in determining job specifications for conductive printing by providing insight into the appropriate substrate selection in relation to rub resistance.

Rub resistance is the ability of a substrate to withstand marking, smudging or scuffing while being handled in packing, distribution, and end use (Rub resistance, 2015). This is an important property of conductive ink because they must maintain a consistent ink film thickness in order to remain functional. If the conductive ink cannot withstand abrasion, the ink film thickness will diminish and break the electrical circuit, leading to lost conductivity. In many cases, damage occurs on “conveyors and during processing on machines such as gluers, packaging machines, and those used in print finishing in graphics end uses” (Rub resistance, 2015). However, conductive inks are generally produced in small quantities and are not required to withstand the rough handling that other printed products are subjected to during post-production.

SUMMARY

The abrasion resistance test is used to determine the rub-off qualities of the conductive ink on a variety of paper types upon printing. The interaction between the conductive ink and the substrate was visually analyzed to determine which substrate offers optimal absorption while maintaining ink conductivity. This analysis provides insight into the print requirements that must be met in order to produce high quality printed products with optimal conductivity.

To determine and compare the abrasion tolerance variance between each substrate, twenty rubs or lateral movements were applied to each paper type, using a 2 lb weight on the Sutherland Ink Rub Tester. When printing using lithographic and flexographic processes, it is important that an ink and substrate, in combination, produce a high rub resistance. However, the rub resistance for inkjet conductive inks will be slightly lowered depending on the type of stock used, as the ink must remain above the paper's surface to ensure conductivity. For this test, it is expected that the Epson Inkjet Paper will have the lowest tolerance for abrasion and friction. This stock has a microporous layer, which permits the ink to absorb only into the top layer. This allows for immediate drying while maintaining vibrant colour. Due to the absorbent properties of newsprint as a substrate, it is expected that it will have the highest abrasion tolerance and sustain the least amount of damage to the printed area.

INTRODUCTION

The initial goal of this test was to construct a printed paper circuit using conductive inkjet printing in order to illuminate an LED bulb. If successful, a two-wire circuit will produce a "never ending looped pathway for electrons [...]" (All About Circuits, 2016). The flow of electrons from the energy source through the printed wires will conduct enough electricity to power the light source. For the circuit board to work, LED lights and batteries must be used to create "live" and "negative" power lines. If for any reason, the circuit is broken, the flow of electricity will be disrupted and therefore will not reach the LED. The paper circuits were printed using several line widths and matched with varying light sources to determine a pairing, which resulted in optimal electrical conductivity. The first set of lights that were tested failed to emit light. As a result, it was hypothesized that the bulbs could not receive electrical current due to their size and type. Another model of LED bulbs was tested; however, after numerous attempts the LED continuously failed to emit light.

Next, the type of stock being used was taken into consideration. After printing the circuit board, the ink remained wet for a prolonged period of time and only set upon the use of a dryer. After extended research, it was determined that conductive inks must be printed on a coated stock specific to inkjet printers – i.e., microporous paper.

After detailed consideration, the major limitation of this test was determined to be the restricted ink film thickness that could be achieved during the printing process. Due to the nature of inkjet printing, it is difficult to create a thicker ink film, which is required to increase circuit conductivity. Other printing processes, such as flexography and offset lithography, allow for a greater control over ink film thickness in comparison to digital processes. This limitation was responsible for the initial testing failure.

It was hypothesized that by passing the substrate through the printer multiple times while repeatedly printing the same line of ink, the conductivity of the circuit would increase and successfully light the LED bulb. Due to time constraints, the scope of the project was altered. However, if provided with more time, a greater depth of research and further testing could have been performed to confirm this assumption. While carrying out the original testing process, conductive inkjet printing proved to be a more affordable, time efficient, and innovative way to work with conductive inks. For this reason, an alternative testing process was created in order to continue exploring this type of specialized digital printing.

The redesigned test focused on the rub resistance of water-based conductive ink when printed on varying substrates using inkjet printing processes. Throughout the production process, printed products come in contact with a variety of surfaces, some being more abrasive than others. This is something that must be considered when handling printed jobs, especially soon after an ink has begun its drying process. Depending on ink selection, as well as the substrate it was applied to, the product's resistance to damage will vary. Typically, coated paper has lower porosity and therefore a lower absorptivity than uncoated paper. When printing on coated paper the "ink stay[s] on the top of the paper or the coating" (Print Outlet, n.d), which contributes to a much lower resistance to abrasion.

If an ink has a very low abrasion resistance, meaning that it scuffs very easily even after it is dry, special consideration will need to be made in order to maintain print quality. Depending on the printing process that is selected, the rub resistance of a printed piece may vary as well. It "takes about 24 hours for an inkjet print to fully cure and dry" (Red River Paper, n.d.), even though it appears dry much sooner. This perceived dryness can cause premature handling leading to damage.

Aqueous based conductive inks used in inkjet processes "do not require secondary curing or additional processing on many coated substrates" (Methode Electronics, n.d.). To maintain conductivity, inks must be printed on coated substrates due to the low absorptivity. However, this requirement means that the printed inks will have a much lower resistance to abrasion even after drying. Since no curing is required, the printed ink will not be exposed to heat, meaning that the inks dry much slower through the release of solvents. When working with conductive inks to produce printed circuit boards, the connection must remain unbroken in order to allow a continuous flow of electricity. If damage occurs to the printed circuit due to ink abrasion, the circuit will become ineffective.

To test the rub resistance of conductive ink when printed on various substrates, the Sutherland Ink Rub Tester is used. It can be expected that the highest resistance to abrasion will be seen on uncoated, highly absorbent substrates. Alternately, the paper with the lowest resistance to abrasion will be seen when testing samples printed on coated papers. This will provide an understanding of the sensitivity of conductive inks and the level of care that printed circuit boards must be handled at during production and in end use in order to remain effective.

definitions

Abrasion/Rub-off:	Abrasion is the process of a material wearing away. In the case of this test, it is the transfer of printed ink film to an adjacent sheet of paper due to rubbing (Glossary, 2015).
Abrasion resistance:	Determined by the extent of rub-off that has occurred of the original ink to another sheet of paper (Abrasion, Rub and Scuff Resistance, 2015).

Conductive Ink:	A type of ink that uses PTF technology. It contains conductive silver nanoparticles and is able to achieve electrical resistance as low as 200 milliohms per square within minutes of printing (Methode Electronics, n.d.).
Polumer Thick Film (PFT):	Materials and process technology used to create printed circuit boards, which are suitable for small features and layers (Methode Electronics, n.d.).
Microporous layer:	Typically used for inkjet photo paper, this layer is a superior coating containing micropores or nanopores which are typically silica or alumina based. Inks "sit" on these pores (Photo Paper Direct, n.d.).
Receptor:	Film, paper, or fabric of a specified abrasiveness onto which coatings removed from the specimen are deposited during the abrasion test (ASTM International, 2011).

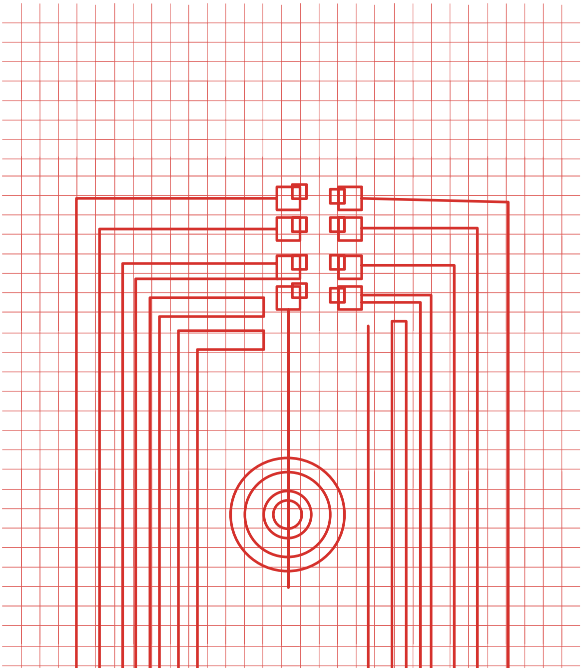
TESTING PRINCIPLES

This test is a valid means of determining the rub resistance of conductive ink since it clearly shows the comparison between each substrate when reviewing the qualitative results. In order for the ink to remain conductive after printing, it requires the use of a substrate with a high level of coating. Typically inks that are printed on these types of papers have a low resistance to abrasion due to low absorptivity, and the same holds true for conductive ink. When testing the number of "rubs" determines how much-prolonged friction is applied to the print before reviewing whether the ink has scuffed or fully come off. This test produces tangible samples, which is useful for visually comparing the abrasion tolerance of each substrate.

The ink being tested is water-based conductive inkjet ink. In order to print using this ink, an inkjet printer is required and must contain removable ink cartridges. The black ink cartridge must be removed from the printer and replaced with a refillable cartridge filled with conductive ink. As a result, the inkjet printer must have cartridges that can be manually replaced by the user. The printer used during this test was the Epson WorkForce WF-3640. This Epson printer features "a revolutionary high-density print chip which can generate up to forty million precise dots per second [...]" (Epson WorkForce WF-3640, 2017). Each paper type was printed on the Epson printer.

The Sutherland Ink Rub Tester, located in Ryerson University's Heidelberg Centre Print Lab, was used to test abrasion resistance. The Sutherland Ink Rub Tester is an industry standard, motor-driven testing instrument for moving a set weight over a printed sample (Gardco: Sutherland Ink Rub Tester, n.d.). For this test, a 2 lb weight was used on the rub tester, with a total of twenty rubs applied per paper type. This test replicates end-use conditions that a printed product may be subjected to during handling. Inks are designed and formulated to meet the requirements of a printing process and end-use applications (Bhore, 2013). By subjecting conductive printing inks to abrasion in a controlled environment, the abilities and limitations of the ink can be better understood so that the correct job specifications can be outlined and met.

Printing inks are usually composed of a filler, a binder, solvent(s), and additives (Bhore, 2013). However, the difference between a graphic ink and conductive ink is the type of filler used (Bhore, 2013). Graphic inks are made of pigments for providing colour, compared to conductive inks which are made of conductive materials such as silver or copper. These properties provide the desired electrical characteristic of conductivity (Bhore, 2013). Due to fundamental differences in the makeup of these inks, they must be used with the expectation that they will react differently in regards to abrasion resistance and must be handled with care and consideration.



MATERIAL TESTED

- Uncoated Paper
  - Domtar | 45" x 50", 455 M, 80 lb. basis weight
  - Newsprint | 28" x 40", 78M, 30 lb. basis weight
- Coated Paper
  - Epson Inkjet Premium Photo Paper Glossy
  - Gusto Gloss | 20" x 29", 73 M, 60 lb. basis weight
  - Supreme Gloss | 24" x 36", 182M, 100 lb. basis weight
- Ink
  - Methode Electronics: 9100 Series Inkjet Conductive Silver Ink

"Methode's aqueous-based inkjet formulations are designed for all drop on demand printhead technologies as well as a variety of flexible and rigid substrates" (Methode Electronics, n.d.).

EQUIPMENT USED

1. Epson WorkForce WF-3640
2. Ink Owl Easy to Refill Cartridge for Epson WF-3640
   - CMYK 252XL Cartridges
3. Sutherland Ink Rub Tester
   - Brown Company Kalamazoo Michigan Serial No. 1714
4. Conductivity Reader
   - Oakton Con 6 Acorn Series Conductivity/°C Meter

PROCEDURES

1 Obtain inkjet conductive ink

- **a** Purchase an empty inkjet cartridge
- **b** Fill the empty cartridge with the inkjet conductive ink

2 Setup inkjet printer

- **a** Remove black ink cartridge
- **b** Insert the cartridge filled with the inkjet conductive ink
- **c** Allow printer to re-calibrate with the new cartridge

3 Gather different types of paper substrates

- **a** Obtain coated/uncoated paper, newsprint, and inkjet paper
- **b** Print a rectangle on each of the different substrates with the conductive ink
- **c** After being printed on, cut each paper type into a rectangle

4 Set up the Sutherland Ink Rub Tester

- **a** Ensure the equipment is properly calibrated and zeroed
- **b** Set the Sutherland Rub Proof tester to perform twenty rubs
- **c** Attach the printed sample with the ink on the flat surface using tape
- **d** Attach a blank, unprinted paper sample of the matching stock with tape to the 2 lb weight (referred to as receptor paper)

5 Perform rub resistance testing on Sutherland Ink Rub Tester

- **a** Allow equipment to complete twenty movements
- **b** Remove substrate sample and receptor paper for analysis
- **c** Complete steps 4B - 5B for remaining substrates

RESULTS

Rub Resistance at 20 rubs with 2 lbs.

1 Epson Inkjet Premium Photo Paper Glossy (Figure 1)
Coated

2 Gusto (Figure 2)
Coated

3 Supreme (Figure 3)
Coated

4 Domtar (Figure 4)
Uncoated

5 Newsprint (Figure 5)
Uncoated

*** Abrasion tolerance has been analyzed and rated using a scale of 1; lowest tolerance to 5; highest tolerance (Reference in Appendix)*

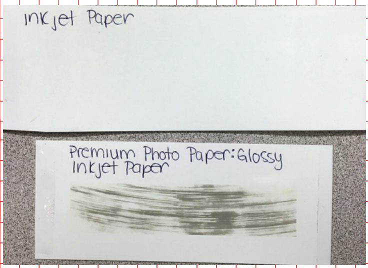


figure 1

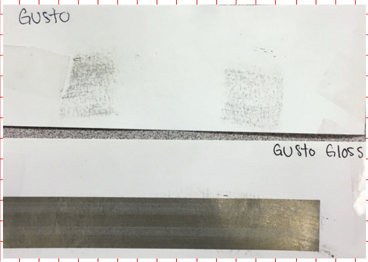


figure 2

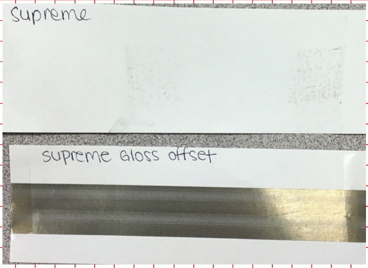


figure 3

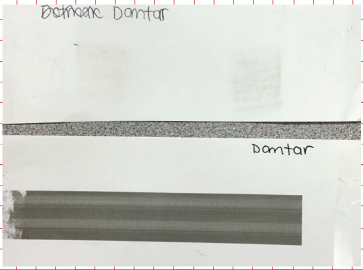


figure 4

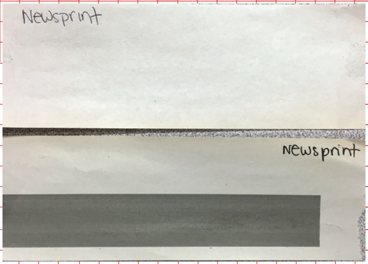


figure 5

DISCUSSION OF RESULTS

When analyzing the results produced using the Sutherland Ink Rub Tester, a large variance was seen when comparing the abrasion resistance of conductive ink when printed on coated versus uncoated paper. In order to quantify results, the rub resistance of each substrate was rated using a scale of 1 to 5. A higher value signifies a higher tolerance to abrasion, meaning that the conductive ink was less prone to rub off and damage.

As expected the substrate with the highest level of coating, which in this case was the Epson Inkjet Premium Photo paper, had the lowest resistance to abrasion. As seen in Figure 1, the damage done to the printed sample under the specific testing conditions was quite significant. The photo paper used is considered to be microporous, which is a requirement of successful conductive ink printing. "The microporous layer is the superior coating used for inkjet photo papers. The coating has micropores or nanopores (smaller pores than micro) which are silica or alumina based" (Joseph, 2011). This substrate is suitable for producing printed circuit boards using conductive ink, as it allows for "fast drying of the deposited ink due to the microporous ink-receiving layer which allows fast removal of the solvent" (Mater, 2015). The ink reaches the microporous layer of the substrate; however, the coating maintains ink conductivity as it does not absorb any further into the paper.

As seen in Figure 1, much of the ink was rubbed off from the inkjet photo paper but, there is no evidence of rub off seen on the receptor paper that is included in the image. This can be explained by the high level of coating on the surface of the substrate. Although microporous substrates can be highly coated and produce desired conductivity results, its abrasion resistance is extremely low. This means that products using conductive inks printed on inkjet paper must be handled extremely carefully and given an extended drying period regardless of the microporous and fast drying properties of the substrate.

Alternately, uncoated substrates, as well as substrates with lower amounts of coating, had a much greater resistance to abrasion. When reviewing the printed samples, newsprint (Figure 5), followed by Domtar paper (Figure 4), had the highest resistance to abrasion and the lowest amount of rub off on the receptor. Both substrates are uncoated, which allowed them to fully absorb the conductive ink. Although this prevented rub off and damage to the printed area, the conductive ink would not be successful in producing a printed circuit board as the conductive trace will absorb too deeply into the paper as it dries. When observing the receptor used while testing newsprint (shown in Figure 5), there was little to no rub off that could be seen. This is because of the porosity and absorptivity of the uncoated substrate, which limits the ink transfer from the sample.

It can be concluded that there is an indirect relationship between the rub resistance of a substrate and the performance and effectiveness of conductive ink. Therefore, the lower the resistance to friction a substrate and ink combination has, the more optimal the conditions are for creating highly conductive printed circuit boards. However, this conclusion is problematic, as the ideal conditions for creating printed circuit boards lead to products with very low abrasion resistance. This high risk of damage must be considered when choosing whether to use inkjet conductive printing processes.

For future testing, it would be beneficial to work with conductive varnishes in addition to conductive inks to determine whether rub resistance is improved when specialized varnishes are used. "In the electronic market segment, [the] transparent coatings are used mainly to protect fragile or exposed components against the humidity and improve the thermal resistance" (Von Roll, n.d.). However, they may prove useful when working with printing products, as well.

When considering the testing process, there are weaknesses that can be acknowledged. When working with The Sutherland Ink Rub Tester, it was determined before testing that the device was not properly calibrated. This was compensated for when determining the number of rub repeats that each printed sample would be subjected to. However, inaccuracies such as this, are not optimal when performing testing. In addition, the difficulty of working with conductive inkjet inks is a notable weakness that led to the scope alteration of the project. The ink produced conductivity readings while still in (unprinted) liquid form. Although, after printing traces (wires) using the Epson printer, a significantly lower amount of conductivity was given off. Conductive ink requires a specific amount to be applied in order to allow a flow of current that is equivalent to other conductive options. However, it was difficult to determine the exact amount that the process required due to unclear material and equipment specifications.

RECOMMENDATION

PRINTABILITY

Printability is an important consideration when using specialized inks, as it determines the inks' ability to conduct electricity. Due to the inkjet printing process, the ink film thickness cannot be increased. In many situations, this can be beneficial as there is reduced "ink consumption, ink setoff, drying problems, slight degradation of light colors, graininess of print due to irregular dot gain, excessive emulsification of ink, and low contrast in the shadows due to dot gain" when compared to other processes (ZX Printer, n.d.). The printability of conductive ink, in combination with the selected substrate, is a determining factor in the success or failure of a printed circuit board. If the compatibility of the two variants is flawed, the process will be unsuccessful, resulting in a circuit that is non-functional.

RUNNABILITY

Depending on the end use of the conductive ink, the substrate selection will vary. Conductive ink can be printed on a variety of substrates including "flexible substrates such as polyester, synthetic polymer sheets, coated papers and rigid substrates" (Methode Electronics, n.d.). As mentioned previously, paper and ink compatibility is important. Due to the requirement of coated stock when completing a printed circuit board, considering the amount of ink printed is crucial. When working with conductive inks, an adequate amount of ink is required in order to achieve functionality. However, heavy solid colours can cause issues in paper runnability as the inks are water-based. Laying down too much ink in one spot can cause wavy paper, and this, in turn, can cause jamming in the printer and damage to the printed circuit.

END USE

End use considerations are extremely important when focusing on abrasion resistance of conductive inks and should be the primary focus when determining job specifications. The constant requirement of printing with conductive inks will be achieving electrical conductivity; however, the functional use of the printed circuit will vary between products. To achieve a continuous flow of current through the circuit, the print quality must be maintained for a prolonged period of time. This can be extremely difficult in certain end use scenarios if the printed product is used frequently and subjected to rough handling. Conductive inkjet printing presents itself as a very affordable option when compared to printing conductive inks using other methods. However, due to the high risk of damage due to substrate requirements in some cases, it may be determined that using conductive inks is not always the most logical choice when attempting to create a flow of electricity.

REFERENCES

Abrasion, Rub and Scuff Resistance. (2015). Retrieved March 10, 2015, from http://www.smitherspira.com/services/print-quality-and-durability/abrasion

ASTM International,. (2011). Standard Practice for Abrasion and Scuff Resistance of Inkjet Media by the Sutherland Rub Tester. Retrieved 31 March 2017, from http://editorbar.com/upload/ReBooks/2013-4/dbef8230d3e39cbccdb570f714854a1a.pdf

Bhore, S. S. (2013). Formulation and Evaluation of Resistive Inks for Applications in Printed Electronics. Retrieved from http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=1434&context=masters_theses

Epson WorkForce WF-3640. (2017). Retrieved March 30, 2017, from https://epson.ca Gardco: Sutherland Ink Rub Tester. (n.d.). Retrieved March 30, 2017, from https://www.gardco.com/pages/abrasion/sutherland_inkrub.cf

m Glossary. (2015). Retrieved March 10, 2015, from http://www.glatfelter.com/learning/glossary_s.aspx

Iggesund,. Rub Resistance. Retrieved 30 March 2017, from https://www.iggesund.com/globalassets/iggesund-documents/rm-pdfer/2.-surface-and-app earance/rub_resistance_en.pdf

Inkformation. (2013). Retrieved from http://www.hubergroup.ca/fileadmin/_migrated/content_uploads/INKFORMATION_4_en_ 02.pdf

Joseph,. (2011). Microporous vs Cast Coated Photo Paper | Photo Paper Direct Blog.

Photopaperdirect.com. Retrieved 31 March 2017, from http://www.photopaperdirect.com/blog/?p=118

Methode Electronics. (n.d.) Conductive & Resistive Inks. Retrieved February 08, 2017, from http://www.methode.com/sensors-and-switches/conductive-and-resistive-inks.html#.WJ voHLYrJsM

PH and Conductivity. (n.d.). Retrieved March 23, 2015, from http://www.unigraphinternational.com/en/pdf_infotech/pH_and_conductivity.pdf

Photo Paper Direct. (n.d.) Mircoporous vs. Cast Coated Photo Paper. Retrieved from: http://www.photopaperdirect.com/blog/?p=118

Pocket pal: a graphic arts production handbook. (20th ed.). (2007). International Paper. New York: International Paper Co..

Print Outlet,. The Difference Between Coated and Uncoated Stock. Printoutlet.ca.Retrieved 30 March 2017, from http://www.printoutlet.ca/coated-uncoated.php

Red River Paper,. How long should I let my inkjet prints dry?. Retrieved 30 March 2017, From http://www.redrivercatalog.com/infocenter/tips/inkjet-print-drying-time-guide.html

Svanholm, E. (2007) Printability and Ink Coating Interactions in Inkjet Printing. Retrieved from http://www.diva-portal.org/smash/get/diva2:6256/FULLTEXT01.pdf.

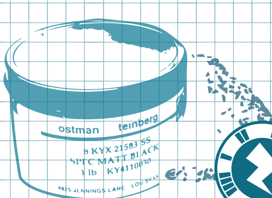
Von Roll,. Coating varnishes. Vonroll.com. Retrieved 31 March 2017, from http://www.vonroll.com/en/coating-varnishes/

ZxPrinter. (n.d.) Ink Film Thickness. Retrieved from http://www.zxprinter.com/support/ink-film-thickness.html

2

an investigation of thermochromic ink properties on different substrates

- Aleisha Hodri
- Xin Lin [Joyce] Li
- Brian Sour
- Kara Wesny



SCOPE + SUMMARY

The purpose of performing this test is to determine both the effectiveness of thermochromic ink on common flexographic substrates and how these materials, in combination with the ink, can be utilized for different end use applications. By determining the performance variability of a controlled amount of ink on these substrates, predictions will be made regarding uses for thermochromic ink in product packaging. This will be achieved by testing the reaction time of the ink at specific temperatures and the ability of the substrate to retain changes in colour based on hot or cold temperatures. The results of this test will be beneficial in differentiating which materials are the most and least suitable for thermochromic ink applications.

Based on this test, corrugated board had the best results with regards to its ability to hold a change in colour for the longest amount of time after exposure to hot or cold temperatures. Acetate was able to react the quickest to fluctuations in temperature. In general, it was found that the substrates were able to retain the cold temperature for a longer period of time than they could the hot temperature. Based on these results, it is recommended that a proper anilox roller with a small line screen ruling and large BCM be chosen. Conditions of the press room, doctor blade ink metering system, print speed (40-60 meters per second), and amount of thermochromic pigment used all need to be considered for proper and accurate printability. In regards to runnability, thermochromic ink needs a large amount of pigment within the flexographic ink, which can have implications on press. The nature of end use applications involves substrates being exposed to extreme temperatures. Ideal materials should be chosen based on their ability to resist melting or freezing, while also providing a visible change in colour.

INTRODUCTION

This test looks at the versatility of thermochromic ink when being used as a marketing tool and as an aspect of smart packaging design. It has the ability to catch a viewer's eye, change the way a product looks, and enhance the user's interactivity with the product. Thermochromic inks utilize the property of thermochromism, which refers to materials that change their hues in response to temperature fluctuations (Chandler, 2012). Common products made with thermochromic inks include thermometers, clothing, paint, and a wide variety of food packaging. There are numerous companies who are trying to incorporate thermochromic ink into their packaging to attract consumers. With this strategy of smart packaging in place, it allows consumers can interact with and observe changes in their product(s), such as watching their beverage becoming cold in the fridge or their cup of tea brewing.

This test is significant because it evaluates which substrates are ideal for the use of thermochromic ink and can help make decisions about what types of packages can be made to change colour. By determining what substrates result in acceptable colour change and assessing their ability to retain relevant temperatures, an understanding about which substrate is most suitable for specific end use applications will be gained. This test will provide knowledge for individuals in the printing and graphic arts industries to make informed decisions when choosing to use thermochromic ink in their products and will provide information about which substrate yields the most relevant results for their applications.

definitions

Thermochromic: when a substrate undergoes a reversible change of colour when heated or cooled (Oxford, n.d).

Leuco Dyes: microencapsulated droplets of colorant, developer, and solvent, either transparent or hued depending on their thermal state (Henry, 2015).

TESTING PRINCIPLES

There are numerous standards that need to be set when testing the reactivity level of the thermochromic ink on various substrates in order for the results to be accurate. If the substrate is directly affected by the thermochromic ink reaction, the temperature of the ink must remain constant. By testing the ink on different substrates, an in-depth understanding about whether the end use of the product is applicable or not will be provided. This testing will also give an understanding on determining which substrate is best to be used with thermochromic ink. Additionally, it will demonstrate whether or not different substrates are able to retain hot and cold temperatures. Simulating the process of flexography printing using the Phantom QD proofer provides an accurate environment to create proofs on substrates typically used. Thermochromic inks have been used in the packaging industry and are accommodated by the flexographic press. When high colour is desired, an anilox roller with the smallest line screen and highest BCM volume is ideal (B&H Colour Change, n.d). Since the testing principle is to simply both observe the change in colour and the substrates' ability to retain the temperature, the consideration for colour accuracy was irrelevant. However, when it comes to commercial production of packaging and other printed products, this consideration must be taken seriously.

By testing the various substrates' ability to retain hot and cold temperatures under constant environments, each substrate can be analyzed to determine which ones are most applicable and most desirable for specific end use applications. The temperature of colourization and decolourization of the leuco dyes in the pigment is caused by the melting point of the solvent (heat sensitive pigments) and the solidification point of the solvent (cold sensitive pigments) (Kulcar & Friskovec, 2010). Although this does not physically melt the ink due to it being encapsulated by the flexography ink, it allows the particles to become more spaced out and active, which results in the colour change. By isolating the hot temperature change (65°C) and the cold temperature change (10°C), we are able to create an environment accurate for testing these properties. After the decolourization (heat) and colourization (cold) has been observed, the time it takes for the colour to return back to its room temperature state will be measured (white to red for heat and blue to white for cold, colourization and decolourization, respectively).

MATERIAL TESTED

- Coated Paper supplied with Phantom Proofer
  - Caliper: 0.0100
- Uncoated Paper supplied with Phantom Proofer
  - Caliper: 0.0100
- Acetate
  - Caliper: 0.0045
- Corrugated Board
  - Caliper: 0.1365; single flute
- Environmental Inks & Coatings
  - PS + Opaque White FR flexographic ink
- Red Thermochromic pigment
  - Red to White at 65°C
- Blue Thermochromic pigment
  - White to Blue at 10°C

EQUIPMENT USED

1. Harperscientific Phantom QD Proofer
2. Anilox Roller - 4.5 BCM, 360 LPI
3. Eco Tester Electronic pH Meter
4. Environmental Inks & Coatings:
5. Print Clean Additive (pH adjuster)
6. Zahn Cup #2
7. 500 mL beaker
8. Stopwatch
9. Thermometer
10. Iron
11. Hygrometer

PROCEDURES

1. Pour white flexo ink into a mixing jug and test the viscosity of the ink with Zhan cup #2, making sure to adjust the viscosity using water or more ink until it is between 20 - 25 seconds.

2. Test the pH of the ink with Electronic pH meter and make necessary adjustments using the pH balancer solvent until the pH is between 8.5-9.

3. Mix 5g of blue thermochromic pigment with 10 mL of opaque white flexographic ink in a beaker. Mix well until pigments are completely encapsulated in the flexographic ink. Repeat for red thermochromic pigment.

4. Use the phantom proofer with a 4.5 BCM, LPI 360 anilox roller, and position an uncoated paper roll on it to being printing.

5. Attach the doctor blade and anilox roller to the Phantom Proofer and begin rolling its handle along the length of the Proofer to apply ink onto substrate.

6. Detach the pieces of the Phantom Proofer and clean them to get ready for the next print.

7. Repeat step 5 to 6 for the coated paper roll.

8. Repeat step 5 to 6 for the acetate and corrugated board, this time making sure to tape the substrates securely to the Phantom Proofer before printing.

9. Make sure each proof has an area with a thin ink film and an area for a thick ink film for testing purposes.

10 Using a hygrometer, test the relative humidity of the pressroom and a thermometer to test for temperature. Ideal conditions of the pressroom for relative humidity should be around 35% and 23°C for temperature.

11 Place the substrates with the blue pigment within a sealed plastic bag. Submerge them in a sink of cold water at 10°C until the pigment has completely changed from white to blue in reaction to the cold. The temperature of the water can be tested using a thermometer.

12 Remove the sample from the water and begin timing. Take note of when the colour returns to its neutral state (blue, back to white) at room temperature in both the areas of thin and thick ink films.

13 Record these observations.

14 Heat up a hot iron and place a soft fabric around substrates with red pigment to ensure the heat does not burn any materials. Hold the iron with a temperature of 120°C against the substrate until the pigment has completely changed from red to white in reaction to the heat. The temperature of the heat tested can be found on the temperature gage of the iron.

15 Remove the sample from the heat source and begin timing. Take note of when the colour returns to its neutral state (white, back to red) at room temperature in both the areas of thin and thick ink films.

16 Record these observations.

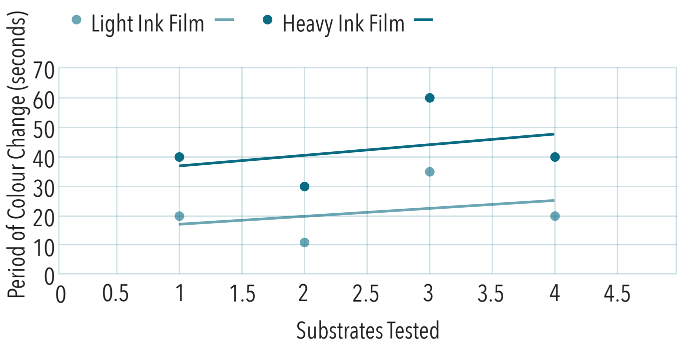
RESULTS

BLUE PIGMENT:

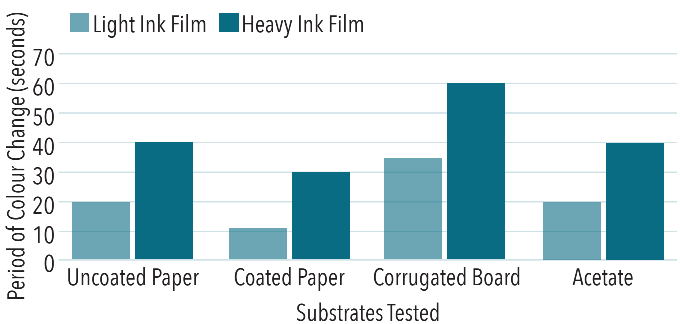
Period of Colour Change*:

	Uncoated Paper	Coated Paper	Corrugated Board	Acetate
Light Ink Film	20 seconds	11 seconds	35 seconds	20 seconds
Heavy Ink Film	40 seconds	30 seconds	1 minute	40 seconds

*Length of time ink on substrate takes to revert back to neutral state from point of colour change (5° to 23° C).



Scatter graph of the period of colour change with trendline to show average.



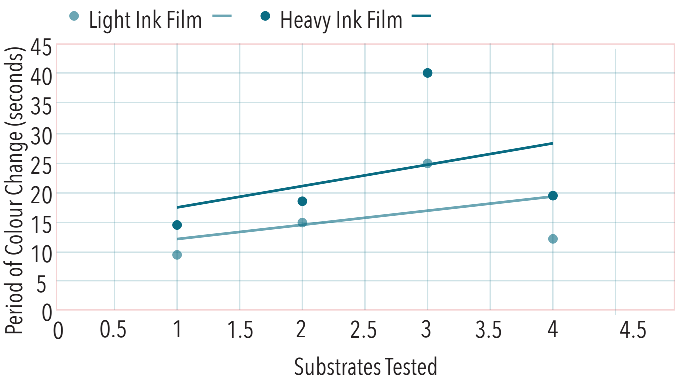
Bar graph of the period of colour change.

RED PIGMENT:

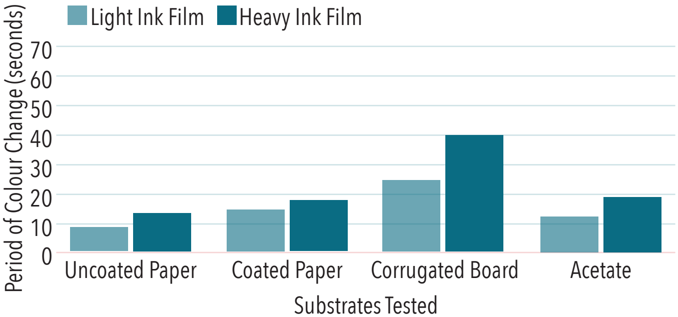
Period of Colour Change*:

	Uncoated Paper	Coated Paper	Corrugated Board	Acetate
Light Ink Film	9 seconds	15 seconds	25 seconds	13 seconds
Heavy Ink Film	14 seconds	18 seconds	40 seconds	19 seconds

*Length of time ink on substrate takes to revert back to neutral state from point of colour change (65° to 23° C).



Scatter graph of the period of colour change with trendline to show average.



Bar graph of the period of colour change.

BLUE PIGMENT ON ACETATE

The reaction of the blue ink on acetate was quite instant. The ability for the ink to stay changed on the acetate was dependant on the ink film thickness. Looking at the chart above, the heavy ink film maintained its colour change for twice as long as the thin ink film. The ability for the ink film to be able to hold its colour change is dependant on the temperature of the substrate in which it is printed on. Therefore, acetate is able to hold the cold temperature at about an average rate. The acetate is also very susceptible to temperature influence as it will change the temperature really quickly when in contact with human skin, whereas different substrates will take a bit more time.

BLUE PIGMENT ON COATED & UNCOATED PAPER

The time for which the ink held its colour change on coated paper was shorter than the time for which it held its colour change on uncoated paper. This shows that coated paper is able to hold its temperature longer than uncoated paper. This may be due to the fact that the fibres of uncoated paper can absorb more of the heat or cold and hold on to it for longer. The heavy ink film on both coated and uncoated paper holds up to at least half a minute, which was not as long as the acetate.

The time for the uncoated paper matches the acetate exactly. This means that although they are made of different materials, they both have the same properties when it comes to retaining cold temperatures. The coating on the uncoated paper eliminates the temperature retention time by approximately 10 seconds. Both time measures are about 10 seconds lower than uncoated paper.

BLUE PIGMENT ON CORRUGATED BOARD

The corrugated board held the temperature the longest, and, in turn, held the ink colour change longer. This can be due to many factors, such as the material and the caliper of the substrate. The caliper of the corrugated board printed on during this test is 0.1365 microns. The caliper of the coated and uncoated paper is 0.0100 microns, and the caliper of the acetate is 0.0045 microns. Thus, the caliper of the corrugated board is 13.65 times as thick as the paper and 33.34 times as thick as the acetate. The material of the cardboard is fibrous and is similar to paper.

The corrugated board's ability to hold the colour change of the thin ink film could match the other substrates' ability to hold thick ink film. More so, the corrugated board's hold of thin ink film is still longer than the coated papers' hold on thick ink film. This capability may be due to the fact that the corrugated board is fibrous and of a higher caliper. After looking at the results from the coated and uncoated paper, it was established that the coating decreases the ability for the paper fibres to hold the temperatures.

The corrugated board not having a coating and being thicker in paper fibre means that the more fibre there is, the more a substrate can hold its' temperature. It is worth noting that the corrugated board lost its ability to retain the change in colour first from the edges, then towards the middle. This means that the flutes of the corrugated board are able to hold the temperature fluctuation better. This makes it the ideal material for printers who want their packages to hold a change in colour longer.

RED PIGMENT ON ACETATE

Unlike the blue pigment, the acetate was able to hold the red pigment for less time. In comparison to the other substrates printed, it held longer than coated and uncoated. This contrast is due to the difference in caliper. Although the light ink film is the second fastest to fade, it is very close to coated paper and has a maximum 2-second difference. Since the acetate is able to hold the blue pigment similar to uncoated paper and red pigment similar to coated paper, it is evident that the properties of the acetate change depending on the temperature. Print thermochromic ink that reacts to heat on acetate is discouraged, as there is a possible chance of the acetate melting.

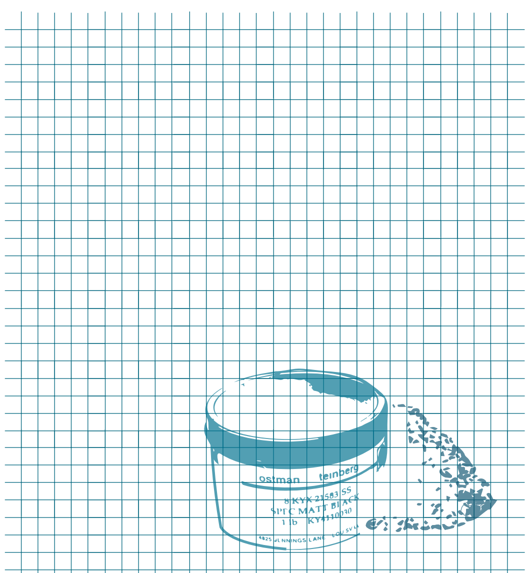
RED PIGMENT ON COATED & UNCOATED PAPER

The time held for the coated paper is longer than the time held for the uncoated paper. This is opposite to the blue pigment, where the coated paper held for less time than the uncoated paper. With both stocks being the same, it can be assumed that a property of the paper is changing because of a specific characteristic only present in one paper. It is obvious that the coating is the only difference between the stocks. Therefore, it is possible to assume that the coating is the factor that attributes to the higher retention rate of heat within the substrate. Even then, the pigment is fast to change back to its neutral state when both printed lightly and heavily.

RED PIGMENT ON CURRGATED BOARD

Similar to the results of the blue pigment, the red pigment printed on corrugated board also holds the longest ink change. The time the corrugated board is able to hold the heat is shorter than the time of the cold. However, it is still higher than other substrates when tested in the same environment. This is expected as a paper with a coating has a higher retention time, as noted from the observations of the red pigment on the coated and uncoated paper.

Seeing as the corrugated board tested did not contain any form of coating, it is similar to uncoated paper. However, it was not able to hold the heat as well as expected given the caliper. Even so, the pigment reverted back to its neutral state at roughly the same time as the coated stock.



DISCUSSION OF RESULTS

Based on the results described above, the substrates were able to retain the cold temperature for a longer period of time than the hot temperature. The average time for the light ink film to revert back to its neutral state (across all substrates) for the blue pigment was 21.5 seconds. For the red pigment, it was 15.5 seconds. The average time for the heavy ink film to revert back to its neutral state (across all substrates) for the blue pigment was 42.5 seconds, compared to the red pigment taking nearly half the time at 22.75 seconds.

These results are in agreement with the article titled "Light fastness and high-temperature stability of thermochromic printing inks" by Kulcar & Friskovec, which explains the ability for a thermochromic ink to retain its colour change only occurs for a short period of time. They also state higher temperatures yield a decolorization (from red to white in this study) and produce a shorter reaction time than thermochromic inks that produce a colorization (white to blue in this study). This confirms that our results produced an accurate representation of thermochromic properties. In addition, the article also states attention must be carefully given to the choice of substrate. The acidity, additives, binders, and coatings in the substrate play a major role in the stability of the colour change of the thermochromic ink (Kulcar & Friskovec, 2012). This provides an educated understanding as to why the coated side (compared to the uncoated side of the same sample of paper) was able to retain heat for a longer period of time, and cold for a shorter period of time.

RECOMMENDATION

PRINTABILITY

When attempting to simulate flexographic press conditions with the Phantom QD Proofer, it is important to consider factors such as the anilox roller chosen, ink metering system, and amount of thermochromic pigment used. According to the Flint Group, it is ideal to use an anilox roller with the smallest line screen ruling (360 or lower) and the largest BCM. The depth of the anilox cells is especially important to accurately transfer the thermochromic pigment onto the substrate. In addition, a doctor blade metering system is better than a metered roller system, as using a metered roller system gives way for the pigment to build up on the surface of the anilox roller, rather than just in the cells (B&H Colour Change, n.d). As well, a print speed of approximately 40-60 meters per minute will result in good ink transfer from anilox roller to plate to substrate ("Thermochromic Inks", n.d).

RUNNABILITY

When running thermochromic ink through a flexographic press, the two main factors to consider are the thickness of the substrate and the amount of pigment in the ink. Depending on the substrate thickness that the press can accommodate, the substrate must be compatible to avoid any damage and/or paper jams. Since the thermochromic pigment is mixed within water-based flexographic ink, materials such as corrugated board can be difficult to print on, especially if proper settings are not taken into consideration. Using thermochromic pigment also requires a longer makeready because it can take awhile to mix into the flexographic ink and be ready to use it on press. Through conducting this test, it was found mixing the pigment and flexographic ink together was very vigorous. Each have a problem becoming a uniform solution sans grains. This can be avoided by purchasing pre-made flexographic thermochromic ink rather than the mixing the ink by hand with pigment. The ink also required a very heavy ink film in order to be opaque on the various substrates. This can cause problems on press as it takes longer for the ink to dry and an anilox roller with a high BCM needs to be used in order to achieve the desired effect.

END USE

The end use of the product is essentially what determines the type of ink to use (heat or cold sensitive) and the substrate most suitable. Some examples and recommendations for products based on our results are as follows:

Corrugated Board

Being one of the most popular substrates used in the transportation of goods from one place to another, this substrate can take advantage of both heat and cold sensitive thermochromic inks. For example, heat sensitive ink would be advantageous to use if the box has the potential to come into contact with extremely hot environments (ie: a boiler, furnace, overheating production equipment). An indicator strip on the box would give a hint to move the box away from the heat source in order to protect the goods contained within the box. This recommendation follows a similar principle when using the cold-sensitive ink.

Acetate

Acetate is typically used for clear boxes that hold products such as mugs, cookies, cards, etc. It is difficult to design a thermochromic package since the point of acetate packing is to be clear to see the product inside and not to be covered by ink. Therefore, this material would not be used in a thermochromic setting very often. Another limitation is that the nature of thermochromic packaging is to change colours based on temperature. Many consumers may try to test the product under extreme conditions and risk the acetate melting if it is stored or comes into contact with an excessive amount of heat. Since acetate sometimes contains food products, the thermochromic ink on the acetate box must comply with health and safety regulations surrounding food in order to be safe for consumers. However, it could be advantageous to use cold sensitive thermochromic ink in acetate packaging in a similar fashion as corrugated board - to indicate the atmospheric temperature and how it may affect the product contained within the package.

Coated & Uncoated Paper

End use applications using thermochromic ink on paper can include but are not limited to: colour-changing stickers (which can be applied to a wide variety of objects, depending on the intended use), CD and DVD cover inserts, and disposable coffee cups.

REFERENCES

B&H Colour Change (n.d) Thermochromic Water-Based Flexographic Ink. B&H Colour Change. Retrieved on March 13th, 2017 from http://www.colourchange.com/technical-data/downloads/updates/WB%20Flexo%20TDS.pdf

Chandler , N. (2012, May 08). How Thermochromic Ink Works. Retrieved March 30, 2017, from http://electronics.howstuffworks.com/gadgets/other-gadgets/thermochromic-ink.htm

Henry, P (2015) Thermochromic Imaging: The Colour Shift That's Supposed to Happen. Retrieved on March 30th, 2017 from http://whattheythink.com/articles/76530-thermochromic-imaging-color-shift-s-supposed-happen/

Kulcar, R. & Friskovec, M. (2010) Colorimetric Properties of Thermochromic Printing Inks. University of Zagreb: Faculty of Graphic Arts. Retrieved on March 30th, 2017 from http://www.sciencedirect.com.ezproxy.lib.ryerson.ca/science/article/pii/S0143720810000 215

Kulcar, R. & Friskovec, M. (2012) Light fastness and high-temperature stability of thermochromic printing inks. University of Zagreb: Faculty of Graphic Arts. Retrieved on March 30th, 2017 from http://journals2.scholarsportal.info.ezproxy.lib.ryerson. ca/pdf/14723581/v129i0003/214_lfahsotpi.xml

Robert Olsson. (2007) Some Aspects On Flexographic Ink-Paper And Paperboard Coating Interaction [PDF File]. Retrieved from March 30th, 2017 from http://www.diva-portal. org/smash/get/diva2:5047/FULLTEXT01.pdf

Thermochromic [def. 1]. (n.d.) In Oxford Dictionary Online, Retrieved March 30, 2016from https://en.oxforddictionaries.com/definition/thermochromic

Thermochromic Inks (n.d) Flint Group: Narrow Web. Retrieved on March 30th,2017 from http://www.flintgrp.com/media/3083/i_08_03.pdf

Thermochromic Paint For Sale | Color Changing Leuco Dyes. (n.d.). Retrieved March 30, 2017, from http://www.hallcrest.com/color-change-basics/leuco-dyes hj

3

expanded gamut printing

- Paula Roque
- Thuy Nguyen
- Jasmine Ragial
- Karan Patel

SCOPE + SUMMARY

This project will measure the accuracy of colour mapping with extended gamut printing by using Orange, Green, and Violet inks in addition to the four process colour inks (CMYK). Five samples from different printing processes will be compared. The samples being measured will be gathered from companies implementing extended gamut printing, except the Prüfbau and the Inkjet samples which will be printed by the project team. The purpose of this test is to explore the capabilities of the 7-colour printing process (CMYK+OVG) compared to the standard 4-colour process (CMYK). There are several conditions and factors that need to be taken into consideration, such as the hue angle and chroma of the colourant (ink/toner), the substrate and ink being used between different processes, and more when determining the capabilities that the extended colour gamut can or cannot produce. Overall, the gamut was extended significantly across all the processes, but they did not achieve a similar gamut volume as was hypothesized. These results are further discussed in the Results below.

INTRODUCTION

Each printing process and device outputs colour differently, limiting the available gamut for colour reproduction. This allows for more accurate colour reproduction, which can be critical for end uses like corporate branding and packaging. For this instrumentation, the 7-colour printing process (CMYK +OVG) between all samples created a larger gamut than the standard 4-colour process (CMYK). This instrumentation demonstrated the capabilities of the extended gamut in comparison to the standard 4-colour process. The 7-colour process is more stable than the 4-colour process since the 4-colour process builds from colours that are very far apart on the colour wheel. As a result, a slight shift in density and/or strength of any ink colour can shift a resulting build colour at high scale. On the other hand, seven colours on the colour wheel are close together and density variation in any ink will have very little impact on build colour (Gundlach, n.d). This instrumentation will help determine the possible outcomes that can be produced using OVG inks with CMYK and the several factors that can affect the expansion. It was found that the gamut differed across all the devices due to process variation. Each output has its own specific gamut that cannot be replicated completely by other devices. Therefore, some devices will have an advantage in terms of outputting colours using the colour gamut. The main purpose of the extended gamut is to help achieve a broader range of colours. With this knowledge, CMYK+OVG can replace the multiple varying spot colours in certain jobs. Therefore, print runs, make-ready, and clean up time can all be shortened.

definitions

Colour Gamut: A range of colours that are available on a specific device. Each device (e.g. a monitor or printer) has a different colour gamut. For example, monitors display RGB signals, which have a larger colour gamut in comparison to a printer which uses CMYK (PCMag, 2017).

Delta E: The magnitude of colour difference which is calculated in the L*a*b* colour space. Specifically, the distance between two points are being measured in 3D (Sharma, 2016).

Hue Angle: Hue and saturation are based around a circle that is depicted by an angle which is either positive or negative. These angles express the actual pigment colour and if the brightness of the colour is unchanged. For example, cyan has a hue angle of 180 degrees, magenta has a hue angle of 300 degrees, and yellow has a hue angle of 60 degrees (McClelland & Fuller, 2017).

Rendering Intent:	Rendering intents are located within ICC profiles and they define how colour reproduction should cope and react, under certain circumstances when two colour spaces do not match. These circumstances could be colours that are outside or near the edge of the device's colour gamut. There are four different ICC rendering intents: perceptual, saturation, relative and absolute colourimetric (Sharma, 2016).
Mono-Pigmented Ink	Inks that are made up of their own individual components (Zeleznik, 2011).

TESTING PRINCIPLES

The test samples will consist of images and a 7-colour ink target with varying tonality. These samples will come from many different printing processes (digital, flexography, offset, etc) in order to fully compare the effects of using a 7-colour printing process. The samples that will be measured for this test will be provided, except for the Prüfbau sample and the inkjet sample. Solid ink patches of all seven colours will be created using the Prüfbau press. The colour gamut of each device will be examined using the L*a*b* values of those targets. The L*a*b* values will determine the shape and volume of the gamut. This principle will be tested by using the L*a*b* values of the PANTONE colours and examining its position relative to the colour gamut calculated using CHROMIX ColorThink Pro. The test targets will be used to measure print characteristics to analyze any process variation.

MATERIAL TESTED

- Stock (Inkjet Proof)

  - Epson Coated Photo Paper 44"

- Ink Cartridges:

  - Orange 021 C, Green C, Violet C

- Stock (Offset Proof)

  - Earnscliffe Linen 182M, 148 gsm

- Offset Ink

  - hubergroup Esko Orange 2 ONX 5150-V
  - hubergroup Esko Prem. Violet 3 ONX 51501-V
  - hubergroup Esko Green 4 ONX 51502-V
  - Black
  - Process Cyan
  - Process Magenta
  - Process Yellow

EQUIPMENT USED

Software

1. X-Rite i1Profiler software on the iMacs
2. CHROMIX ColorThink Pro
3. Esko Equinox Photoshop Plugin
4. EFI Fiery RIP

Machines

1. Prüfbau - Dr.Ing. H. Durner, #82380
2. Pipette
3. Spectrophotometer - X-Rite, eXact #nghxr
4. X-Rite, i1 pro 2 Spectrophotometer
5. Epson SureColor P9000

PRINTED SAMPLES

1. Xerox iGen 5 Sample
2. Flexographic Sample
3. Heidelberg Offset Sample

PROCEDURES

preparation

1 Gather and convert test images to 7-colour ink set using the Esko online server and Esko Equinox Photoshop Plugin.

2 Create a test form with these test targets to print from the different devices.

3 Gather digital process test samples from Xerox Corporation USA.

4 Gather offset and flexography samples from sources.

inkjet proofing samples

1 After converting the test form to an extended ink set, open the file on EFI Fiery RIP and select the HT (Halftone workflow) and assign the spot colours as PANTONE inks used in the Epson SureColor P9000.

2 Print the test form and analyze the solid colour patches using X-Rite i1 spectrophotometer and i1Profiler software.

offset proofing samples

1. Prepare the inks to be printed (Black, Cyan, Magenta, Yellow, Orange, Violet, Green) and the coated paper stock. Skin the ink if necessary.

2. Fill the pipette up to 250mm^3 with each colour resulting in solid ink patch.

3. One colour at a time, transfer the ink from the pipette onto the roller of the Prüfbau.

4. Initiate the rollers and wait until they achieve an even coat of the ink. Load the paper sheet onto the tray.

5. Once the ink is even throughout the roller, engage the blanket cylinder and let the ink transfer.

6. Once finished with the ink transfer, move the blanket cylinder onto the printing hinge and make a print.

7. Repeat steps #2 to #6 with remaining colours.

measurement

1. After achieving all samples, use the X-Rite i1Pro spectrophotometer and the X-Rite i1Profiler software to record and measure the L*a*b* values.

2. Under the advanced settings select the M1 mode and D50 lighting condition.

3. Measure the test chart and save the L*a*b* values as a text file using a dongle.

4. Repeat this step for all test samples. Export all the text files on CHROMIX ColorThink Pro and analyze the gamut area.

RESULTS

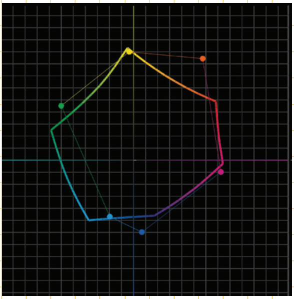
Epson SureColor P9000

Xerox iGen 5 Sample

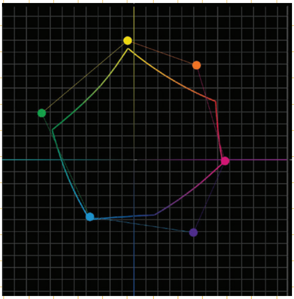
Heidelberg Offset Sample

Prüfbau Sample

Flexographic Sample



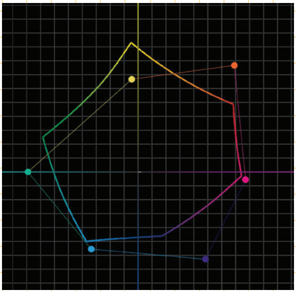
Epson SureColor P9000 V/s GRACoL 2013



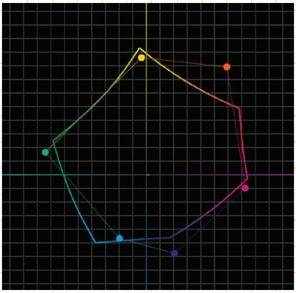
Flexographic Print Sample V/s GRACoL 2013

The primary inks used in this test for gamut expansion were Orange, Green, and Violet, in addition to Cyan, Magenta, Yellow, and Black. Based on the colour theory and expected outcomes, the more stable 7-colour process printing has a gamut area larger than the unstable 4-colour process printing (Gundlach, n.d). Therefore, the seven colours being close together builds a stronger gamut that has the capability to output colours that fall outside the normal CMYK colour gamut. The samples, when compared to the GRACoL 2013 specifications, indicate an area (or a volume in three dimensions) on the plane where the 4-colour process printing device uses rendering intent to output colour that falls beyond the gamut.

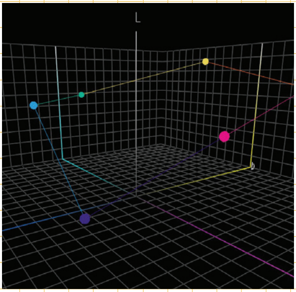
However, it is evident from the results that the additional three inks used in this test cover that area, and thus have the capability to accurately output colours that are out of the CMYK colour gamut without using any rendering intent (Sharma, 2016). Although the results indicate that the extended gamut has the capability to output more colours compared to 4- colour process gamut, the colour values in the first and fourth quadrants cannot accurately be reproduced using some processes. For instance, the measured extended gamut of the Heidelberg offset sample cannot accurately reproduce some colours that are associated with green and yellow hues. Although the images indicate that the gamut is not capable of outputting particular colours in that area, consideration must be given to the fact that the gamut volume is indicated on three-dimensional space and the collected data is insufficient to measure the volume of that particular gamut in 3D space.



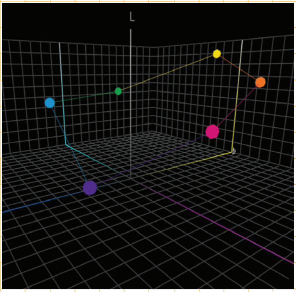
Heidelberg Offset Print Sample V/s GRACoL 2013



Xerox iGen 5 Print Sample V/s GRACoL 2013



Flexography Colour Gamut in 3D Space



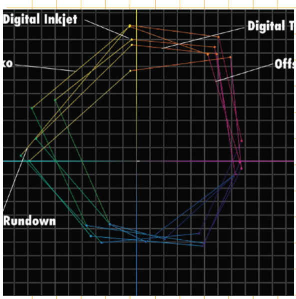
Prüfbau Sample in 3D Space

FACTORS AFFECTING EXPANSION OF GAMUT

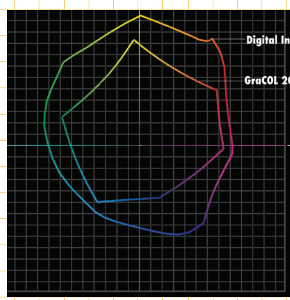
Hue angle: The primary factor affecting the expansion of gamut is hue angle. For any printing process to fall within the G7-ISO L*a*b* ink colour standards, the extended gamut inks (Orange, Green, and Violet) need to fall within the proper hue angle of the specifications (Baldwin, 2016). For instance, the O, G, and V PANTONE inks for any printing process should have hue angles of 58 degrees, 180 degrees, and 311 degrees, respectively, to accurately project the expansion of the colour gamut of the output device (PANTONE Extended Gamut Coated, n.d.). The values measured from the samples listed below indicate that the hue angle of Orange is very off compared to the PANTONE specifications. The reason behind this is that the samples were printed using different PANTONE inks for different printing processes, and variation in hue results in variation in the hue angle. This variation also relates to the contamination of inks commonly known as hue error (Lychock, 1996). However, the Green and Violet hue angles are very close to the specifications of which projects the accuracy of colour mapping.

Sample	Orange Hue Angle	Green Hue Angle	Violet Hue Angle
Epson SureColor P9000	35	173	318
Heidelberg Offset Sample	43	144	270
Flexographic Sample	44	140	298
Xerox iGen 5 Sample	36	160	284
Prüfbau Sample	46	154	308
PANTONE Standard	58	180	311

Chroma and Value: Chroma relates to the amount of visual difference from the grey of the same colour (VITA North America, n.d.). Value, on the other hand, describes overall intensity to how light or dark the colour is (Briggs, 2017). These two factors of the selected additional ink determine the area of expansion between the process colour inks. For instance, when the Heidelberg sample was tested using the i1 spectrophotometer, the ink patches that were measured appeared different on the i1Profiler software, which indicates that the device has a small margin of drift in its sampling algorithm when isolating colour information.



Extended Gamut Comparison across different printing processes



CMYK Gamut Comparison across different printing processes

It was hypothesized that if similar gamut volume across all printing processes can be achieved, then a similar print using any printing process can be output. However, in the test conducted, the substrate and the type of PANTONE ink used for the extended gamut sample were not able to be controlled across all printing processes. As a result of this inconsistency, variation in the position of gamut on the two-dimensional space when compared across all the processes occurred. This inconsistency occurred regardless of the fact that the constant factor in this test is the M1 testing mode, used in the spectrophotometer, which corresponds to standard D50 lighting conditions. The other factor that indicates variation in colour gamut is the value of Delta E, offering a numerical representation for the drift present between given samples. Also, consider that process variation such as impact versus non-impact printing determines the gamut volume of a printing device (Sharma, 2016). With the offset process, the factors associated with the plate and blanket cylinders - such as pressure, ink to fountain solution ratio, hardness of blanket, ink key settings, and the temperature and relative humidity of the materials and location affect the printability, ultimately causing process variation. Similarly, for the digital printing process, the type of toner used for the testing, the process of toner transfer, and heat fusion determines the gamut volume of the device.

RECOMMENDATION

PRINTABILITY

Printability depends on the effectiveness of ink trap where one ink prints on top of another, to simulate the final desired colour during the offset printing process. With this, printers should consider factors of ink tack and paper characteristics; specifically, how paper surfaces directly impact the capabilities of ink tack during the ink trap phenomena (Pritchard, 2009). The additional factors of ink opacity and transparency, coverage, and the printing process being used are all considerations in determining the best lay down and sequence of ink (Pritchard, 2009). Ultimately, ink trap is important because it influences a loss or gain of reproducible colour volume in a gamut. In extended gamut (XG) printing, seven inks are being printed rather than four. Therefore, the sequence of inks printed becomes more complex and varies between printing processes. To optimize XG abilities, printers need to be able to determine the transparency of ink in relation to overprints, in order to determine how colours are reproduced and the most effective printing sequence (O'Hara, 2016). Lastly, in offset lithography, dry and wet ink trapping methods also affect final output; how well inks are able to adhere to one another and how light or dark colours will turn out (Chung, 2008).

Strong corporate branding will use spot colour inks to accurately reproduce brand colours. Spot colours have to be prepared and mixed by ink suppliers beforehand, which can be a timely and expensive process (Spot, n.d.). Spot colour inks consist of blended pigments that reduce chroma and therefore print flat colours (Zeleznik, 2011). By contrast, CMYK+OGV printing consists of seven different inks made up of their own purely individual components. This ink individuality is known as mono-pigmented ink (Zeleznik, 2011). This is beneficial for clients who request the printing of accurate colours, but are not able to afford spot colours. Additionally, because there are seven colours being printed, it allows for more ink combinations to be created.

RUNNABILITY

Similar to ink trap, ink tack is a major component of the runnability of the press. Ink tack is the stickiness of how ink adheres from one surface to another. This is essential, as it dictates how excessive or insufficient ink tack will affect how ink transfers from roller to roller, or roller to substrate (Podhajny, 2002). Considerations lie within the substrate of choice, where the most optimal paper will have the paper strength to print accurate colours accordingly (often found in uncoated papers). For example, newsprint papers have very poor surface strength capabilities when inks with very high tack combinations are printed (Savastano, 2009). Papers should run through the press without any difficulties. This is especially important for the offset printing process. However, ink tack will vary for inks being used in different printing processes.

END USE

Recently, the process of Extended Gamut Printing has found popularity within the packaging industry because of its added benefits of being cost efficient and producing accurate colours in a timely matter. According to Esko, the "demand for shorter packaging production runs for targeted campaigns and product variations are increasing" which promotes the need for XG because of corporate branding (Equinox, n.d.). It is very important for companies to retain a consistent colour in order to gain brand recognition, which reiterates the importance of strong corporate branding. Companies want to be able to reproduce their own colours identically in all their products. A good example of this would be the colour of the sophisticated mahogany Tim Hortons cups. Extended Gamut Printing will allow companies to do just this, in a timely manner and at a lower cost than using the CMYK plus spot colour printing process.

Overall, XG is beneficial for printers as it provides a more inexpensive and quality solution for the replication of accurate colours. XG is an excellent system because it allows printers to reproduce spot colours better than the CMYK process, as seen in the picture above, with no changeover of inks (Zeleznik, 2011). At the same time, it allows printers to gang jobs that contain various branding colours where in contrast, printers would print CMYK+PMS limiting press sheets to client specific work (Zeleznik, 2011).

REFERENCES

Baldwin, C. (2016, May). Expanded gamut printing 101 - Nilpeter. Retrieved March 31, 2017, from http://web.nilpeter.com/media/Expanded_gamut_L_L_issue2_2016.pdf

Chung, R., & Hsu, F. (2008, January). A Study of Ink Trapping and Ink Trapping Ratio - ResearchGate. Retrieved March 30, 2017, from https://www.researchgate.net/publication/242221694_A_Study_of_Ink_Trapping_and_Ink_Trapping_Ratio

Briggs, D. (2017, February 19). PART 1. THE DIMENSIONS INTRODUCED. Retrieved March 31, 2017, from http://www.huevaluechroma.com/011.php

Equinox: Extended Gamut Printing. (n.d.). Retrieved March 30, 2017, from https://www.esko.com/en/products/equinox

Extended Gamut Coated Guide. (n.d.). Retrieved March 31, 2017, from https://www.pantone.com/extended-gamut-coated-guide

Gundlach, M. (n.d.). The EXTENDED GAMUT Advantage for Printers. Retrieved February 06, 2017, from http://www.printing.org/the-extended-gamut-advantage-for-printers.

Hue, Value and Chroma. (n.d.). Retrieved March 31, 2017, from https://vitanorthamerica.com/products/shade-management/color-theory/understanding-color-overview/hue-value- and-chroma/

Lychock, G. (1996, April 19). A Brief Explanation of Hue Error and Grayness WHY? Retrieved March 31, 2017, from http://www.xrite.com/-/media/xrite/files/apps_engineering_techdocuments/h/ga00034a_hueerror_grayness_en.pdf

McClelland, D. (2013). Hue Shifting and Colorizing. Retrieved March 30, 2017, from http://flylib.com/books/en/2.816.1.70/1/

O'Hara, L., Congdon, B., & Gasque, B. (2016, November 01). Printing in Color: Optimizing the Print Sequence for Expanded Gamut. Retrieved March 30, 2017, From https://www.flexography.org/flexo-prepress/printing-color-optimizing-print- sequence-expanded-gamut/

PCMag. (2017). Colour Gamut. Retrieved March 30, 2017, from http://www.pcmag.com/encyclopedia/term/39985/color-gamut

Podhajny, R., Dr. (2002, October 1). What is the Role of Tack in Printed Inks? Retrieved November 28, 2016, from http://pffc-online.com/ar/487-paper-role-tack-printing

Pritchard, G. (2009, July 13). Ink Sequence - 4/C process & beyond. Retrieved March 30, 2017, fromhttp://the-print-guide.blogspot.ca/2009/07/ink-sequence-4c-process-beyond.html

Savastano, D. (2009, October 10). Analyzing Offset Inks. Retrieved March 30, 2017, from http://www.inkworldmagazine.com/issues/2001-08/view_features/analyzing-offset- inks/

Sharma, A. (2016, April 19). Expanded Gamut Printing. Retrieved February 06, 2017, from http://www.printaction.com/colour-control/expanded-gamut-printing-3563.

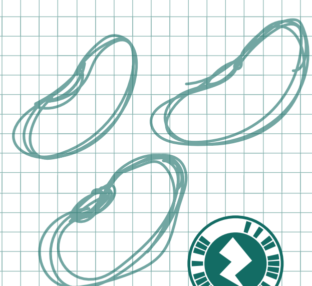
Spot vs. Process Color. (n.d.). Retrieved March 30, 2017, from https://www.pantone.com/spot-vs-process-color

Zeleznik, K. (2011, April). Standardized data sets for expanded color gamut. Retrieved March 30, 2017, from https://www.researchgate.net/publication/295166131_Standardized_deta_sets_f Or_expanded_color_gamut

4

evaluation on soy-based inks

- Christopher Cho
- Avis [Man] Ku
- Xiao Ying [Sylvia] Ma
- Vivian To



SCOPE + SUMMARY

The purpose of this report is to evaluate the capabilities of soy-based inks when compared to traditional petroleum-based inks. This test will be limited to analyzing three major aspects: colour reproduction, rub resistance, and ink opacity on three types of paper (newsprint, uncoated and coated) due to the time constraint. By testing each property, collected data can be analyzed to conclude the major results and recommendations of this report.

Both the soy-based and petroleum-based inks are printed on the drawdown paper to evaluate the ink opacity. The results show that the soy-based ink is more vibrant and less transparent when compared to the petroleum-based inks.

The soy-based inks were printed on newsprint using the Prüfbau Printability Tester, as well as on uncoated and coated paper to allow for better comparison between density, L*a*b*, and ΔE values. Results showed that the soy-based inks offer CMYK density values similar to those of traditional petroleum-based inks. Also, by comparing the L*a*b* of the printed samples, it was made known that the soy-based inks tend to produce higher L* values in the colour space system. Furthermore, the ΔE values of the soy-based and petroleum-based inks illustrate that on a newsprint substrate, the soy-based inks produce the lowest colour difference, when compared to other types of substrates.

In terms of the rub resistance, the results demonstrate that there is the least amount of rub off from newsprint, and the most from coated paper, since newspaper absorbs more ink whereas the inks on coated paper have the tendency to stay on top of the paper. As a result, more inks are rubbed off from the coated paper than newsprint.

Overall, the soy-based inks performed better than the traditional petroleum-based inks in the tests conducted. According to the findings of these tests, soy-based inks would a better substitution to petroleum-based inks for newspaper printing or mass production.

INTRODUCTION

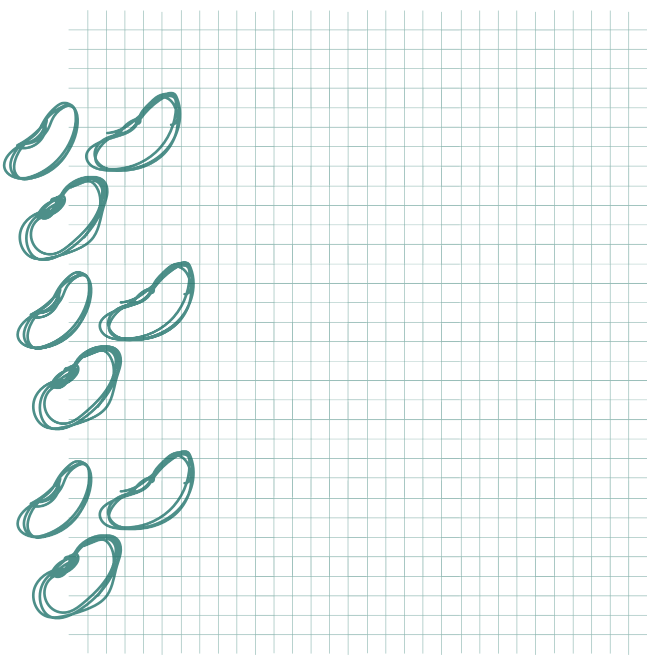
Traditional, petroleum-based inks have been the most common choice in the printing industry for a long time. However, high volatile organic compounds (VOC) in the petroleum-based inks can be harmful and irritant to both the people and the planet in the long run (PsPrint, n.d.). Therefore, the soy-based ink would be a solution to ease the environmental and health concerns of print companies.

With many print companies focusing heavily on sustainability and eco-friendly production, it is becoming essential to find a viable alternative to the traditional petroleum-based inks. The significance of the test is to critically evaluate the performance of soy-based ink, and determine if it would be a better alternative to replace the traditional petroleum-based ink, without sacrificing printability.

The objectives of this report are:

- To determine whether soy-based inks would be a preferable alternative to the traditional petroleum-based inks overall.
- To evaluate colour reproduction by measuring and analyzing the ink densities, L*a*b*, and ΔE values (colour reproduction test).
- To differentiate between strong and weak ink coverage for both inks, as well as their tape test to the substrate (rub resistance test).
- To evaluate and compare the opacity, strength, and colour hue of both inks (ink opacity drawdown test).
- To identify shortcomings of the soy-based inks and recommend ways to improve upon the problems for print production.

By conducting different testing methods, some insight will be gained in order to better understand how to evaluate the quality of printing inks (both soy-based and petroleum-based) in different aspects. Since soy-based inks are still not widely used by many print companies in Canada, it will be useful to obtain primary results regarding them. In addition, these results may demonstrate how to make proper adjustments to achieve the best quality while printing with soy-based inks. Thus, the results of this test prove that it is essential for printers to have a good balance of achieving high print quality while being sustainable and environmentally-friendly.



definitions

Soy-based inks:	Soy-based inks provide the more eco-friendly solution to the printing industry. They are similar to traditional petroleum-based inks, the only exception being that they contain 20-100% soy oil instead of petroleum (Mc-Creary, B., 2010).
Traditional petroleum-based ink:	Petroleum-based inks tend to contain a rather high amount of VOCs (volatile organic compounds), including toluene, benzene, and xylene. These compounds can be very harmful to the environment, wildlife and people (Soy-Based Inks vs. Petroleum-Based Inks, n.d.).
Ink opacity:	Ink opacity refers to the covering power of ink; the extent to which the printed ink will permit or prevent the transmission of light through it, either blotting it out or allowing it to be shown through (DeJidas, p.293).
Rub (abrasion) resistance:	Rub resistance describes the ability of ink or printed surface to withstand marking, scuffing or smudging in moving contact with other surfaces (Paperboard reference manual, p.104).
Delta E (ΔE):	Delta E refers to colour difference; a single number that represents the 'distance' between two colors (Upton, 2015).
L*a*b* colour space:	The Lab colour space can be defined as a colour-opponent space composed of three components: L represents the lightness, and a and b are colour-opponent dimensions (Armada, M., p.221).

equation

$$\Delta E=\sqrt{(L2-L1)^2+(a2-a1)^2+(b2-b1)^2}$$

ΔL = Difference in lightness and darkness

Δa = Difference in red and green

Δb= Difference in yellow and blue

ΔE= Total colour difference

TESTING PRINCIPLES

INK OPACITY

This test is valid for evaluating the coverage (opacity) of both soy-based and petroleum-based inks by the drawdown technique and is carried out in this manner because it is both sufficient and quick to compare the batches of both inks against each other. By visual inspection of both ink batches on the black strip, the colour strength (hue and brightness) and mass-tone difference of the inks can be evaluated, and whether or not the soy-based ink is more capable of ink coverage than the petroleum-based ink can be determined. Further, it can be proved that the results of the colour reproduction (L*a*b* values) match the visual inspection of the drawdown sheets. This test simulates the practical application of the testing inks in real-world situations whereby high ink opacity and colour strength, in particular, can be seen as beneficial towards the overall quality of the job.

RUB RESISTANCE

This test determines the rub resistance of the different prints by using a 4lb weight to rub over the dried printed sample with the same paper type multiple times. By rubbing the same paper type over the printed sample multiple times, how easily the ink will rub off is tested. The loss of ink due to paper rubbing can show that there is poor ink absorption from the substrate. The test is carried out in this method to simulate real life end use situations, such as reading a book or magazine, where pages are constantly rubbing against each other, or shipping and handling.

COLOUR REPRODCTION (in terms of density, L*a*b* and ΔE values)

This test is valid for finding density values by using a Spectrodensitometer to determine if the same amount of soy-based and petroleum-based inks generate similar ink density when printing on the Prüfbau Printability Tester. The density measurements of the two inks in this method can illustrate the relationship between the ink volume and density. By measuring and comparing the density values, it can determine whether or not the soy-based inks are capable of reaching the same density values as the petroleum-based inks.

Additionally, by measuring the L*a*b* values of the printed samples using a Spectrodensitometer, the relationship between the colourimetric values of both soy-based and petroleum-based inks can be compared. This observation is used to see how bright and saturated the soy-based ink colour can appear on different types of paper. Depending on the brightness of the colour, the corresponding L*a*b* values can be shifted either to positive or negative values.

The L*a*b* values of the prints with the petroleum-based inks were used as the standard values, while the ones printed with the soy-based inks were considered the samples. This is done to help determine ΔE values to see if there is a colourimetric difference between the soy-based and petroleum-based inks. The colour difference (ΔE) values of the two types of prints show how accurately the colour reproduction of the soy-based inks can match that of the traditional, oil-based inks. If the density, L*a*b*, and ΔE values differences of these three tests are within acceptable tolerance, then the soy-based inks can achieve or produce the same colour quality as the petroleum-based inks.

MATERIAL TESTED

- Paper for prints:

  - Supreme Gloss Offset 24″x36″, 182M, 100lb, 148 g/m2

  - Earnscliffe Linen Bond Paper 11″x17″, 24M, 24lb, 90 g/m2

  - Newsprint 28″x40″, 78M, 30lb, 49 g/m2

- Inks:

  - Traditional petroleum-based offset inks:

    Hostmann-Steinberg - 43F 10PX-V PERFEXION-ECO Cyan

    Hostmann-Steinberg - 42F 10PX-V PERFEXION-ECO Magenta

    Hostmann-Steinberg - 41F 10PX-V PERFEXION-ECO Yellow

    Hostmann-Steinberg - 49F 10PX-V PERFEXION-ECO Black

  - Soy-based offset inks:

    Universal Color Corporation - 5800 Soy Process Black

    Universal Color Corporation - 5801 Soy Process Cyan

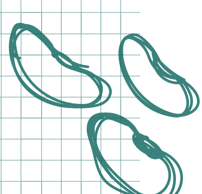
    Universal Color Corporation - 5802 Soy Process Magenta

    Universal Color Corporation - 5803 Soy Process Yellow

- Draw-down papers (coated and uncoated)

EQUIPMENT USED

1. **Prüfbau Printability Tester**
   - Prüfbau Dr-Ing.H Dürner, 82380 Peißenberg/München
2. **Sutherland Rub Tester**
   - U.S. PAT 2734375 Canadian PAT 532864
3. **Drawdown bar**
   - Precision Gage & Tool Co. B-3
4. X-Rite eXact Spectrodensitometer
   - **520 series Certified**



PROCEDURES

ink opacity test

1. Obtain 4 traditional offset (petroleum-based) inks and 4 soy-based inks - Process Cyan, Magenta, Yellow, and Black.
2. Remove the layer of ink skin (if applicable) using an ink knife.
3. Place one dab of each ink, the traditional petroleum-based ink and soy-based ink, on the drawdown sheet.
4. Spread the inks firmly all the way down the sheet to cover the black strip by applying pressure on the drawdown bar.
5. Repeat steps #3 - #4 for each of the process colours on the drawdown sheets.
6. Tape all completed drawdown sheet on the board to let them dry.
7. Compare and evaluate the opacity of both inks on the black strip when the drawdown sheets are completely dried.

colour reproduction test
(in terms of density, L*a*b*and △E values)

1. Obtain 10 sample strips of newsprint, coated, and uncoated paper.
2. Turn on the cold water valve before running the Prüfbau Printability Tester.
3. Skin the ink and measure out an ink volume of 150 mm^3 of each ink on the ink pipette.
4. Place the ink on the Prüfbau Printability Tester and wait approximately one minute for the ink to be evenly distributed.
5. Place the printing roller onto the printing unit. Wait approximately a minute for the ink to be evenly distributed.
6. Make sure the speed is set to 0.5 m/s and print each ink (the 4 traditional petroleum-based inks and the 4 soy-based inks) on each sample strip of newsprint, coated, and uncoated paper (10 samples of each paper).
7. Measure the density and L*a*b* values of each sample using the spectrodensitometer, making sure it is calibrated to the specific paper type.
8. Repeat steps #2 - #7 for the other sample strips.

rub resistance test

1. Cut the substrate into a long strip and tape a blank strip of the same type of paper to it at the bottom, with the printed sample (from the colour reproduction test) facing down.
2. Place the taped strips under the 4 lbs weight of the Sutherland Ink Rub Tester.
3. Tape it in the position of the weight and turn on the dial to 90.
4. Flick the switch to Automatic and press ON to start.
5. Wait until it turns off automatically after counting down to 0 from 90 (every rub back and forth is counted as 1).
6. Remove the substrate.
7. Repeat all the above with all printed samples of inks - for both the traditional petroleum-based inks and the soy-based inks.
8. 16 sample strips are obtained from the test in this test.
   a. Sample #1 and #2 - each process colours of each ink
9. Compare and evaluate on the results regarding the rub-off of both inks.

RESULTS + DISCUSSION

● ink densitites - cyan

figure 1.1

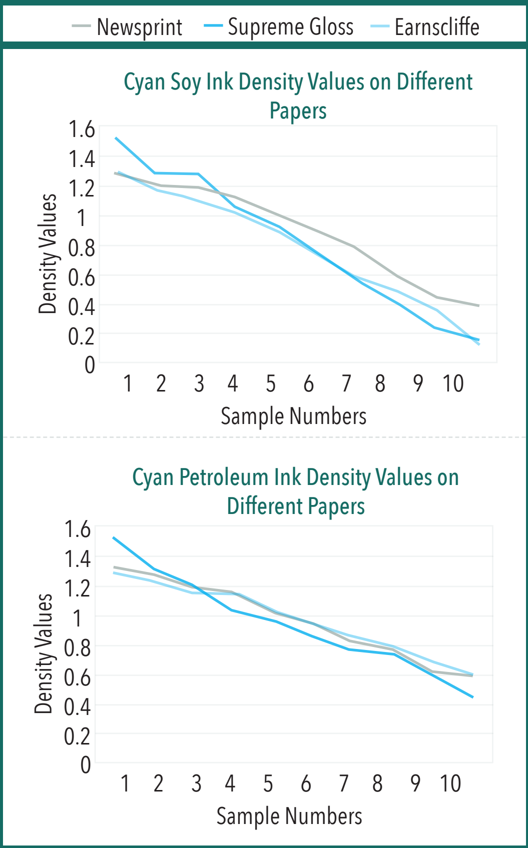


Figure 1.1: Graph of Cyan ink density values of both Soy ink and Offset ink

figure 1.2

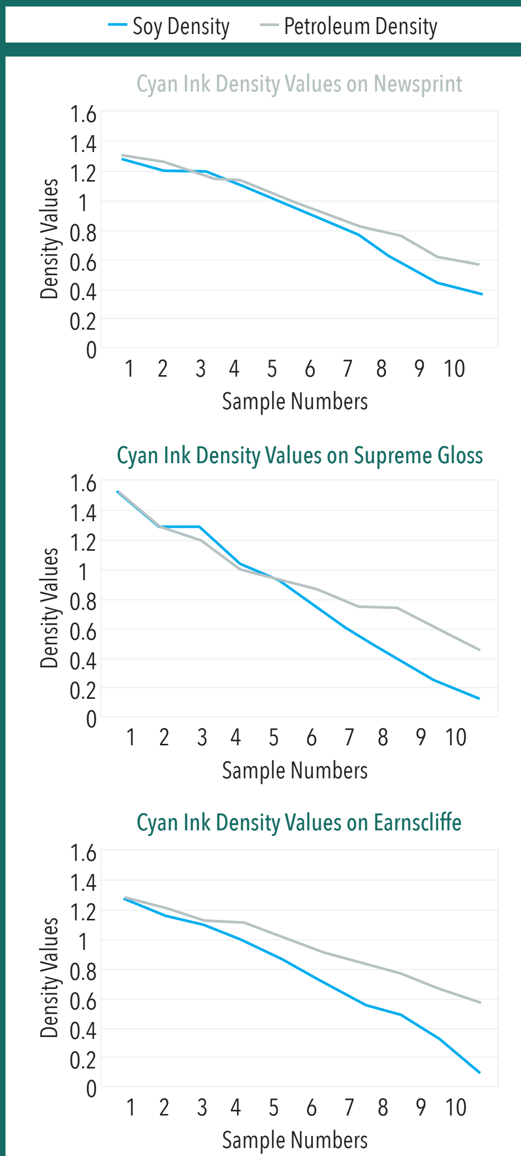


Figure 1.2: Graph of Cyan ink density values of both Soy ink and Offset ink on each paper type

ink densitites - magenta

figure 2.1

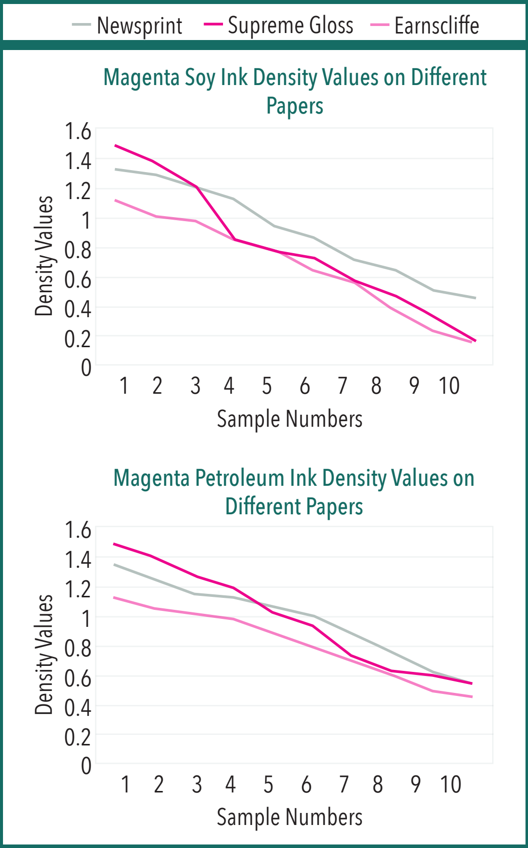


Figure 2.1: Graph of Magenta ink density values of both Soy ink and Offset ink

figure 2.2

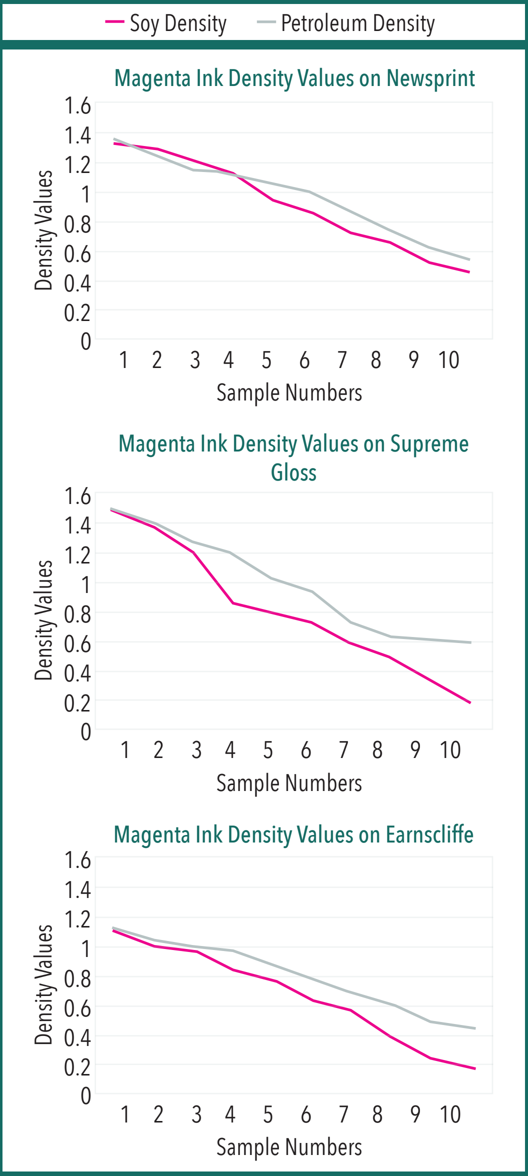


Figure 2.2: Graph of Magenta ink density values of both Soy ink and Offset ink on each paper type

ink densitites - yellow

figure 3.1

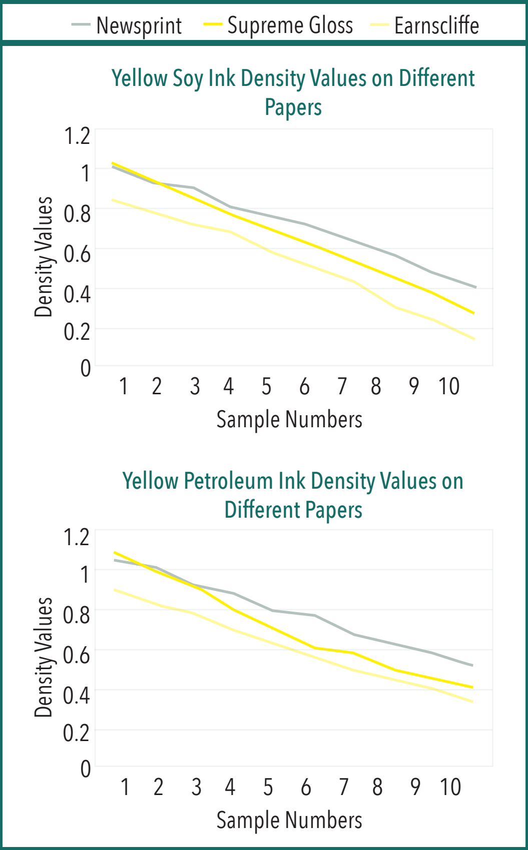


Figure 3.1: Graph of Yellow ink density values of both Soy ink and Offset ink

figure 3.2

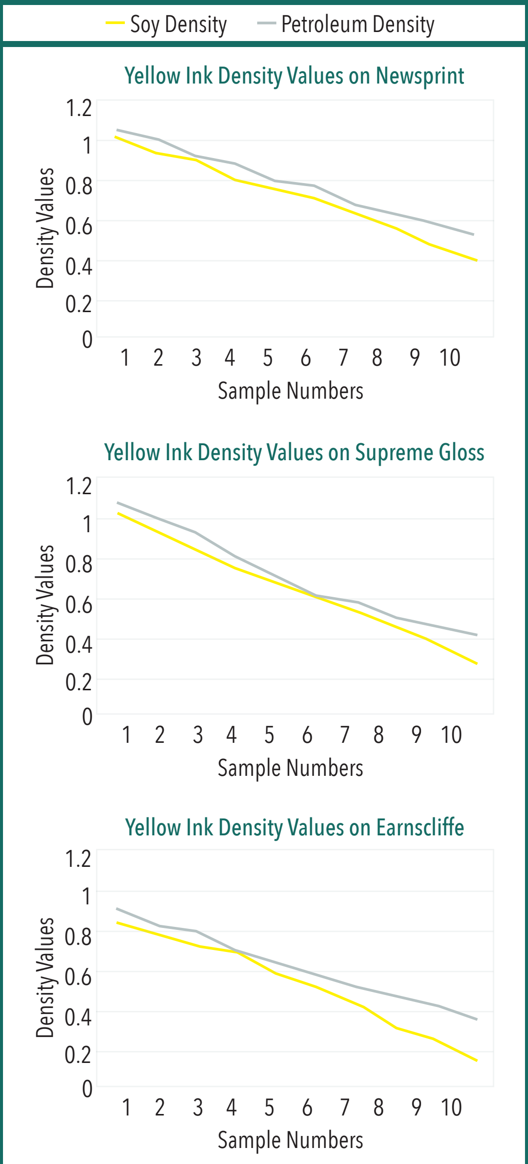


Figure 3.2: Graph of Yellow ink density values of both Soy ink and Offset ink on each paper type

● ink densitites - **black**

figure 4.1

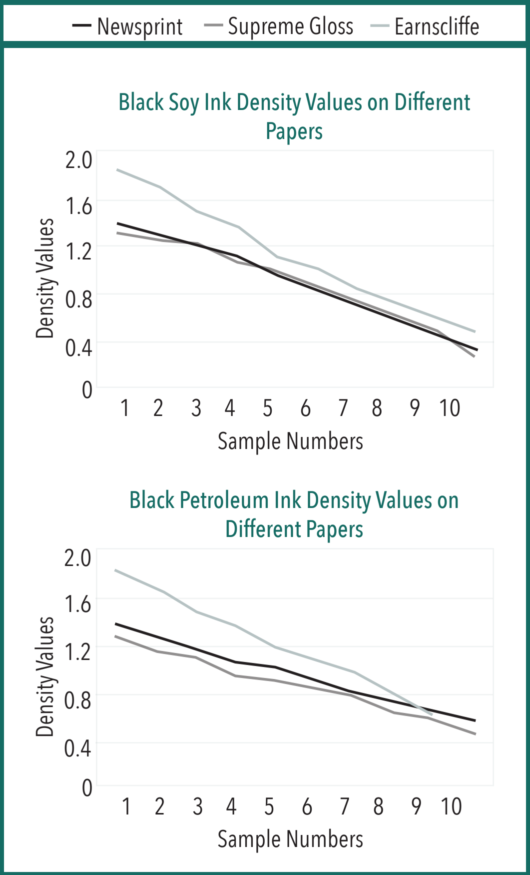


Figure 4.1: Graph of Black ink density values of both Soy ink and Offset ink

figure 4.2

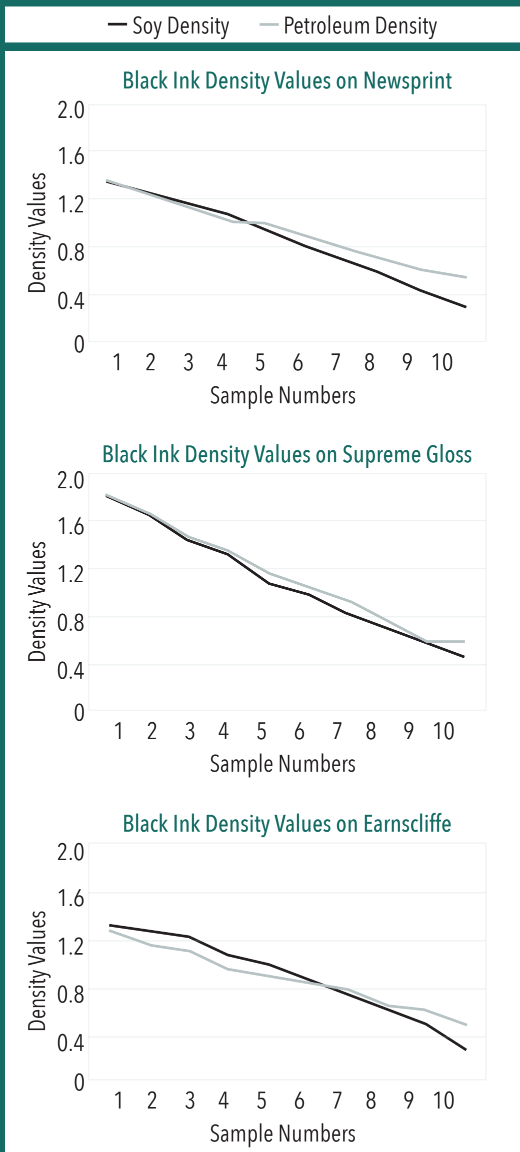


Figure 4.2: Graph of Black ink density values of both Soy ink and Offset ink on each paper type

delta E (ΔE) values

Table 1: Result of ΔE(ab) values (Delta E) between both inks on each paper type

Delta E (ΔE) Values			
Ink Colours	Newsprint	Supreme Gloss	Earnscliffe
Cyan	2.14	4.17	3.49
Magenta	2.08	4.09	5.96
Yellow	4.06	2.70	9.73
Black	1.21	0.33	1.09

figure 5

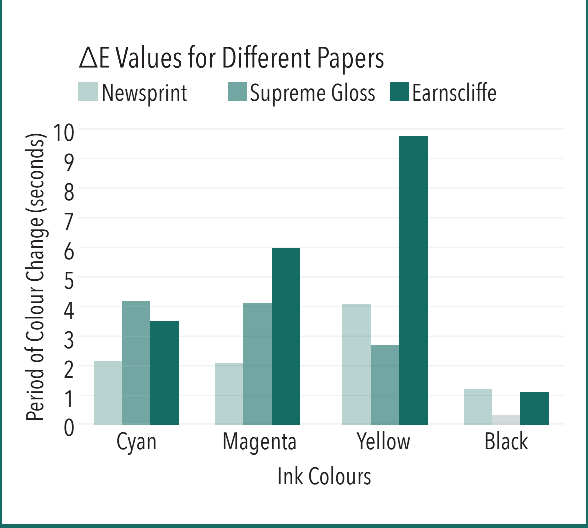


Figure 5: Graph of ΔE values between both inks on each paper type

L*a*b* values - cyan

figure 6.1

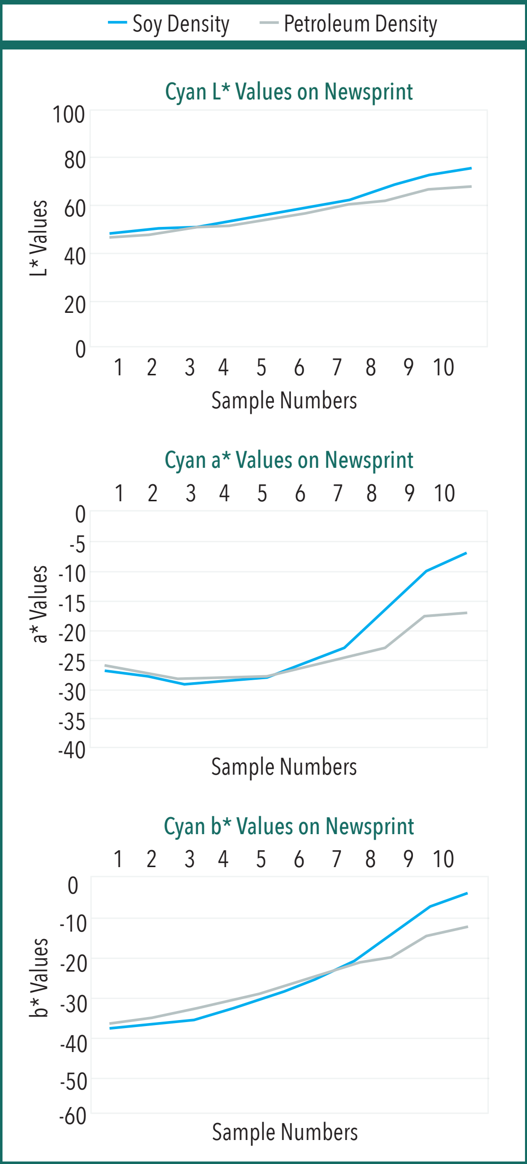


*Figure 6.1: Graph of L*a*b* values of Cyan on Newsprint*

L*a*b* values - cyan

figure 6.2

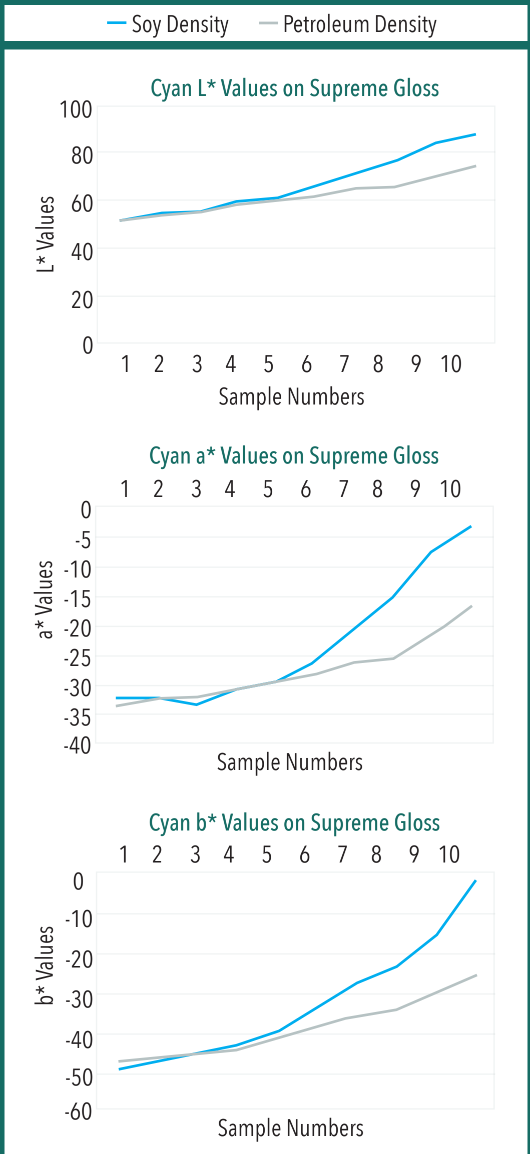


*Figure 6.2: Graph of L*a*b* values of Cyan on Supreme Gloss (Coated)*

figure 6.3

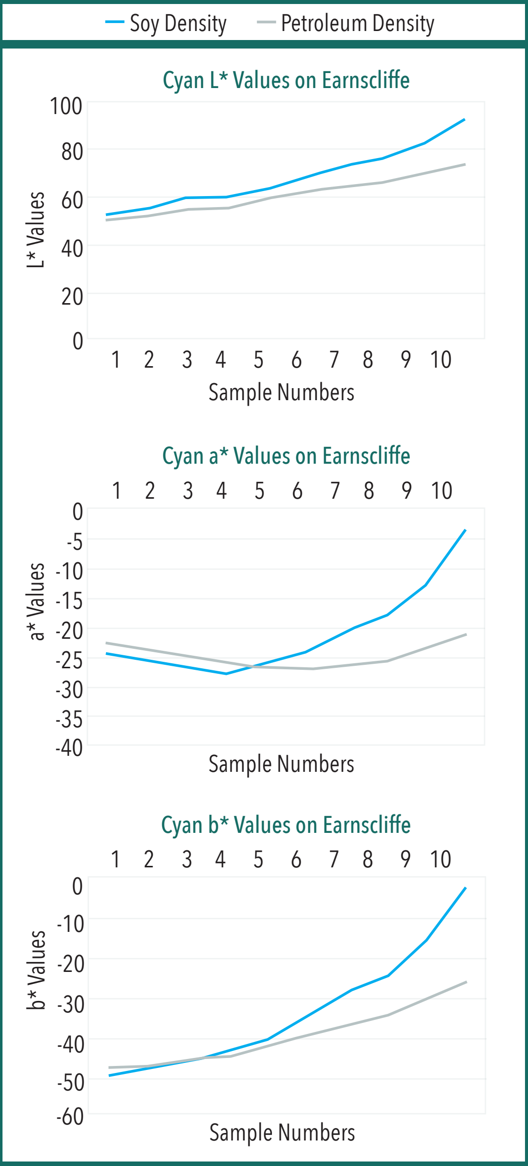


*Figure 6.3: Graph of L*a*b* values of Cyan on Earnscliffe (Uncoated)*

L*a*b* values - magenta

figure 7.1

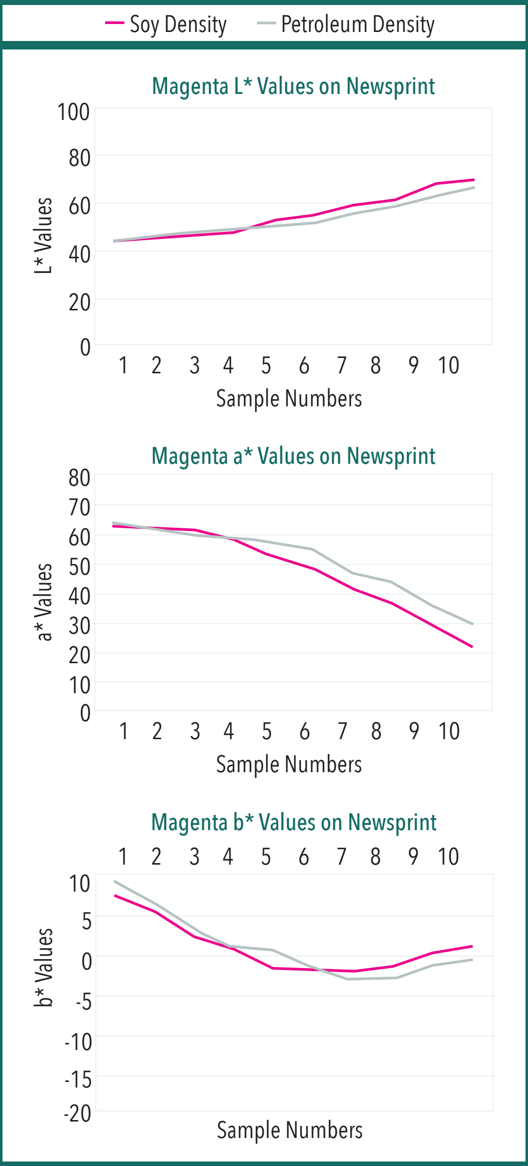


*Figure 7.1: Graph of L*a*b* values of Magenta on Newsprint*

figure 7.2

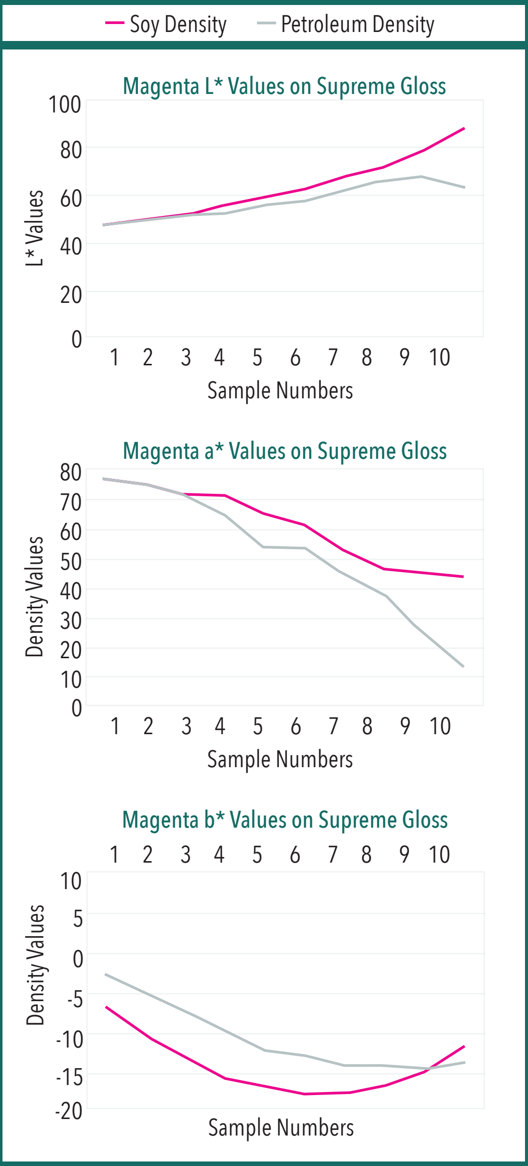


*Figure 7.2: Graph of L*a*b* values of Magenta on Supreme Gloss (Coated)*

figure 7.3

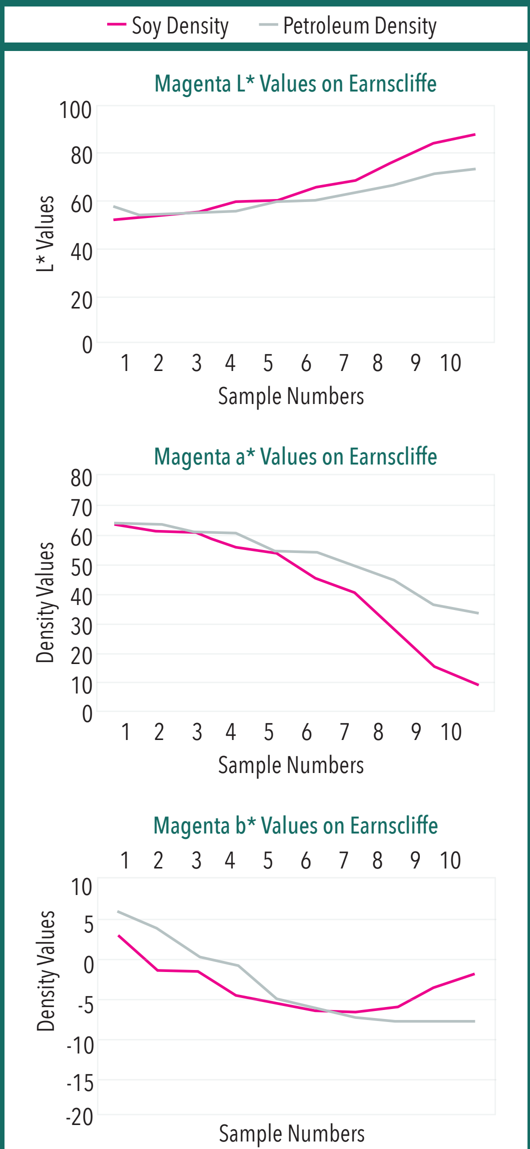


*Figure 7.3: Graph of L*a*b* values of Magenta on Earnscliffe (Uncoated)*

L*a*b* values - yellow

figure 8.1

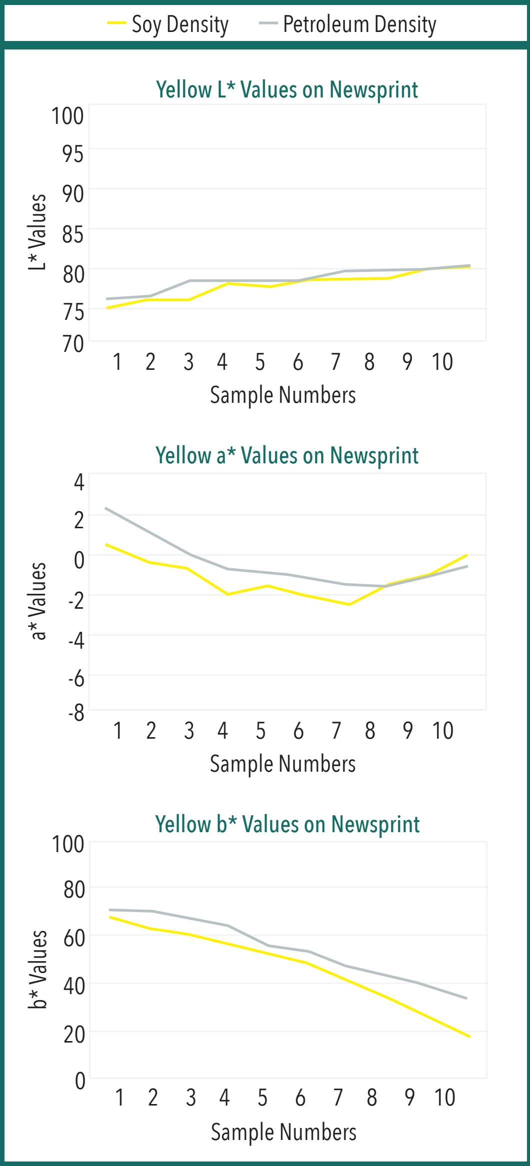


*Figure 8.1: Graph of L*a*b* values of Yellow on Newsprint*

figure 8.2

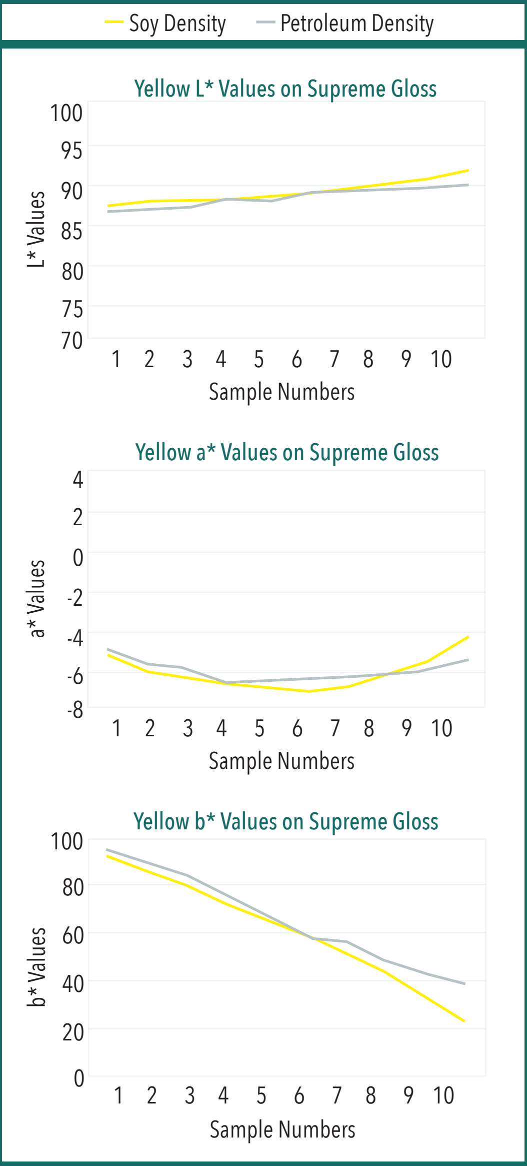


*Figure 8.2: Graph of L*a*b* values of Yellow on Supreme Gloss (Coated)*

figure 8.3

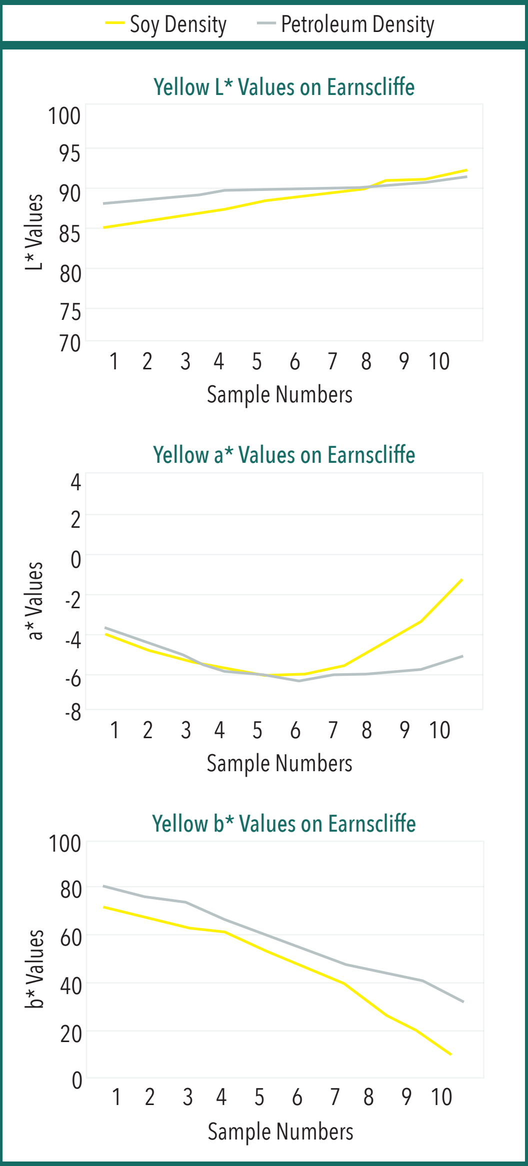


*Figure 8.3: Graph of L*a*b* values of Yellow on Earnscliffe (Uncoated)*

● L*a*b* values - black

figure 9.1

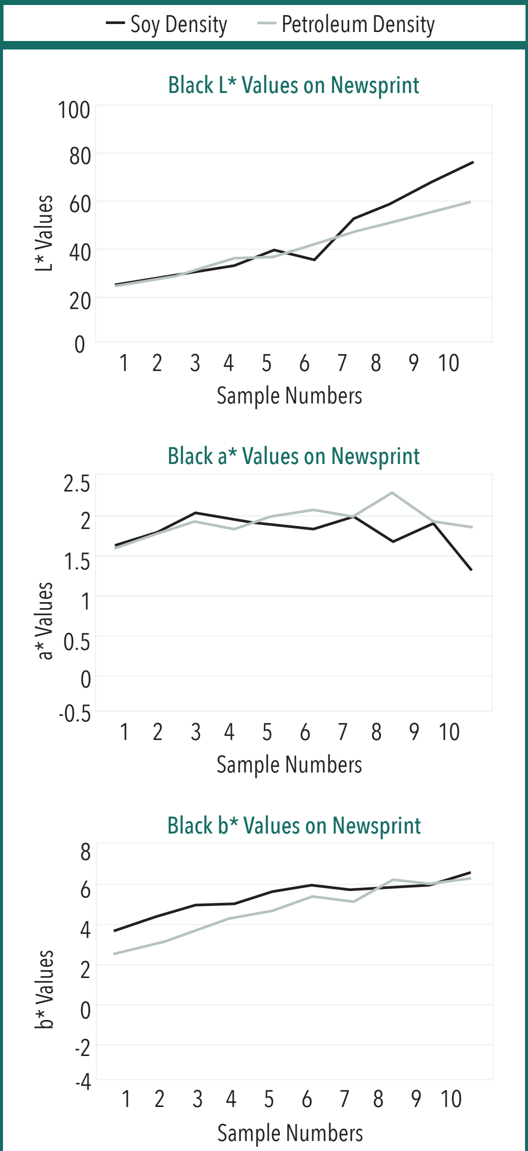


*Figure 9.1: Graph of L*a*b* values of Black on Newsprint*

figure 9.2

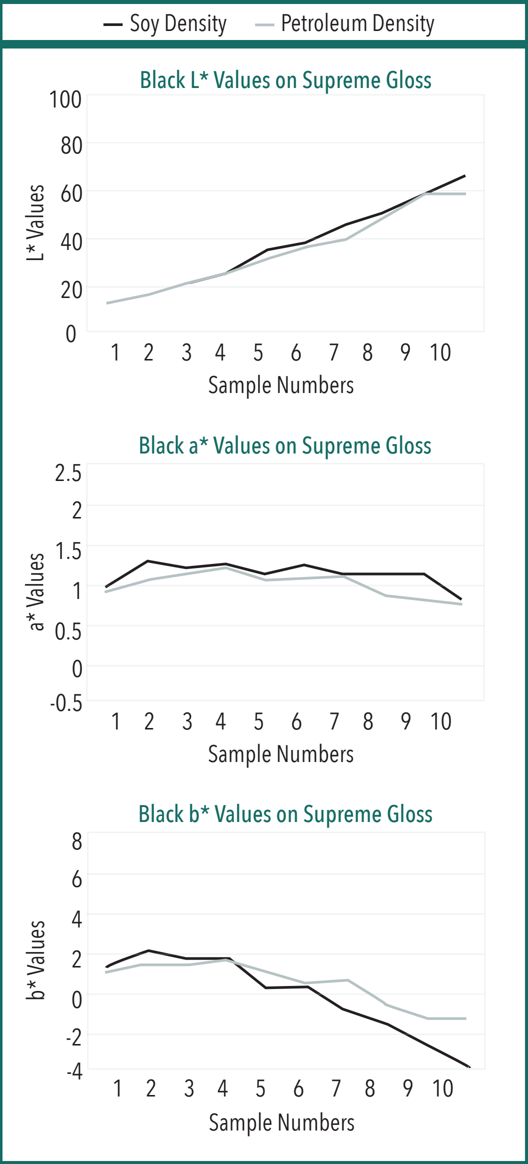


*Figure 9.2: Graph of L*a*b* values of Black on Supreme Gloss (Coated)*

figure 9.3

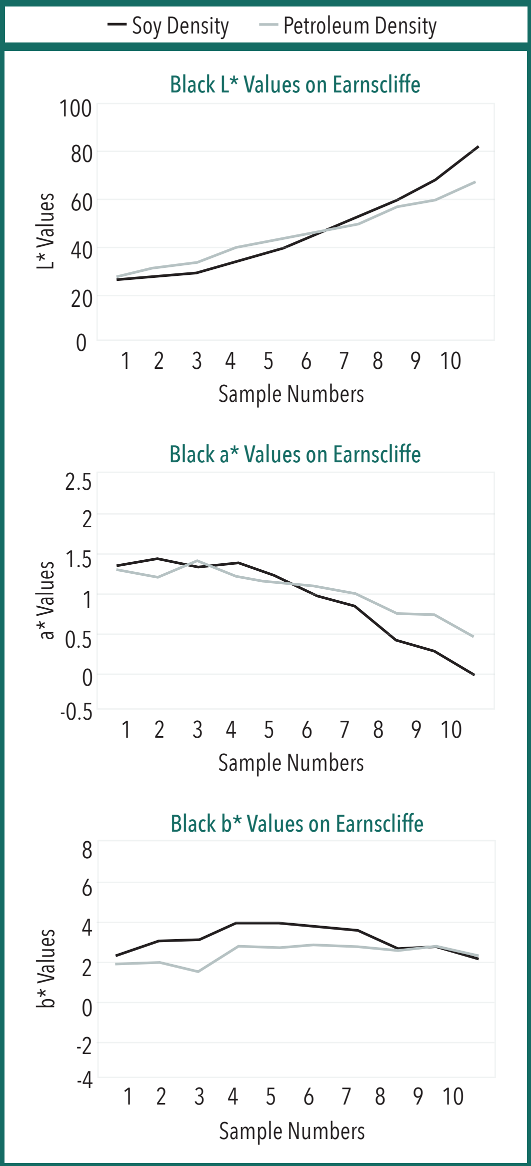


*Figure 9.3: Graph of L*a*b* values of Black on Earnscliffe (Uncoated)*

The ink density values of the soy-based inks and petroleum-based inks are compared across three different types of paper. In the results of this test, it is clearly visible that the two types of inks have little difference in density when printed with the same amount of ink on the Prüfbau. For example, refer to Figure 4.2 - the black soy-based and petroleum-based inks provide similar density trends.

Regarding the L*a*b* values and ΔE values, three types of paper (newsprint, uncoated, and coated) were compared with both soy-based and petroleum-based ink. The results proved the previous prediction that for the L*a*b* values, the soy-based inks tend to have higher L* (lightness) values when compared to traditional petroleum inks. For instance, as seen in Figure 7.2, the magenta L* values of the soy-based ink are slightly higher than the L* values of the petroleum-based ink.

In the results, the ΔE values for newsprint generated the lowest ΔE values, when compared to uncoated and coated paper. Referring to Table 1, the ΔE values for newsprint for CMYK are 2.14 ΔE, 2.08 ΔE, 4.06 ΔE, and 1.21 ΔE, respectively. On the other hand, the ΔE values for Earnscliffe produced the highest colour difference, with cyan at 3.49 ΔE, magenta at 5.96 ΔE, yellow at 9.73 ΔE, and at black 1.09 ΔE (Referring to Table 1). Therefore, the soy-based inks are best when printed on newsprint, because it yields the least colour difference.

After conducting different tests to compare whether soy ink is better than petroleum-based ink, it has been proven that soy ink produces more vibrant and saturated colours than its petroleum-based counterparts. The reason why soy-based ink has a better colour payoff than petroleum-based ink is because the soybean oil is more translucent, thereby resulting in brighter colours. Additionally, unlike petroleum-based ink, the oil used tends to be more murky. The pigmentation of the ink when being printed with soy ink will appear deeper or richer in the yellow and red areas (Dharavath, N. & Hahn, K., n.d., p. 37).

Therefore, the test results confirmed that soy ink can print the same quality as petroleum-based ink. Also, this test showed that soy ink is superior when it comes to reproducing colours that are much brighter and saturated than the standard offset ink.

The weakness of this test is that not all the inks samples were printed on the Prüfbau on the same day. Some of the printed strips were measured just after they were printed on the Prüfbau when the ink had not fully dried yet. The other samples were measured a week later due to time constraints during lab hours. This may have resulted in some inaccuracy when using the Spectrodensitometer to measure the density and L*a*b* values and could have caused the ink densities and L*a*b* values to fluctuate. To maintain consistent measuring conditions, measure everything before leaving the lab.

Another weakness in the test is that the ink printed across the samples using the Prüfbau Printability Tester is not consistent. The cause of this problem might be that the transfer roller was not clean or the roller did not have enough time to distribute the ink evenly. A suggestion to minimize this error in the future is to clean the transfer roller two times with solvent and let the ink evenly distribute on the rollers by waiting approximately one minute.

Figure 10.1: Result of rub resistance of Traditional Petroleum-based inks

Magenta rub-off on Newsprint

Magenta rub-off on Earnscliffe

Magenta rub-off on Supreme Gloss

Figure 10.2: Result of rub resistance of Soy-based inks

Magenta rub-off on Newsprint

Magenta rub-off on Earnscliffe

Magenta rub-off on Supreme Gloss

RUB RESISTANCE

In terms of rub resistance, the prediction made prior to testing was proven correct. Referring to Figure 10.1 and 10.2, when testing the rub resistance on the Sutherland Rub Tester, it was noted that the soy ink that was printed on newsprint, uncoated, and coated paper had a slightly higher resistance to rubbing than the petroleum-based inks.

During the manufacturing of soy-based inks, the natural solvent and resin mixed with the soybean oil increases the rub resistance of the ink. When the ink is mixed, the soybean oil acts as a protective coating layer which aids in preventing scuffs and scratches. This is similar to adding linseed oil to increase rub resistance to petroleum-based inks. In addition, it can be also seen that both types of inks rub off the least on newsprint and the most on coated paper. Newsprint and uncoated paper absorb more of the ink, so less of it is rubbed off. However, on coated paper, less ink is absorbed into the paper and more settles on top, which requires more drying time.

A weakness of this test is that both the paper attached to the weight and the paper with the printed ink need to be firmly attached to their corresponding surfaces. For this test to perform accurately, the papers need to be rubbing against each other with as minimal amount of movement possible. If the tape holding down the paper that is printed upon allows the paper to drag a bit with each rub, the amount of rubbing will lessen, giving a result that shows higher rub resistance. In order to tackle this problem, when taping down the paper to secure it in place, ensure the tape is completely flush with the paper and the table and that enough tape is being used.

Another weakness this test has is due to print consistency. In order for this rub test to be accurate, the printed samples that are being compared need to both have the same ink densities. If the two printed samples being compared have different ink densities, it can cause the results to become skewed. A sample printed with a higher density on coated paper may show more ink being rubbed off compared to another sample printed on the same paper with a different ink due to there being more dry ink on top of the paper's surface.

Figure 11.1: Result of ink opacity (drawdown test) of Cyan inks on coated paper

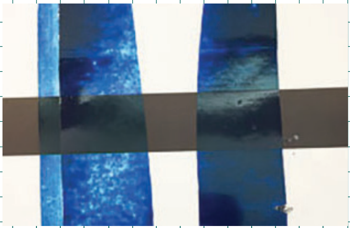


Figure 11.2: Result of ink opacity (drawdown test) of Cyan inks on uncoated paper

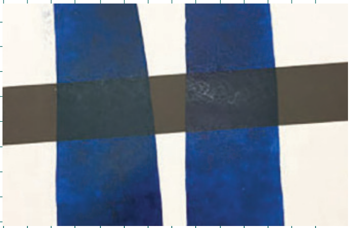


Figure 12.1: Result of ink opacity (drawdown test) of Magenta inks on coated paper

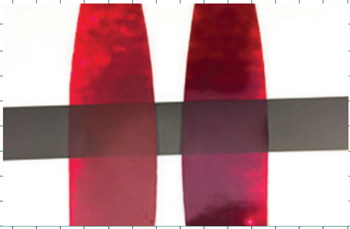


Figure 12.2: Result of ink opacity (drawdown test) of Magenta inks on uncoated paper

Figure 13.1: Result of ink opacity (drawdown test) of Yellow inks on coated paper

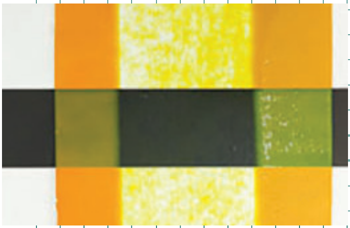


Figure 13.2: Result of ink opacity (drawdown test) of Yellow inks on uncoated paper

Figure 14.1: Result of ink opacity (drawdown test) of Black inks on coated paper

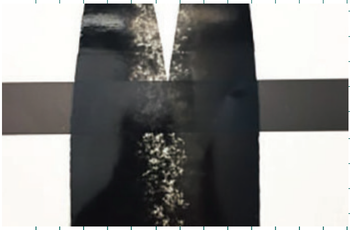


Figure 14.2: Result of ink opacity (drawdown test) of Black inks on uncoated paper

INK OPACITY

Regarding ink opacity, the expectation that the soy-based ink would be more opaque than the traditional petroleum-based inks was proven correct. Referring to Figures 11 - 14, it was noticed that the soy-based inks had better ink coverage ability than the traditional petroleum-based inks. The results of the ink drawdowns, especially on coated paper, clearly showed that the soy-based inks are less transparent than the petroleum-based ones.

The reason for soy-based inks being more opaque is that the use of soybean oils leads to less pigment being necessary to achieve the full chromatic potential in the ink. As a result, it is easier to produce a more intense colour on the substrate. Moreover, the higher ink coverage of soy-based inks is proportional to the visibility of colours laid underneath it, leading to lower trapping potential. Therefore, it results in an opaque colour of the ink (Deshpande,S., 2011).

Regarding the colour strength, it was correct to believe that the soy-based inks were capable of producing more vibrant colours than the traditional petroleum-based inks. Referring again to Figures 11 - 14, the colours produced by the soy-based inks were much more vibrant and intense than those of the petroleum-based inks. There was a noticeable colour difference of yellow between both inks in Figure 13.1 and 13.2. The yellows of petroleum-based ink appeared to be dark and murky, while the ones of soy-based ink were much brighter. The soybean oils in the inks are naturally clearer than the petroleum, which can dilute the colours. Also, the translucence of soybean oils causes pigment to appear brighter, deeper, and richer, contributing to greater printing mileage (McCreary, B.,2010). As stated previously, with the clearer soybean oil grades, less pigment is necessary to produce the same optical effect (Scherer, A., 2016).

One weakness in the ink opacity test is that the pressure applied to the drawdown bar is not constant across the sheet, which causes uncertainties and influences the results. This human error can be solved by using both hands to apply uniform pressure on the drawdown bar to produce a better visual for inspection when determining the opacity.

Additionally, the amount of ink being used for the drawdown test can have an impact on the results. When there is too much ink on the drawdown paper, the black strip will be fully covered with the thick and heavy ink film thickness, which makes it harder to observe the opacity. This human error can be minimized by making sure to scoop out only a small amount of ink onto the drawdown paper.

Another finding discovered while conducting this test is the ink drying time. Although the ink drying test was not conducted because of time and material constraints, it was found that the soy-based inks take a longer time (approximately more than 96 hours) to completely dry than the traditional petroleum-based ink. One possible reason for this is the absence or reduction of additives and chemicals which causes a slower drying time than that of regular inks. Contrarily, petroleum-based inks contain materials ranging from heavy metals, used in colouring, to solvents, used to accelerate the drying process and result in faster drying time (McCreary, B.,2010).

RECOMMENDATION

PRINTABILITY

Printing on newsprint can be difficult due to the colour of the substrate, as its unbleached pulp results in paper that is not white. When choosing which ink to use to print on newsprint, it is more suitable to use soy ink because of the ink saturation and clarity on dull, coloured paper.

The disadvantage of petroleum-based ink is that it tends to be naturally darker compared to the soy ink, which is relatively clear and bright. Therefore, soy ink is able to print more impressions by using the same amount of ink than petroleum ink because of its clear/bright pigments when reproducing coloured images. This can result in a 5 to 50% increase of transfer efficiency when printers choose to use soy ink (Carstensen, M., 1997, p.5).

For ink opacity, the traditional petroleum-based inks are slightly more transparent than soy-based inks. If the ink is transparent, there will be less ink coverage on the printed surface. So, the traditional petroleum-based inks are less bright and saturated than soy-based inks even when the same amount of ink are being used. According to the findings of this test, it is suggested that soy-based inks could be a better option than the petroleum-based inks because they are more capable of achieving high print quality for mass production.

RUNNABILITY

In terms of runnability, it is important to remember that the print spoilage is a major factor. If printing with soy ink, the clean up of the presses will be much easier because soy ink is able to spread about 15% further than petroleum-based ink. This means that printers are able to use less ink on the press and can prevent ink build up on plates and blankets (Horton, Warkentien, and Gogolski, n.d., p.4). As well, the soybean oils in the ink allow smoother ink flow during the press run, which reduces print spoilage (Alternatives to Petroleum- and Solvent-Based Inks, n.d). If the inks do not penetrate enough into the substrate, this can cause the problems such as set-off and paper jam. As a result, it is recommended that the press operator should always ensure a proper adjustment of the inks before actually running the job.

END USE

In terms of the end-use application of the soy-based inks, the printed substrates need to be considered. If the soy-based inks are printed on coated paper for packaging purposes, it is always best to apply a gloss coating or special varnish to protect the colour from rub off.

In addition, soy-based ink takes longer to dry than the standard petroleum ink used in most commercial printing. To decrease the drying time when printing with soy ink, the print operator would have to adjust the amount of ink being used. Soy ink can achieve the same or similar ink densities with petroleum-based ink by using a thinner ink film (Weisenbach, D., 2000). For example, the print operator can run a thinner ink film with soy ink on thicker substrates, such as corrugated boxes. The colour will still appear vibrant compared to petroleum-based ink, which requires a thicker ink film to make colours look brighter.

However, printing with soy ink can be expensive if printing in large quantities, as soy-based inks can cost up to 30% more than the traditional petroleum-based inks. For this reason, it is preferable to use petroleum-based ink for newspaper. However, this applies primarily when printing with black ink; mixing CMY newspaper ink requires less oil than black ink. As mentioned previously, colour newspaper ink needs approximately 30% of oil in the ink component, while black ink needs 40-50% of oil. Since soybean oil costs a dollar per pound, this can result in a 25% to 50% cost increase compared to petroleum ink, which only costs pennies per pound (Abramowitz, H., 1996). Therefore, it is more cost efficient to print with petroleum-based ink if printing with large quantities, such as newspaper.

REFERENCES

Abramowitz, H. (1996). Oh, soy, can you print! Editor & Publisher, 129(4), 3. Retrieved from http://ezproxy.lib.ryerson.ca/login?url=http://search.proquest.com/docview/194296581?accountid=13631

Alternatives to Petroleum- and Solvent-Based Inks. (n.d.) Fact Sheet 6. Massachusetts Toxics Use Reduction Institute. Retrieved from infohouse.p2ric.org/ref/02/01504.pdf

Armada, M., Ferre, M., & Sanfeliu, A. (2014). ROBOT2013: First Iberian Robotics Conference: Advances in robotics. Cham: Springer.

Carstensen, M. (1997). Biochemicals for the Printing Industry. Retrieved from http://www.pneac.org/sheets/all/Biochemicals_for_the_Printing_Industry.pdf

DeJidas, Lloyd P. and Destree, Thomas M. (1995). Sheetfed Offset Press Operating, 2nd edition. Sewickley, PA: GATF Press.

Deshpande ,S. (2011). Screen Angle Combinations And Effect On Print Quality Parameters. International Journal of Advanced Engineering Technology.

Dharavath, N. & Hahn, K. (n.d). Green Printing: Colorimetric and Densitometric Analysis of Solvent-based and Vegetable Oil-based Inks of Multicolor Offset Printing. Retrieved from http://files.eric.ed.gov/fulltext/EJ906151.pdf

Horton, Warkentien, and Gogolski. (n.d.). Agriculture in Print: Soy Ink. Retrieved from http://grownextgen.org/workspace/uploads/files/make-soy-ink.pdf

McCreary, B. (2010, February 10). Converting Clients and Designers: Sustainable Print Design. Retrieved from http://brandbyblake.com/2010/02/converting-clients-and-designers-eco-friendly-print-design/

Paperboard reference manual. (2004). Iggesund: Iggesund Paperboard AB.

PsPrint. (n.d.). Soy-Based Inks vs. Petroleum-Based Inks. Retrieved from https://www.psprint.com/resources/soy-based-inks-vs-petroleum-based-inks/

Scherer, A. (2016, January 26). Soy Ink. Retrieved from https://www.webpackaging.com/en/portals/actpackaginginc/assets/11161480/soy-ink/

Soy-Based Inks vs. Petroleum-Based Inks. (n.d.). Retrieved from https://www.psprint.com/resources/soy-based-inks-vs-petroleum-based-inks/

Weisenbach, D. (2000, February). Don't Wait To Try Soy Ink. Quick Print Products, 3(2), 76. Retrieved from http://bi.galegroup.com.ezproxy.lib.ryerson.ca/global/article/GALE%7CA61195624/88ac032cee04bc7134af5b40a84088d4?u=rpu_main

5

digital printing on traditional media

- Darren Brandt
- Rachel Grenier
- Maya Seto
- Miriam Tingle

SCOPE + SUMMARY

The purpose of this project is to determine the capabilities of a digital xerographic press as applied on traditional artistic media and appropriate paper stock. Swatches of toner are printed on art paper and on various traditional media, then tested for colour accuracy in different combinations, including rub resistance and text reproduction capabilities. These tests will determine the viability of using xerographic printing processes as a useful supplement to traditional artistic work, and in what manner it may be useful given the results.

The project has found that xerographic printing processes experience no difficulty when printing on the tested media, but do not combine well enough with traditional media; specifically, when attempting to accurately reproduce colour to expect adequate, reliable results. The printed toner behaves much as it might when printing on any heavy uncoated stock, but is not the right opacity to block out underlying media, nor to blend with it to produce expected colours. This causes difficulty when attempting to reproduce exact colours. However, the process's reliable runnability and printability make it very useful as a supplement to artistic pieces.

INTRODUCTION

In the past twenty years, artists have been devising new ways to combine technology with traditional media in order to push beyond conventional methods. For digital printing technology, the use of inkjet printers has dominated the extensive exploration of applying digital images onto various non-paper surfaces, including mixed media digital printing. However, the use of toner from laser printers has not been notably researched, despite its already-known ability to produce finer detail and better lines on paper in comparison to inkjet printers. This report intends to determine if toner from a laser printer has similar potential to that of ink from an inkjet printer in artistic pursuits. It should offer insight into how toner could effectively work on traditional media while complying with machine operation specifications as outlined by the manufacturer. In addition, it will assess how feasible the process would be for commercial or artistic endeavours.

Given that using inkjet is the immediate best practice when intending to print on unconventional materials, there is seemingly no research available to imply that a test of toner onto mixed media has already been explored. The closest real-world examples of any digital printing onto mixed media have utilized inkjet printing and have been artistic experiments, exploring "how artists can bring together the old and the new, retaining the finest qualities of each to best tell their tale," (Schminke et al, 2004). Consequently, testing methods and targets have been newly developed specifically for this test and the equipment available.

definitions

Colourimetry:	The measure and definition of colour as perceived by humans.
Traditional Media:	Any medium used to apply colour to a flat surface for artistic purposes.
Mixed Media Digital Printing:	Digital work imprinted onto various singular or combinations of traditional media (Meredith, D., 2015)
Delta E:	The quantified difference between two colours' L*a*b* values $\Delta E = \sqrt{(L_2-L_1)^2 + (a_2-a_1)^2 + (b_2-b_1)^2}$

TESTING PRINCIPLES

A spectrophotometer records wavelengths of light as is absorbed or transmitted from a sample. The wavelength of the light that is transmitted from the sample is converted into L*a*b* readings. Using the L*a*b* readings from the Cyan, Magenta, Yellow, Black, Red, Green, Blue, and CMK colour test patches will help to determine colour accuracy and tolerances between the toner and each medium. With the potential for unique products to incorporate overlapping combinations of toner and mixed media, it is important to be aware of the limitations for colour accuracy, since such combinations can

result in undesired outcomes.
An Ink Rub Tester simulates rubbing of a printed surface in order to evaluate the abrasion resistance as per a use case scenario. Using the ink rub tester will determine the abrasion resistance of samples with toner and toner with mixed media applications on the chosen stock. This information will provide an understanding as to how well the surface of a product can avoid being compromised during handling, packaging, transportation, distribution and general use.

A text reproduction test provides observational information regarding the legibility and readability of text against a chosen medium. The visual evaluation of this test determines the capabilities of a certain medium to accept text in terms of size, style, and overall usefulness. This information is important to determine if a change in text size or in applied media is necessary for the specific end user requirements of the product being printed.

Testing within printing specifications of the selected laser printer and using a single substrate narrows the focus specifically to toner on top of variable mixed media. The choice of single substrate is based on the criteria that the thickness be within press specifications and cold pressed to absorb water and ink faster and avoid warping.

MATERIAL TESTED

- Strathmore Bristol, vellum surface
  - 100lb (270 gsm) cut to 11" x 17"
- Turner Artist's Water Colour
  - Quinacridone Magenta, Permanent Yellow, Cerulean Blue and Black
- Turner Design Gouache
  - Magenta, Cyan Blue, Permanent Yellow and Black
- Copic Sketch Markers
  - Magenta, Cyan, Yellow and Black
- Xerox Digital Printing Toner

EQUIPMENT USED

1. Xerox 700i Digital Press
2. X-Rite 500 Series Reflection Spectrodensitometer
3. Brown Co. Sutherland Ink Rub Tester (S/N 1714)
4. Above Ground Paintbrushes

PROCEDURES

1. Print test form outlines (see Appendix A) on Xerox 700i.
2. Use traditional media to fill in test patches.
3. Print test forms (see Appendix A) on Xerox 700i.
4. Make visual comparison of toner and traditional media.
5. Take L*a*b* readings of each test patch, record, and average.
6. Find and use Delta E values, along with visual comparison and L*a*b* value comparison, to determine colour reproduction capabilities and opacity of toner.
7. Cut Rub Resistance strips and perform Rub Resistance test with the Sutherland Tester and strips of the same bristol board (4lbs for 60 seconds).
8. Observe toner abrasion and transfer.
9. Observe text reproduction on traditional media.
10. Create painted piece on bristol board.
11. Print on painted piece with Xerox 700i.
12. Observe reproduction capability and aesthetic value.

RESULTS

Original data for the following tables can be found in Appendix B. Qualitative analysis of colour and text reproduction can be found in the Discussion section.

figure 1 colour comparison

	Water Colour	Gouache	Marker
C	31.74	20.41	13.27
M	15.21	24.05	17.79
Y	5.58	20.33	10.32
K	26.42	30.26	14.80
R	16.99	21.98	27.47
G	35.15	33.63	19.34
B	53.83	18.80	21.95
CMY	44.43	28.85	19.03

Figure 1. Delta E values, comparing colour of three traditional media and Xerox toner.

figure 2 colour comparison

	Water Colour	Gouache	Marker
R(Y)	8.35	22.59	9.27
R(M)	25.41	17.75	26.50
G(Y)	16.77	26.22	7.82
G(C)	61.96	32.84	23.29
B(M)	5.51	10.56	6.66
B(C)	35.15	24.68	24.97

Figure 2. Delta E values, comparing overprint colour of three traditional media and Xerox toner.

The letter inside the parentheses indicates the first-down traditional media colour.

figure 3 rub resistance

	Water Colour	Gouache	Marker
C	4	2	1
M	2	4	2
Y	3	1	3
K	1	3	4

Figure 3. Rub resistance ranking, comparing rub off of four traditional media onto bristol paper. 1 indicates least rub resistance, whereas 4 indicates most rub resistance.

DISCUSSION

COLOUR COMPARISON

Across all three types of traditional media, the most accurate colour is yellow, with the lowest DE values of 5.58 (watercolour), 20.33 (gouache), and 10.32 (marker). The least accurate colour is black with DE values of 26.42 (watercolour), 30.26 (gouache), and 14.80 (marker). A visual examination of the test chart confirms these findings: the yellow watercolour patch appears to be an extremely close match to the yellow toner patch.

Overall, marker is the most colour-accurate of the three traditional media tested; on average the marker C, M, Y, R, G, B, and CMY mix patches measure lower DE values than watercolour or gouache. The solid black marker patch has the lowest DE measurement at 14.80 and is confirmed by a visual inspection, indicating that the marker black was the most opaque black of the three solid black traditional media patches. The solid black watercolour patch measured 26.42 and the gouache patch 30.26, both with lower lightness (L*) values than the more colour-accurate marker black patch. The patches of black toner printed on top of C, M and Y watercolour, gouache, and marker appear dark but less opaque than expected, allowing the observer to clearly identify the colour applied to the paper beneath the toner.

Visual inspection reveals most of the solid watercolour patches appear washed out and many of the overprint patches are bad reproductions of the desired colours. The most accurate watercolour overprints are the blue patch with watercolour magenta beneath toner cyan, measuring a DE of 5.51, and the red patch with watercolour yellow below toner magenta, measuring 8.35. To the naked eye, both patches appear very similar to the solid patches printed fully with toner. It is surprising the blue patch had a lower DE than the red patch, despite the yellow watercolour being closer than the cyan watercolour to its toner equivalent. The inconsistent application of media from visible brush strokes in the watercolour and gouache patches could be a factor, however this was mitigated by taking multiple L*a*b* measurements from the same patch and averaging the results. The most colour-accurate gouache overprint patch is the blue patch, with a DE of 18.80, comprised of gouache magenta and toner cyan on top of it. While there is a negligible difference between the DE values of solid gouache yellow and solid gouache cyan compared to solid toner patches of the same colours (20.33 and 20.41, respectively), the gouache yellow looks better than the cyan. This is because the lightness of the colour masked the brush strokes visible in other patches. Visually, the gouache appears to have more vivid colour, but the RGB overprints and CMY mix patches all appear to be tinted with a magenta hue.

The comparatively high colour accuracy of the marker patches is unexpected, with three overprint patches measuring a DE of less than 10.00. The blue overprint patch with magenta marker under cyan toner measures DE 6.66, significantly less than both the other blue overprint patch with cyan marker below magenta toner (24.97) and the cyan/magenta marker mix (21.95). It must be noted that unlike watercolour and gouache, marker inks cannot be mixed before being applied to the paper, and the cyan and magenta marker had to be overlaid to create the blue mix patch. Despite this weakness, marker appears the most visually accurate of the three traditional media.

The three composite pieces produced all turned out very well, with the black and blue toner producing sharp lines and clear colour on top of the watercolour, gouache, and marker. In the larger patches of black toner, it is possible to see the brush strokes and marker lines underneath. If the black toner text reproduced were smaller it might be difficult to read on top of a complex mixed media pattern. Complicated contrasting art beneath toner would likely affect readability much more than printability.

RUB RESISTANCE

When visually comparing rub resistance of the toner-only and toner with mixed media samples against the bristol paper, the most resistant samples had the combination of toner on top of watercolour media. Of this combination, the most resistant colour was black, followed by magenta, yellow, and cyan, respectively. However, the combination of toner on top of gouache media resulted in the most evident rub edge against the bristol paper. Of this combination, the most resistant colour was yellow, followed by cyan, black, and magenta, respectively. The combination of toner on top of marker media resulted in a slightly less evident rub edge against the bristol paper compared to the gouache media. Of this combination, the most resistant was cyan, followed by magenta, yellow, and black, respectively. The toner-only sample also resulted in a slightly less evident rub edge against the bristol paper compared to the gouache media. Overall, the worst toner on top of gouache combination sample along with the worst toner on top of marker combination sample and toner-only sample were more evident of rubbing against the bristol paper than the toner on top of watercolour combination. The application of watercolour media before toner appears to improve the adherence property to bristol paper. The small grains of powdered plastic within the toner may have fused to pigment particles found within watercolour media as it was being melted by the fuser within the Xerox 700i Digital Press. Depending on the colour, the pigment particles could contain either synthetic organic material from petrochemicals or inorganic material from chemical reactions such as oxidation or natural such as calcium carbonate, calcium sulfate, diatomaceous silica, china clays, carbon, iron- oxide, siennas, umbers, compounds of chromium, compounds of cadmium or iron (Simmons, 2015; Pigment, n.d.).

In addition to the standard rub resistance test, adhesion resistance was observed in the samples when removing them from the testing weight. Generally, the tape used to secure the samples were either removed cleanly or removed a layer of bristol board; in the former case, it can be seen that the toner is sufficiently resistant to adhesion. In samples where marker was used as the base media, the toner was minimally removed by the tape. Given the nature of scotch tape to have an easily released pressure-sensitive adhesive, properly applied toner should not be removed in this manner (Understanding the Basics of Pressure Sensitive Adhesive Tapes - Tape 101., n.d.). Marker as a base layer seems not to affect rub resistance, but to slightly reduce resistance to adhesion. A more formal testing may be required if desired applications of this research involve adhesive materials.

TEXT REPRODUCTION

Gouache paint is the darkest out of the three traditional media; the low contrast between paint magenta and black text, combined with the visible brush strokes makes this text more difficult to read. The 4pt serif and sans-serif texts are challenging to make out, but all other sizes of text are completely legible.

Marker magenta measured a lightness value of L* 52.97, only marginally lighter than the gouache (L* 51.64), but is noticeably more readable than the gouache because of the evenness of the marker strokes in horizontal lines across the page. The edges of the marker patches are darker than the centres. This is explained by prolonged contact between marker head and paper during application. This made reading the very small sans-serif text more difficult.

Because the watercolour paint is the lightest magenta of the three media and has the most paper show-through, the high contrast between the paint and the black text renders the serif and sans-serif type legible and easy to read. Despite moving in the same direction as the reader’s eye, the horizontal brushstrokes are slightly distracting, but overall this is less influential on legibility than the contrast.

RECOMMENDATION

PRINTABILITY AND RUNNABILITY

What has been repeatedly made clear by this test is this method of printing is best suited for artistic endeavours. The inconsistency of colour within areas of traditional media, the difficulty in accurate colour reproduction, and the opacity of toner all make technically correct printing and colour creation through mixing media inadvisable or, with some media, impossible. If accurate solid colour reproduction is absolutely imperative for a project, a medium with high colour accuracy must be chosen. Of the media tested in this report, marker would serve best. Gouache, with its high volume of pigment, should not be used along with similarly formulated media. This creates much more vivid colours not suitable for print-accurate colour (Cohn, 1977). When overprinting with mixed media, colours involving yellow elements should be painted yellow, then printed over. Bluer tones should be printed cyan on top of magenta media. These formulations allow for the most accurate colour, as shown in this report. Alternate formulations have been experimentally shown to create less desirable colours due to the opacity of toner and its influence over the final visible combination. When attempting to create different colours by mixing media, tests should be conducted to determine the optimal printing order to ensure pleasing colour. Alternatively, areas where accurate colour is imperative (logos, for example) may be printed at the actual values in a space where no media has been laid down. This way any desired colour is possible to create with toner alone if required.

Considerations should be made for the paper and media used when running such jobs. Many commercial digital printers will allow for paper up to 300 gsm and 12″ x 18″. Running anything thicker than this raises the risk of paper jams, while anything larger would not be physically possible to print. Prepared pages should also be sufficiently dry and flat before printing, which may be difficult with some of the more water-forward methods of painting like watercolour. Ignoring this would lead to paper jams and inconsistency in toner laydown. Thicker paper, as would be used in these artistic projects, should be oriented properly to ensure it passes through the rollers without any problems. In testing, letter-sized bristol board running long end first had difficulty running through the press. This is likely due to the greater dimensional stability of the sheet in the shorter dimension. This hindered it when curling through rollers, which means pages should be turned to run short end first. A final consideration for runnability is the medium's tolerance for heat. Media such as acrylic were not used, due to the melting point of solid acrylic being lower than the running temperature of the 700i's fuser (Xerox Technical Support Canada, personal communication, February 1, 2017). With the media chosen, there was no risk of causing damage to the rollers or press, as confirmed by test sheets running clean after printing. With such a heat-intensive process, the medium being printed on must be chosen carefully.

END USE

This method of printing has little practical use but provides an innovative way of creating one-of-a-kind works of art. The traditional media not only enhances the physical appearance but also provides a textural element to the final product. The end result is a novel art form that could be used to great effect to create visually unique products. The printed toner allows for sharper edges, creates smoother tones, and adds finer details efficiently (only if the underlying paper and media allow for it without bleeding or mixing undesirably) where fine art capabilities would take a significantly longer time to produce, as well as a high level of skill. Art made using this method must be conceptualized with the physical and digital components in mind simultaneously. Templates and parallel design processes may be needed. This ensures greater accuracy of alignment when printing. Short runs are recommended when printing with this method, as it would take an extensive amount of time to make identical fine art images. However, if one were so inclined, this method allows for very fast production of the digital images once traditional media base images are finished. Rub resistance and readability of text were generally unaffected through this process as compared to normal toner-on-paper printing, so end use applications should not be limited in this way. If readability of small text is imperative for a project, it is recommended that brush strokes or colour lines be made horizontally so as to aid the reader's eye in flowing over the text.

REFERENCES

Cohn, M. (1977). Wash and gouache. Cambridge: Center for Conservation and Technical Studies, Fogg Art Museum.

Meredith, D. (2015). Process. Diana Meredith Retrieved February 5, 2017 from http://www.dianameredith.com/process_article_mixedmedia.php

Pigment. (n.d.). Retrieved March 31, 2017, from https://www.britannica.com/technology/pigment

Schminke, K., Krause, D. S., & Lhotka, B. P. (2004). Digital art studio: Techniques for combining inkjet printing with traditional art materials. New York, NY: Watson-Guptill Publications.

Simmons, L.(2015, March 23). Inside Laser Printer Toner: Wax, Static, Lots of Plastic. Retrieved March 31, 2017, from https://www.wired.com/2015/03/whats-inside-printer-toner/

Understanding the Basics of Pressure Sensitive Adhesive Tapes - Tape 101. (n.d.). Retrieved March 31, 2017, from http://www.tesatape.com/featured/technology_journal/understanding-the-basics-of-pressure-sensitive-adhesive-tapes-tape-101,8805648,1.html

Xerox Technical Support Canada. (2017, February 1). Phone

MEET OUR TEAM

CO-PRESIDENTS

My name is Jeremy Page, and it is both my absolute pleasure and privilege to be leading the Ryerson TAGA Chapter with my partner Antek this year. In driving a team as diverse and dedicated as the Ryerson Chapter, I have been absolutely blown away by the passion in their performance that I see with every year of our continued success. Each day I am humbled by the opportunity to aid these soon-to-be titans of industry in learning and exploring the technologies and relationships that will define their futures. I will now and forever thank them for showing me that this project is truly greater than the sum of its parts and that together we can achieve what would be impossible alone.

CO-PRESIDENTS

A little from me, my name is Antek Krystecki and I have been part of the RyeTAGA for 3 years and what a ride it has been. The amount I have been able to learn from not only our experiences, but those of our fellow TAGA teams has been staggering. Attending the conference each year has only strengthened my resolve to continue my growth within the graphic industries and with each opportunity that comes my way, my TAGA experiences will always be ones I gladly tell to others.

EDITORIAL DIRECTOR

This year, I had the great opportunity of working on the RyeTAGA executive team as the editorial director after originally joining the student group last year as an associate member. As a second-year Graphic Communications Management (GCM) student, I am extremely fortunate and grateful to have been a part of this executive team. Being able to work with such a great group of passionate and talented individuals has been an invaluable experience for me. This team has dedicated many months to taking this journal from its initial conception to a final, tangible product, and being a part of this process has given me a greater appreciation of the intricacies of the graphic arts industry. I hope to further my work with RyeTAGA during my coming years in the GCM program, and continue to welcome the industry experience and opportunities that this incredible student group provides.

CREATIVE DIRECTOR

I originally joined RyeTAGA in my first-year at Ryerson as an associate member, where I made multiple posters and tickets for events. Now, being a third-year student, I am so grateful to have been able to be a part of the RyeTAGA executive team in the role of Creative Director. It has been an amazing experience for me to have been in a role where I was able to develop the concept of the book and execute its design with my wonderful team of associate members. It is incredibly rewarding to know that all of our hard work has paid off in the form of the physical, printed book. This opportunity had really brought to light for me how real projects are executed in industry and given me a better respect for all the work involved in the process. I am very thankful to have worked with such an amazing team and will never forget this experience with RyeTAGA.

PRODUCTION DIRECTOR

This is the second time I have been a part of the RyeTAGA executive team. Coming back from exchange in Germany the previous semester has been an eye-opening experience to a variety of different ideas and aspirations for this year's journal. Two years ago, as one of the Co-Presidents of RyeTAGA, I learned many valuable leadership and communication skills. Going into my fourth year of Graphic Communications Management (GCM), however, I wanted to be challenged in a completely different aspect, aside from managerial. I wanted to take my learned technical skills from many of my GCM classes and put them to the test. RyeTAGA has been a well-rounded experience that has pushed my boundaries to their limits. It has been an honour to have had RyeTAGA be such a big part of my post-secondary experience.

MULTIMEDIA DIRECTOR

Being a part of RyeTAGA for the second year in a row as Multimedia Director, I have had the opportunity to test out different technolog and find ways to integrate it with a printed journal. This role has allowed me to see how much printed content benefits from the addition of a digital layer. Instead of trying to replace print, the message comes across more successfully when print and digital components work together to deliver content. By using an augmented reality app, I have provided readers with an insight to the hard work our published authors, executive members, and team associates have put into this project, from writing the papers to printing and binding the journal. My goal is to take these new perspectives I developed through RyeTAGA and look to my future with an open mind to new possibilities and continue taking risks.

COROPORATE RELATIONS DIRECTOR

This has been an experience I will never forget. I had the pleasure of working with an amazing team of bright individuals that shared a larger goal and worked together in order to achieve it. This team exceeded my personal expectations and pushed my abilities as a professional. Being able to work through the entire production cycle from conception to production has enhanced my knowledge of the processes involved in the graphic arts industry. This experience has allowed me to utilize my academic and professional skills in a managerial position but also as a group member. As the Corporate Relations Director, I was able to reach out to the industry, and with an outstanding response. I am honoured to be able to put our hard work on display, as well as show off our individual skills. I hope we have inspired new members to join our team and that you enjoy reading the 2018 journal as much as we enjoyed producing it.

TREASURY+ ADMIN DIRECTOR

Being a part of the RyeTAGA team means that I have had the opportunity to work with some truly talented individuals to create something amazing. It gave me the chance to put myself into action while gaining more experience and valuable skills for the graphic arts industry. As the Treasury and Administration Director, I have been able to learn more about managing a project by helping to keep the executive team organized and up-to-date, our assets balanced and in check, and scheduling everything from meetings to conferences - a role that not every student is so lucky to have and learn from. I have always loved getting involved and expanding my horizons, and RyeTAGA allowed me to do just that with the invaluable experiences it gave me. RyeTAGA is an amazing group where all of our members were able to grow both individually and as a team through creating something uniquely our own. I am truly honoured to have been a part of the team this year, and cannot wait to see what the next year will bring.

MARKETING + EVENTS DIRECTOR

It has been an incredible learning experience to be a part of the RyeTAGA executive team this year. Being a part of RyeTAGA has given me an opportunity to apply the knowledge and skills I have learned during my time in the Graphic Communications Management program. It has been fascinating to witness the journal process from brainstorming to producing a tangible product that the team is proud of. I am so grateful to have worked with a team of passionate students, and I hope to continue to work closely with RyeTAGA again during the rest of my years at Ryerson.

COLOPHON

typefaces:
- Avenir Next Condensed
- Futura
- Helvetica

software + equipment
- Adobe Photoshop/Illustrator/InDesign CC 2017
- Kodak Preps + Prinergy
- EFI Fiery Command Workstation
- AccurionJet KM-1 Digital Press
- AccurioJet KM-1 UV Inkjet Press
- MGI JETvarnish 3DS with iFOIL S

finishing equipment
- MBO multi unit folder

stocks
- Spicers Supreme Digial Silk Cover 130#
- Neenah Paper - Classic Textures Stipple Digital, 100t. 7.5pt. 148 GSM 25"x38" Uncoated

ASSOCIATES

editorial associates
Annika Boyer
Lauren Henderson
Lindsay Martin
Pauline Reyes

creative associates
Janet Cheung
Samantha Chung
Andrea Mendoza
Satveer Singh
Kaitlin Wilson

multimedia associates
Priscilla Lay
Erin Gurette

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Konica Minolta partners with Ryerson University and Canada's 1st KM-1 UV Inkjet Press customer, Flash Reproductions to produce this year's RyeTAGA Student Journal

It's an award-winning combo – our very own AccurioJet KM-1 UV Inkjet Press and the MGI JETvarnish 3DS with iFOIL S.

Konica Minolta Business Solutions (Canada) Ltd. a leader in the Graphic Communications industry has taken its ongoing support of future leaders in the printing industry to an entirely new level. Proud partner with Toronto's Ryerson University and Platinum Sponsor of RyeTAGA, we seek to inspire the next generation of Ryerson Graphic Communications Management (GCM) students – while also supporting the Canadian print industry in its mission to attract the best possible talent. In doing so, Konica Minolta has exposed students to some of the most ground-breaking technologies in the market today.

For more information about Konica Minolta Canada and its industrial print product portfolio, please visit www.konicaminolta.ca

Production Notes:
The RyeTAGA Student Journal was printed on the AccurioJet KM-1 UV Inkjet Press. The cover page was digitally embellished using spot UV coating, 3D embossing and hot foil stamping with a variable data application, all finished on the MGI JETvarnish 3DS with an iFOIL S attachment.

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