The Effect of Ink Tack in Four Colour Printing

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1 Abstract

In this test, tack graded inks have been tested for their ability to trap overprint colours. A set of inks with ascending and a set with descending tack values were tested to compare the different results. The inks were each tested on one coated and one uncoated substrate. Tack-reduced inks were created by mixing the regular inks with linseed oil. This allowed both samples to be printed using a CMY colour sequence but with opposite tack order. The purpose of this test was to discover how much of an influence tack has on multicolour printing, specifically colour reproduction. Preucil's trap equation and colour hexagons were used to determine the outcome of this experiment.

The results of this test showed that the descending tack order inks resulted in slightly better trap values on both coated and uncoated paper. The colour gamut produced by the colour hexagons also showed a slightly larger gamut for the descending tack inks.

It was found that there are many factors which influence tack and trap. Resins and additives in ink influence its original tack value. On press, tack increases as speed increases, and tack increases as ink film thickness is lowered. As temperature increases, tack decreases and press design will influence how well colours trap. There are also many factors which influence the colour sequence chosen other than tack values such as colour reproduction, moiré, and transparency. When trying to solve these problems tack should still be taken into consideration when moving colours on press. One solution which allows for colours to be rearranged without changing tack sequence is to use quickset inks.

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2 Introduction

In this research report, we conducted an experiment testing the difference between printing inks in an ascending and descending tack order. Tack is the resistance of an ink to splitting between two surfaces, or the “stickiness” of an ink (Eldred & Scarlett, 1990). On a printing press, tack is most important at the printing nip where the ink is being transferred from the blanket cylinder to the substrate. Tack most directly influences the printing process colours by affecting trapping, whether or not paper will pick, and is partially responsible for how sharp the printed image will be (DeJidas & Destree, 1995).

When a layer of ink is printed on top of previously printed ink it will not be transferred as completely as if it were being printed directly onto the substrate. This is the inevitable problem of trapping, which is acknowledged and accepted within certain tolerances. Trap is measured as the ratio of the second down ink film on a previously printed ink film to the second down ink film on white paper alone. This measurement is taken by measuring the density of an overprint colour (i.e., red), subtracting any portion of the second down colour which may be present in the first down colour (yellow within magenta), and dividing it by the measurement of the second down colour on its own (yellow) to get a percentage (Breede, 1999). Ideally the result should be 100%, but as stated above this is not possible. Normally acceptable values for wet-on-wet trapping are between 75%–95% (Field, 1999). The lower this number, the more the overprint colour, red, blue, or green, will tint towards the colour of the first down ink.

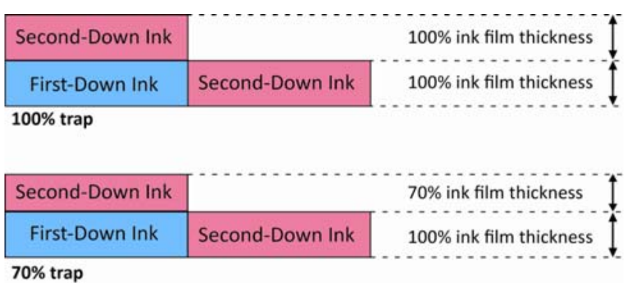


Figure 1. *Ink trap.*

Tack of inks must be taken into consideration to produce the best trapping results in multicolour printing and therefore the best colour. Is it commonly stated that trapping will be best when the first down ink has the highest tack value and the succeeding colours have progressively lower tack values (Eldred, 2001). This is printing with a descending tack order.

The purpose of this test is to compare trapping inks which have a descending tack order and a set with an ascending tack order. Expected educational gains from this test include determining how much of a colour difference will be produced by printing in the non-recommended tack order compared to the regular inks, as well as a study on the various influences on tack and trapping. This test is significant because printers sometimes try to switch the order or tacks of their inks to produce better colour quality and solve printing problems. How important tack order is to good print quality and how to properly change colour sequence should be determined before this is attempted.

Some of the topics which will be discussed in this paper include the printing process factors of tack, printing problems linked to tack, and the impact of colour sequence on print quality.

3 Definitions and Equations

Crystallization: The ability to print one ink film on top of a dried ink film that has hardened repelling ink (PrintWiki, 2008).

Dry Trapping: Describes the adhesion abilities of a wet ink film over a dried ink film (Lawler, 1995).

Picking: The force of the printed ink film exceeding the paper's resistance causing rupturing or deformation of the surface of a substrate (PrintWiki, 2008).

Trap:

$$Trap = \frac{Density\ of\ two\ colour\ overprint - Density\ of\ first\ down\ ink}{Density\ of\ second\ down\ ink}$$

Where density is measured through the complementary filter of the second down colour (Breed, 1999).

Wet Trapping: Describes the adhesion abilities of the overprint ink when it is printed wet on wet (Lawler, 1995).

4 Testing Principle

Both tack and trap were measured in this test. Tack was measured using an inkometer and a defined volume of ink. The inkometer measures the force required to split an ink film at the roller nip while running at a specified speed, replicating printing conditions. The inkometer is a three-roller model of an inking unit of a press. One brass and two rubber rollers are used. The brass roller is set to a specific temperature, keeping the ink temperature constant. One rubber roller acts as the vibrator, distributing ink evenly, and the other is a rider roller. A counterweight is attached to a bar to connect to the rider roller, which measures the force needed to keep the rider roller steady. This roller with the lever is attached to a sensor that is pressed as the pressure increases (Eldred and Scarlett, 1990). This process measures the tack value at the nip.

In order to measure trap, three process colours were printed using the Universal Testprinter. Special blanket cylinders were created so that all three overprint colours (RGB) and primary colours (CMY) could be printed on one strip of paper. The blanket cylinders were inked using the Universal Inking Unit and then moved to their positions on the Testprinter. Paper samples were attached to the blanket portion of the Testprinter simulating blanket-to-blanket printing. The Testprinter was used because it has the ability to print all three colours in one pass with precise control of pressure and print speed.

Ink film thicknesses were determined for each substrate based on GRACoL standard target densities. Once a sample was printed, a densitometer was used to read the densities of the primary and overprint colours. These were used with Preucil's equation to find trap values as well as used to produce colour hexagons for each print. More than one print was produced for each set of inks on the same substrate so that any possible problems or outliers would be identifiable and not cause a skew in our results.

5 Materials Tested

5.1 Paper

Coated: Dom Luna Gloss Book 100#, wht: 8.5x11-in. 19.5M, 100508001
Unlimited: Cougar Opaque 70#, smooth finish 8.5x11-in. 13.78M

5.2 Other

Recochem: Boiled Linseed Oil

5.3 Ink

Table 1. *Inks tested.*

	Cyan	Magenta	Yellow
Hostmann-Steinberg - Huber Group Sheetfed Offset + High Gloss 1 Stay Open 42 F 10 RL-V	Reflecta Cyan 5.5Lb SAP: 29 3583-0101 Batch: 8ON17808 PRODN: 102955263	Reflecta Magenta 5.5Lb SAP: 29 3581-010 Batch: 8ON17604 PRODN: 102951956	Reflecta Yellow 5.5Lb SAP: 29 3529-0101 Batch: 8ON18024 PRODN: 102957237
Sun Chemical Tack Altered Inks	Batch# 7100PC1076 AAOSF5222704: FCLT Stay Open Process: C229	Batch#7100PD1846 NWNSF4220369: Stay Open Low Tack MA: C229	Batch#7100PD2444 Yellow NWNSF2220370: Stay Open Low Tack YE: C229
Sapphira SF advance	Process cyan C 2000 Batch # 21F08020	Process magenta M 2001 Batch # 21F128062	Process yellow Y 1000 Batch # 21F108013
Sun Chemical Vegetable Inks	B6815 (90805712) Offset Ecolith Vegetable Process Cyan Batch# 48547028, 1 kg	P6815 (90805631) Offset Ecolith Process Magenta Batch# 48512027, 1 kg	G6815 (90805633) Offset Ecolith Process Yellow Batch# 39975222, 1 kg

6 Equipment Used

Inkometer Pipette
Electronic Inkometer
- Thwing- Albert Instrument Company
- Philadelphia, 19154
- Serial # 33716
- Model # 101-A

R710 Colour Reflection Densitometer
- Fuji Graphic Systems Canada
- Serial #57313
- Manufactured by IHARA Electronic IND.CO., LTD

Testprinter Universal Testprinter
Universal Inking Unit
Three blanket cylinders with overprint patterns cut out

6.1 Software Used

Abacus version 2 for Mac OSX
Universal Testprinter Tools version 1.1

7 Procedures

There were two main components to completing this test. The first was attaining the tack values of the inks being used and creating inks with different tack values. The second was printing the overprints on the two samples papers. The procedure has been divided into these two sections.

7.1 To Attain Tack Values

1. Switch on the Inkometer, start at low speed, then switch to high
2. With the speed at 400 RPM and the temperature at 90° F, zero the machine by turning the black dial
3. Switch back to low speed and turn the drive off
4. Place 1.2 cc of ink (cyan, magenta, or yellow) on the center of the rollers
5. Turn the rollers by hand to avoid misting
6. Press the ‘drive’ button to restart the machine
7. Record the gram-meters after the first minute and every 30 seconds following until 10 minutes have elapsed
8. Switch back to low speed and stop the machine by pressing the drive button
9. Repeat steps 1 through 8 with the other two inks from the same set
   Note: it must be ensured that the machine has been thoroughly cleaned with all solvent removed when measuring a new ink
10. Once a set of ink has been obtained which has a CMY descending tack order, alter the tack of the magenta ink by mixing 15g of ink with approximately 0.25–0.75mL of linseed oil
11. Test this ink as described in steps 1 through 8
12. If the tack is not lower than that of the original yellow ink, add slightly more linseed oil to a new 15g of ink and test it again to receive a tack value
13. Once the magenta is found with a tack value which is less than the yellow ink, mix a higher volume using the same ink to linseed oil ratio
14. Repeat steps 10 through 13 to reduce tack of the cyan ink to lower than the tack of the reduced magenta ink starting with between 0.5–1.25mL of linseed oil
    Note: Never fully turn off the machine unless you are done working with it; turn the machine on/off using the ‘drive’ button.

7.2 To Print Overprints Using the Universal Testprinter

15. Measure one of the unaltered inks using a Prüfbau pipette and place it on the rollers of the universal inking unit
16. Turn on the machine at 100 m/min and place the blanket roller in contact with the black metering roller
17. Let it run for 2 minutes to ensure uniform ink coverage before stopping
18. Tape a strip of uncoated paper onto the blanket section of the carrier on the Universal Testprinter
19. Place the blanket roller onto the appropriate station of the Universal Testprinter (Station 2: cyan, Station 3: magenta, Station 4: yellow)
20. Set the settings as listed in Figure 2 and upload them to the Testprinter:

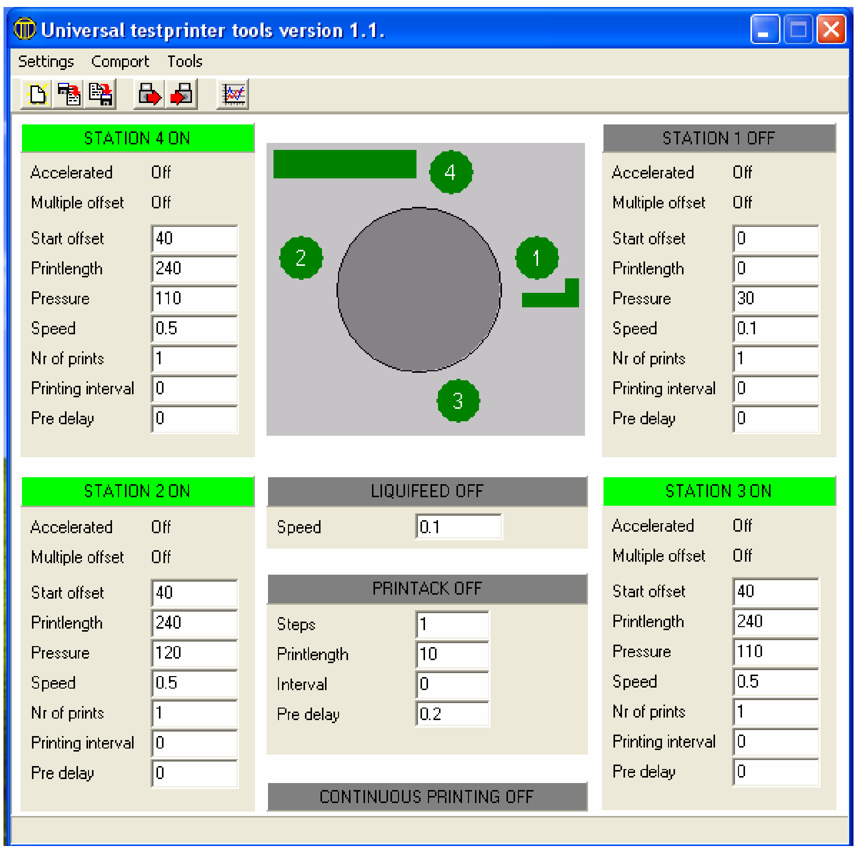


Figure 2. *Testprinter settings.*

21. Run the Testprinter
22. Allow the sample to dry for 5 min
23. Use a densitometer to check the density
24. If the density does not fall within the specified aim-points repeat steps 1–9 with more or less ink as required
25. Repeat steps 1–10 for the other two inks in the set, recording the amount of ink needed to produce the correct density
26. Repeat steps 1–8 printing all 3 inks on one sample using the amount of ink needed to produce the correct densities
27. Use the densitometer to obtain all the density readings for CMY, RGB, and overprint patches
28. Repeat steps 1–13 replacing the cyan and magenta with the tack-reduced cyan and magenta, and then run on coated and uncoated paper

8 Results

8.1 Inkometer Results

Tables 2 through 6 show the tack readings for the inks tested

Table 2. Tack Readings of Sun Chemical Offset Ecolith Vegetable Pro Cyan.

Time (Min)	**Tack (gram-meters) 400 RPM-90° F**
1	10.4
1.5	10.6
2	10.3
2.5	10.1
3	10.1
3.5	10
4	9.9
4.5	9.9
5	10
5.5	10
6	10.1
6.5	10.1

7	10.2
7.5	10.1
8	10.2
8.5	10.3
9	10.3
9.5	10.5
10	**10.5**

Table 3. *Tack Readings of Sun Chemical Offset Ecolith Vegetable Pro Magenta.*

Time (Min)	**Tack (gram-meters) 400 RPM-90°F**
1	7.4
1.5	7.6
2	7.7
2.5	7.5
3	7.7
3.5	7.6
4	7.8
4.5	8.1
5	8.1
5.5	8
6	8.1
6.5	8.2
7	8.3
7.5	8.4
8	8.4
8.5	8.5
9	8.7
9.5	8.4
10	**8.5**

Table 4. *Tack Readings of Sun Chemical Offset Ecolith Vegetable Pro Yellow.*

Time (Min)	**Tack (gram-meters) 400 RPM-90°F**
1	8.2
1.5	8
2	7.9
2.5	7.9
3	7.9
3.5	7.8
4	7.9
4.5	7.9
5	8
5.5	8
6	8
6.5	8.1
7	8.1
7.5	8.1
8	8.2
8.5	8.2
9	8.2
9.5	8.2
10	**8.3**

Table 5. *Sun Chemical Offset Ecolith Vegetable Pro Cyan mixed with approximately 1mL of linseed oil in 15 grams of ink.*

Time (Min)	400 RPM-90°F
1	6
1.5	6
2	6.1
2.5	6.1
3	6.2
3.5	6.2
4	6.3
4.5	6.5
5	6.5
5.5	6.5
6	6.6
6.5	6.7
7	6.8
7.5	7
8	7.1
8.5	7.3
9	7.1
9.5	7.3
10	**7.3**

Table 6. *Sun Chemical Offset Ecolith Vegetable Pro Magenta mixed with approximately 0.6mL of linseed oil in 15grams of ink.*

Time (Min)	400 RPM-90°F
1	6.2
1.5	6.3
2	6.4
2.5	6.5

3	6.5
3.5	6.6
4	6.8
4.5	6.9
5	7
5.5	7
6	7.1
6.5	7.2
7	7.3
7.5	7.4
8	7.5
8.5	7.5
9	7.6
9.5	7.7
10	**7.7**

8.2 Testprinter Results

Tables 7 and 8 show the resulting ink trap and averages for all samples printed. Figures 3 and 4 show colour hexagons which were created from the density readings of the samples. For the original density readings see Appendix A.

Table 7. *Overprint Traps on Uncoated Paper.*

	Descending Tack Order			Ascending Tack Order		
	R	G	B	R	G	B
Sample 1	50.54%	75.27%	53.27%	46.81%	73.40%	58.25%
Sample 2	46.74%	68.48%	48.78%	47.83%	71.74%	57.01%
Sample 3	50.00%	83.70%	71.30%	42.11%	74.74%	56.25%
Average	**49.09%**	**75.81%**	**57.79%**	**45.58%**	**73.29%**	**57.17%**

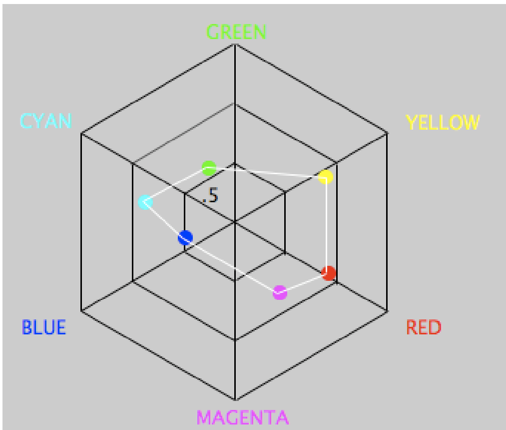
Table 8. *Overprint Traps on Coated Paper.*

	Descending Tack Order			Ascending Tack Order		
	R	G	B	R	G	B
Sample 1	49.55%	79.28%	74.15%	47.06%	69.61%	68.35%
Sample 2	58.18%	82.73%	72.73%	48.57%	72.38%	70.50%
Average	**53.87%**	**81.00%**	**73.44%**	**47.82%**	**70.99%**	**69.42%**

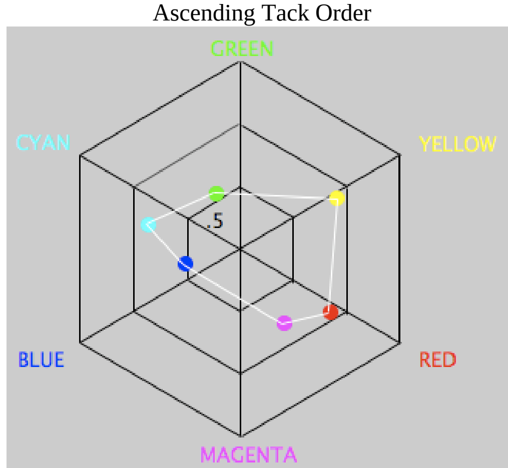
Uncoated Paper

Descending Tack Order

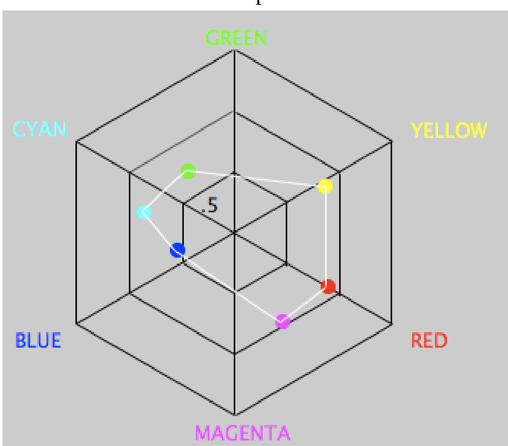
Ascending Tack Order



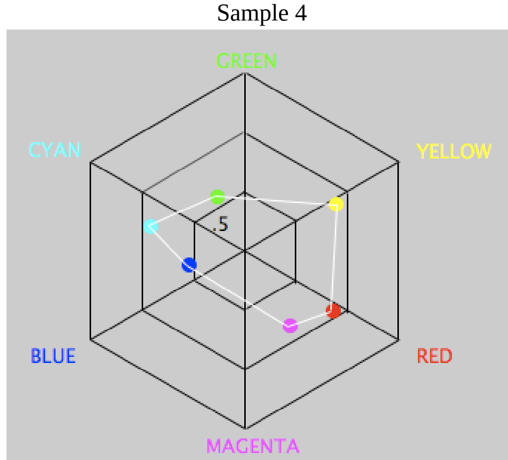
Sample 1



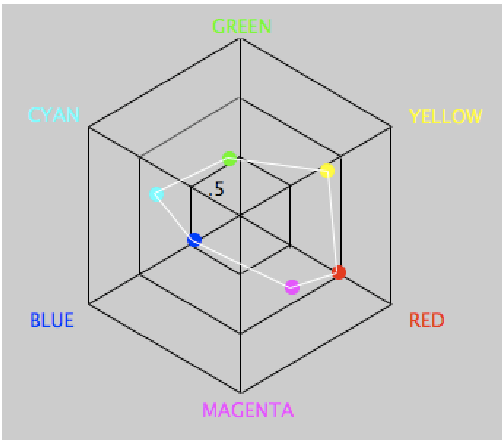
Sample 4



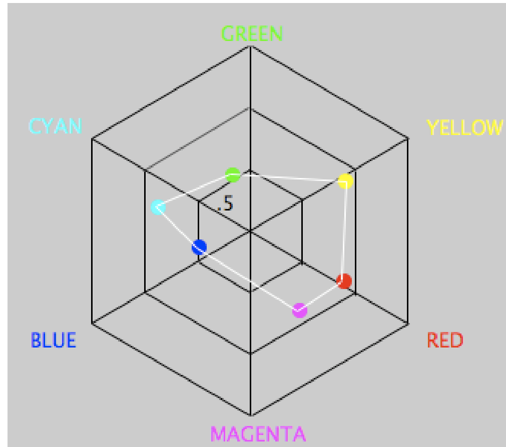
Sample 2



Sample 5



Sample 3

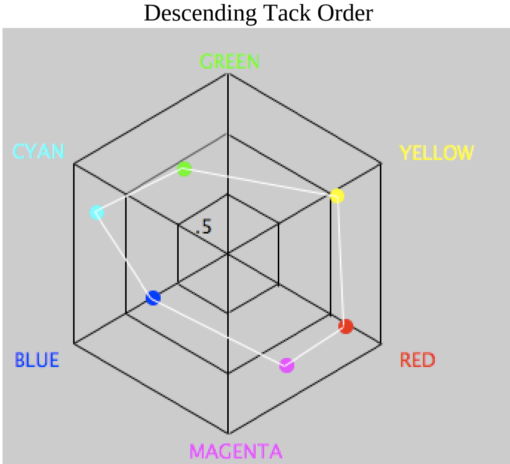


Sample 6

Figure 3: Colour Hexagons from uncoated samples, both normal and reversed tack order

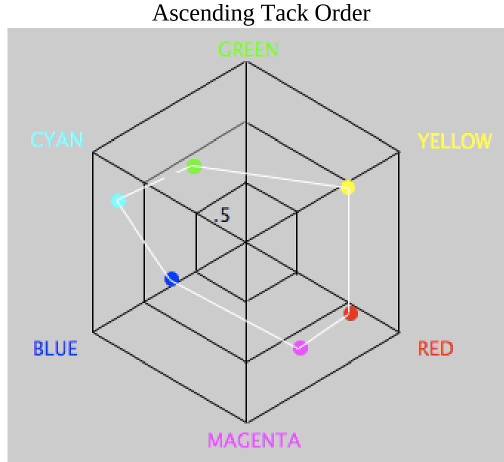
Coated Paper

Descending Tack Order

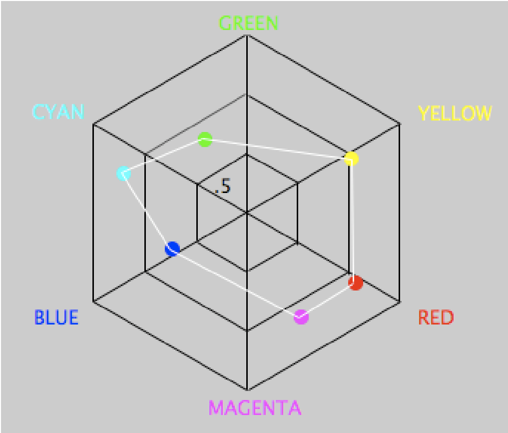


Sample 9

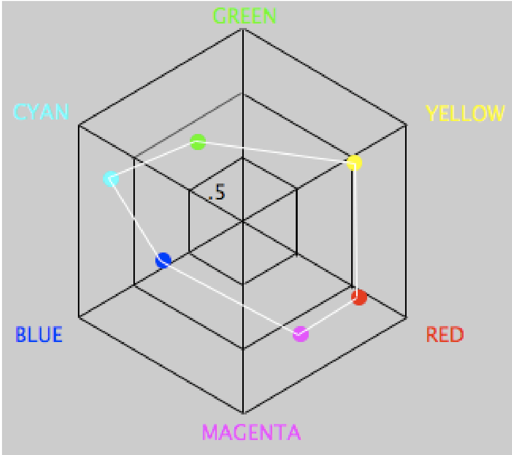
Ascending Tack Order



Sample 7



Sample 10



Sample 8

Figure 4. *Colour Hexagons from coated samples, both normal and reversed tack order.*

9 Discussion

The above results show that slightly better trap values and therefore colour were produced using the descending set of ink than the set with ascending trap. This can be determined from the average trap values as well as a comparison of the colour hexagons. One important value which can be seen when comparing the colour hexagons is that the cyan, magenta, and yellow values produced by the tack-reduced inks had very similar placements compared to the regular inks. This shows that it truly was the trapping which caused the different colour gamuts and not the additives in the different inks. In all samples both blue and green were closer to cyan. As well red had nearly perfect hue even while magenta was very far off. When visually analyzing the results, no obvious difference was noticed between the ascending and descending tack order samples. This is not surprising since the trap average did not show a very large difference between the ascending and descending samples. In general the coated samples showed much more vivid colours which is supported by the larger gamuts shown in their colour hexagons.

Linseed oil was used to reduce the tack of the magenta and cyan Sun Chemical inks. More linseed oil than expected was needed to get the tack to the desired values with 1mL for cyan and 0.6mL for magenta for 15 grams of ink. The original ink printed in descending tack order according to the usual CMY order. The tack for the inks were Cyan 10.5, magenta 8.5, and yellow 8.3 gram-meters.

Although the small difference between the magenta and yellow was not ideal out of all the different ink sets tested, the Sun Chemical inks produced the best results. We lowered the tacks of the magenta and cyan until the yellow had the highest tack value (8.3), followed by magenta (7.7) and then cyan (7.3). We chose to use the 10-minute reading from the inkometer to compare the tack values of the different samples to simulate what the tack values would be after running on press.

The tack of the magenta and cyan were lowered instead of simply running the original inks in YMC order so that the exact same overprint traps would be measured. For example, had the inks been run in reverse, the descending overprint of red would be magenta over yellow while the ascending overprint of red would have been yellow over magenta, resulting in a different shade of red (Mortimer, 1998). By reducing the tack of the magenta and cyan it was possible to use the same inks in the same order but the reverse tack order.

There are four main components of any ink: pigments, solvents, vehicles, and additives. The two components that affect the tack of an ink are its vehicles and additives. The vehicle of an ink carries the pigments to the substrate and binds the ink film to the substrate. The resins in the vehicle promote tack. A common additive to inks is reducers which include varnishes, solvents, oils, or waxy or greasy compounds. These are added to reduce the tack of the ink (International Paper, 2008 and Eldred & Scarlett, 1990). In the case of this experiment we chose to add an oil to reduce the tack of the inks.

There are many sections of the printing process which influence tack. The ones which may have impacted the results of this test are described below. Tack increases as speed increases on press. In the case of this experiment the speed of the inkometer (400 rpm) was set to match the speed of the universal inking unit (100 m/min). Ink film thickness has an impact on tack because a thinner ink film will resist splitting a lot more than a thick ink film. For this test the ink film thickness for each ink was determined by trying to reach target densities. This may have caused skewed results as the regular instructions for measuring the tack of an inkometer require the use of the same amount of ink for each ink, whereas different volumes are used when printing samples. Temperature also has an effect on the tack of an ink, as ink gets warmer its tack will decrease. In this test the tack of all the inks were measured at a consistent temperature, but this could not be controlled on the inking unit or the Testprinter. The design of the printing press will also affect tack and trapping. As the paper passes from one unit to another it will start to set and the tack will increase. This variable was kept consistent during the test as there is equal distance between the units on the Testprinter, and the delay between units was controlled (DeJidas & Destree, 1995, and Field, 1999).

As can be seen in the results the type of substrate used will affect trapping and colour reproduction. The absorbency of the substrate being used affects trap. If the substrate is absorbent, the ink vehicles within the ink will penetrate much more quickly into the substrate. This increases the tack of the surface ink, improving the trapping to the next ink (Eldred & Scarlett, 1990).

The results received from this experiment were in agreement to the general accepted printing principle, found specifically in GATF textbooks, that printing with descending tack values produces better colour as measured by trap. Before conducting this test we were aware of this standard so were expecting our results to show higher trap values when printing with the descending set of inks. We were surprised to see how small the difference was; we were expecting a much larger gap in the trap values. One of the reasons for this may be that neither the ascending nor descending sets of ink had the recommended one to two tack-units difference between each of the inks. Also, in general, low tack values, such as the ones of the inks we were using, can cause poor trapping (Wilson, 2003). Although the trap values of the descending set were higher than the ascending set, very few of our values reached the industry standard for trapping which for sheetfed printing is at least 75% (Wilson, 2003).

There were a number of opportunities during this test for machine and human error. A general concern was machine malfunction or inaccuracy from the aging inkometer. Another issue with the inkometer and the Universal Testprinter was that if the rollers were not cleaned properly or if any solvent was left on the rollers it could cause skewed results. This may explain why of the three sets of inks tested for tack values with only one resulting in the needed tack order (CMY). This may have also been caused by contamination in the inks, another possible source of error. It was also discovered that some of the densitometers in our lab consistently produced inconsistent results. Another source of error was found when printing the overprints. It was ideal that all three overprints and all three primary colours be printed in the middle section of each strip but this did not occur for every sample. As a result some readings had to be taken from the sides of the print where printing pressure would be different and the print more inaccurate.

Another possible source of error is that the densitometric method of trap evaluation does not produce perfectly accurate results. This is a result of first-surface reduction and gloss, multiple internal reflections, opacity of the second down ink, back transfer, and the spectral response of the densitometer. Specifically the use of narrow-band compared to wide-band densitometer filters will effect trap calculations.

10 Recommendations

10.1 Wet Trapping vs. Dry Trapping

The above experiment dealt exclusively with wet trapping. Wet trapping is the result of the second down colour printing while the first down colour is not completely dry. Wet trapping is dependent on the tack of the ink and ink film thickness.

When the first down ink has dried completely before the second colour is printed it is called dry trapping. This could be the case when printing a job on a press that does not have enough units to print all of the colours required in one pass. One problem which can occur during dry trapping is crystallization. Trapping is impaired when crystallization happens because the dried ink causes an extremely hard ink film (Eldred & Scarlett, 1990). The most likely cause of crystallization is when there is too much grease or wax component in the dried ink film (GATF Staff, 1994). For this reason, linseed oil must be used with caution as it is a drying oil (Ultrachem, 2009) and encourages dry trapping and crystallization to form. In general, wet trapping is encouraged whenever possible, leaving only enough time between the application of colours to allow for optimal trapping.

10.2 Problems Caused by Extreme Tack

Tack values which are too high or too low will cause printing problems aside from trapping. Low tack causes dot gain, poor image sharpness, drying problems, and low gloss (Eldred & Scarlett, 1990). Dot gain and poor image sharpness are caused because an ink with low tack will spread out more when transferred from the blanket cylinder to paper.

If tack is too high picking may occur where fibres are pulled from the paper surface. This occurs during ink transfer if the tack of an ink is greater than the force required to break away portions of the paper's surface. Picking is typically less common with coated paper because of the presence of a coating. However if tack is too high when printing on coated paper the entire coating can be pulled off the paper causing a more noticeable problem and possibly causing the coating of the paper to wrap around the blanket cylinder of the press.

Other problems caused by paper which cannot resist the tack of an ink film include piling, linting, or curling. Slowing the press or increasing ink film thickness are ways in which these problems might be remedied without changing the composition of the ink (Eldred & Scarlett, 1990).

10.3 Press Factors

The printing press design can influence trap because it determines the printing nips and impression points. If there is a large space or dryers between printing units, the ink which has been printed on will have time to dry causing an increase in its tack. In combination with the printing speed this will determine the tack of the first down ink at the point when the second down ink is printed. Press speed will determine how quickly the paper passes between units, while the press design will determine the physical space which the paper needs to travel to get from one impression to another. If there is not sufficient time between impressions the preceding ink film may not have enough time to set sufficiently to produce good trap (Field, 1999).

For this reason different printing processes call for different tack requirements. Web printing requires lower tack inks because the press is running at a higher speed compared to sheetfed printing (Wilson, 2003). When printing on a common impression cylinder the tack difference between successive inks may need to be higher since there may not be sufficient time for the inks' tack to rise from setting.

Temperature while printing should be kept in mind because it has a direct influence on trapping performance. It is important to understand that an increase in temperature lowers the tack of ink. Temperature needs to be maintained and kept constant at all times to obtain optimal colour (Field, 1999). In multicolour printing it is important to keep temperature consistent between units. If one unit is warmer or colder than the other, the other ink's tack may increase or decrease. This could negatively affect the set tack order and result trapping variations.

Solvent absorption and evaporation during the printing process affects the tack of an ink. Since the printing plate is kept moist with water, the water can become emulsified in the ink. GATF tests show that the tack of ink on press decreases by about half of the original value once dampening rollers are engaged (Eldred, 2001). Depending on the press design the solvent may evaporate from the ink as it travels through the press causing an increase in tack. The tack will also increase if solvent in the ink is absorbed by the rollers or blankets.

10.4 Quickset Inks

Quickset inks or unitack inks are preferred by ink manufacturers because they allow the setting of an ink increasing the tack from unit to unit and the inks' tacks do not need to be altered in the ink manufacturing process. Unitack inks are not tack-rated but instead all have the same tack values. They are also referred to as quickset inks because they are formulated with a quickset varnish which is absorbed quickly into the substrate during printing process. An ink may have the same tack as the next ink to be printed but it will set sufficiently between printing units so that the tack will increase and proper trapping will occur (DeJidas & Destree, 1995).

The main advantage to this is that it allows one set of process colours to be used in any sequence (Eldred & Scarlett, 1990). This is a good solution for any printing problems which are remedied by changing the colour sequence being printed without changing the tack order being printed.

10.5 Optical Properties

When printing with four colour process, there are 24 possible colour sequences; the three most common sequences are YMCK, CMYK, and KCMY. It is interesting to note that regardless of the sequence selected, black would be printed either first or last because its placement influences the quality of jobs requiring a heavy coverage of black (Field, 1999). Colour reproduction is affected by the order of colours regardless of their tack values. If a colour sequence is changed but still uses a descending tack order (using a new set of inks), this will have an effect on colour reproduction but not on trap. For example, consider trapping magenta over yellow. Since the trapping of the magenta cannot possibly be perfect, the resulting red would be slightly towards an orange instead of a true red. If the colours were reversed the imperfect trapping of yellow over magenta would make the red overprint less orange and more magenta (Mortimer, 1998). This change in colour will take place without any changes in tack sequence. One way to determine the optimal colour sequence may be to determine which secondary overprint colours are most important in the printed product and run a colour sequence which best runs that overprint (Mortimer, 1998).

Moiré patterns occur as a result of the different halftone patterns overlapping. When a moiré pattern occurs it is suggested that the colour sequence be switched, separating the two colours causing the problem (Field, 1999). This should be done with care because switching the printing sequence may influence trapping. If switching the colours is the only option then the tacks should be altered with a reducer to keep a descending tack order. Another option is to use a new set of inks which will print in a descending order in the new colour sequence. Another reason why colour order would be changed is due to mechanical problems such as slur or misregistration. To fix these problems it is recommended that the yellow be printed on the defective unit because yellow is the least visually discernible colour (Field, 1999). The same suggestions listed above in regards to switching colour sequence should be taken into consideration.

If a process ink does not have the proper transparency properties then trap will not be ideal. As determined earlier the colour of an overprint usually shifts towards the first-down colour. However, if the second-down colour is too opaque then the colour of the first-down ink would not show through. As a result the overprint produced would shift towards the colour of the second-down ink (Field, 1999).

10.6 Other Practical Applications

There are many instances when colour reproduction must be accurate and have perfect trapping. Trapping is pertinent for high quality jobs where colour accuracy is important. Accurate colour reproduction is necessary for company logos, such as “Telus green” and “Tim Horton’s red,” because it influences the image of the company and corporate identity. If the company is extremely concerned about a corporate colour, spot colours should selected and used where possible. If a spot colour is used, issues noted above, such as tack, optical properties, and total ink coverage, should be taken into consideration when placing the ink within the colour sequence.

Depending on the ink coverage, the quality of certain jobs would suffer if printed in the regularly used colour sequence. For example, when printing a job with a solid cyan background, cyan would need to be placed on the last printing unit in order to retain the density needed and to improve the quality of the print (Field, 1999).

11 Literature Cited

Breede, Manfred (1999). *Handbook of Graphic Arts Equations*. Pittsburgh: Graphic Arts Technical Foundation.

Dejidas, L.P., and T.M. Destree. (1995). *Sheetfed Offset Press Operating*. Sewickley, PA: Graphics Arts Technical Foundation.

Eldred, N.R. (2001). *Chemistry for the Graphic Arts, Third Edition.* PA: GATF*Press.*

Eldred, N.R., and Terry Scarlett. (1990). *What the Printer Should Know About Ink.* PA: Graphic Arts Technical Foundation.

Field, G. (1999). *Color and Its Reproduction, Second Edition.* PA: GATF*Press.*

GATF. (1994). *Solving Sheetfed Offset Press Problems*. Pittsburgh: Graphic Arts Technical Foundation.

International Paper. (2009). *Ink Makeup*. Retrieved on March 30, 2009, from http://www.internationalpaper.com/PDF/PDFPaper/Ink.pdf.

Lawler, B.P. (1995). *The Complete Guide to Trapping, Second Edition*. Indianapolis: Macmillian Computer Publishing.

Mortimer, Anthony. (1998). *Colour Reproduction in a Digital Age*. UK: Pira International.

PrintWiki. (2009). Encyclopedia of Print. Retrieved on March 30, 2009, from http://printwiki.org.

Ultrachem. (2009). *Hostmann Steinberg Ink Addictives*. Retreived on March 28, 2009, from http://www.ultrachem.co.uk/inks/hs_additives.html.

Wilson, Daniel G. (2003). *Web Offset Press Operating, Fifth Edition.* Pittsburgh: Graphic Arts Technical Foundation.

Appendix A: Original Densitometer Readings

Sample 1

Regular tack order - Sun Chemical Inks (Vegetable Inks) on Uncoated Paper

	R	G	B	
C	1.04	0.42	0.15	
M	0.24	1.07	0.68	
Y	0.02	0.11	0.93	
R	0.24	1.13	1.15	**Trap = 50.54%**
G	1.12	0.53	0.85	**Trap = 75.27%**
B	1.09	0.99	0.6	**Trap = 53.27%**

Sample2

Regular tack order - Sun Chemical Inks (Vegetable Inks) on Uncoated Paper

	R	G	B	
C	1.17	0.56	0.29	
M	0.26	1.23	0.71	
Y	0.03	0.1	0.92	
R	0.26	1.14	1.14	**Trap = 46.74%**
G	1.37	0.64	0.92	**Trap = 68.48%**
B	1.28	1.16	0.73	**Trap = 48.78%**

Sample 3

Regular tack order - Sun Chemical Inks (Vegetable Inks) on Uncoated Paper

	R	G	B	
C	1	0.39	0.15	
M	0.28	1.15	0.79	
Y	0.03	0.11	0.92	
R	0.28	1.25	1.25	**Trap = 50.00%**
G	1.04	0.5	0.92	**Trap = 83.70%**
B	1.23	1.21	0.76	**Trap = 71.30%**

Sample 4
Reverse tack order - Sun Chemical Inks (Vegetable Inks) on Uncoated Paper

	R	G	B	
C	0.99	0.36	0.11	
M	0.22	1.03	0.63	
Y	0.02	0.09	0.94	
R	0.23	1.15	1.07	**Trap = 46.81%**
G	1.03	0.47	0.8	**Trap = 73.40%**
B	1.09	0.96	0.56	**Trap = 58.25%**

Sample 5
Reverse tack order - Sun Chemical Inks (Vegetable Inks) on Uncoated Paper

	R	G	B	
C	1.06	0.39	0.13	
M	0.21	1.07	0.65	
Y	0.01	0.08	0.92	
R	0.23	1.16	1.09	**Trap = 47.83%**
G	1.07	0.48	0.79	**Trap = 71.74%**
B	1.14	1	0.59	**Trap = 57.01%**

Sample 6
Reverse tack order - Sun Chemical Inks (Vegetable Inks) on Uncoated Paper

	R	G	B	
C	1.02	0.38	0.13	
M	0.24	1.12	0.7	
Y	0.02	0.09	0.95	
R	0.22	1.07	1.1	**Trap = 42.11%**
G	1.02	0.47	0.84	**Trap = 74.74%**
B	1.11	1.01	0.62	**Trap = 56.25%**

Sample 7

Reverse tack order - Sun Chemical Inks (Vegetable Inks) on Coated Paper

	R	G	B	
C	1.4	0.42	0.13	
M	0.24	1.39	0.76	
Y	0.01	0.07	1.02	
R	0.22	1.32	1.24	**Trap = 47.06%**
G	1.37	0.48	0.84	**Trap = 69.61%**
B	1.42	1.37	0.68	**Trap = 68.35%**

Sample 8

Reverse tack order - Sun Chemical Inks (Vegetable Inks) on Coated Paper

	R	G	B	
C	1.35	0.41	0.13	
M	0.24	1.39	0.76	
Y	0.01	0.08	1.05	
R	0.21	1.33	1.27	Trap = 48.57%
G	1.32	0.49	0.89	Trap = 72.38%
B	1.44	1.39	0.7	Trap = 70.50%

Sample 9

Regular tack order - Sun Chemical Inks (Vegetable Inks) on coated Paper

	R	G	B	
C	1.42	0.43	0.13	
M	0.25	1.47	0.81	
Y	0.02	0.09	1.11	
R	0.21	1.39	1.36	**Trap = 49.55%**
G	1.45	0.53	1.01	**Trap = 79.28%**
B	1.52	1.52	0.77	**Trap = 74.15%**

Sample 10

Regular tack order - Sun Chemical Inks (Vegetable Inks) on coated Paper

	R	**G**	**B**	
C	1.34	0.41	0.12	
M	0.24	1.43	0.78	
Y	0.02	0.09	1.1	
R	0.22	1.39	1.42	**Trap = 58.18%**
G	1.31	0.5	1.03	**Trap = 82.73%**
B	1.45	1.45	0.74	**Trap = 72.73%**