THE EFFECT OF CARBON BLACK CONCENTRATION AND INK VISCOSITY ON THE PERFORMANCE OF WATER-BASED INKS

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Abstract: Water-based inks containing the same vehicle system have been studied to determine the effect of changing carbon black concentration and/or viscosity within those ranges normally encountered on flexographic newspaper presses.

Inks containing 13.0-17.0 percent by weight carbon black with viscosities in the range of 8-14 seconds, as determined with a Number 3 Shell Cup Viscometer, were printed on a Windmoeller and Hoelscher Journalflex press at the Providence Journal, Providence, Rhode Island. Proofs were evaluated for print density, dot gain, cleanliness of halftones, smoothness of solids and contrast.

The results of these evaluations indicate that increasing carbon black concentration and/or increasing viscosity generally increased the print density, contrast, and smoothness of solids; but produced less clean halftones and increased dot gain.

Evaluations

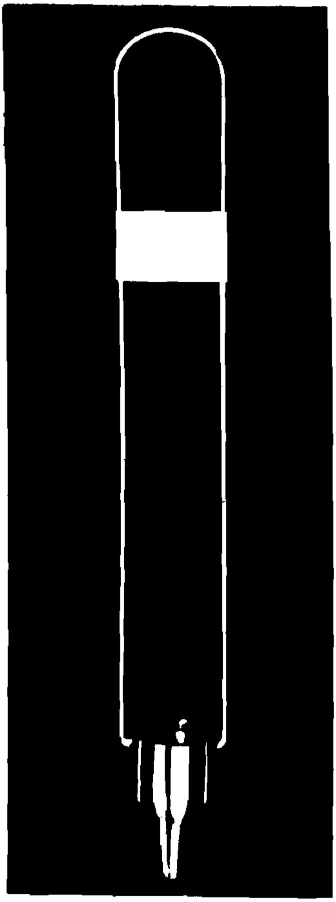
During a joint testing program with the Providence Journal, Flint Ink Corporation was able to evaluate a series of inks representing various carbon black concentrations and viscosity relationships (Figure 1).

Ink	Carbon Black Concentration (percent w/w)	Press Viscosity (seconds)
A	17.0	10.0
B	17.0	8.0
C	15.0	12.0
D	15.0	10.0
E	15.0	8.0
F	13.0	14.0

Figure 1. Formulations Evaluated

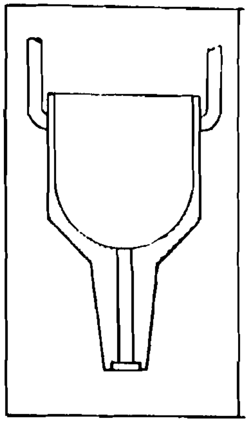
*Flint Ink Corporation

Viscosities were measured at press-side using a Number 3 Shell Cup Viscometer (Norcross Corp.), which is pictured in Figure 2, along with a correlation between readings for ink viscosities by shell cup and by a Brookfield Model LV Viscometer (using a number 1 spindle at 60 RPM).



Ink Viscosities

#3 Shell Cup	Brookfield
8.0 sec	3.0 cps
10.0 sec	20.0 cps
20.0 sec	30.0 cps



Cross Section

Figure 2. Shell cup viscometer and correlation of readings.

The inks were prepared with a 20.0 percent by weight pigmented mill base, using less of the base to obtain a lower concentration of carbon black in the finished ink, and less of a solubilized resin solution in the let-down to achieve a lower finished ink viscosity. Figure 3 illustrates the manipulation of some sample ink formulas to obtain (a) inks with different carbon black concentrations, but with the same viscosity, and (b) inks with different viscosities, but the same carbon black concentration.

	SAME VISCOSITY		SAME PIGMENT CONCENTRATION
	Ink B	Ink E	Ink C
Base	85.0%	75.0%	75.0%
Resin Soln.	1.9%	6.3%	24.1%
Water	13.1%	18.7%	0.9%
	100.0%	100.0%	100.0%
Resin Concentration	3.4%	4.4%	9.8%
Carbon Black Concentration	17.0%	15.0%	15.0%
Vicosity	8.0 sec	8.0 sec	12.0 sec

Figure 3. Sample Formulations

All inks were printed on a Windmoeller and Hoelscher Journalflex press using both ANPA (American Newspaper Publishers Association) and Letterflex Systems test plates prepared with the W. R. Grace 60P polymer. The inks were printed at the same ink temperature (71-72 degrees Fahrenheit), the same press conditions (Figure 4) and speed (40,000 copies per hour), and proofs were pulled at 6,000 copies.

Press:	W and H Journalflex
Plate Underpacking:	Rodgers
Plate Lockup:	Magnetic
Anilox:	Mechanically engraved, chrome 360/3.2 volume*, quad cells
Anilox Impression:	0.003 total
Paper Impression:	0.003 total
Paper:	Donahue
Relative Humidity:	37% to 31% at end of run
Room Temperature:	74-75 degrees Fahrenheit

*Volume x 10^9 cubic microns per square inch

Figure 4. Press Conditions

Proofs were evaluated for print density, dot gain, cleanliness of halftones, contrast, and smoothness of solids.

Print Density

Proofs were examined for print density using a Cosar 61 Smart Densitometer. Figure 5 shows a comparison of formulations C and E, which contained the same carbon black levels but had different viscosities, and a comparison of formulations B and E, which had the same viscosity but different carbon black levels. Print densities were higher with increased carbon black concentration or with increased viscosity, showing a greater difference with increased carbon levels. From the data in Figure 5, it is seen that it required a 10.6 percent increase in viscosity, but only a 1.2 percent increase in carbon black concentration, to increase the print density by one percent.

Ink	Carbon Black Concentration (Percent W/W)	Press Viscosity (seconds)	Print Density
B	17.0	8.0	0.94
E	15.0	8.0	0.85
C	15.0	12.0	0.89

Figure 5. Comparison of Print Densities

Dot Gain

Prints were also measured for percent equivalent dot (PED) using the Cosar Densitometer. PED is calculated automatically by the densitometer by comparing the reflectance of the tint to that of the solid. The change in PED is proportional to the dot gain (non-mechanical). A comparison of PED, on the 65-line print of the ANPA gray scale, for each of the above three inks is shown in Figure 6. The results of these measurements were fairly similar, as would be expected, due to the basic similarities in the inks themselves. Overall, the PED, and, therefore, the dot gain was found to increase with increased carbon black concentration and increased viscosity.

		Percent Equivalent Dot		
65 Line Gray Scale Gradation	Actual Dot (percent)	Ink B (17.0% Carbon 8.0 sec)	Ink E (15.0% Carbon 8.0 sec)	Ink C (15.0% Carbon 12.0 sec)
1	5	8	2	5
2	8	17	9	15
3	12	20	10	19
4	21	29	20	27
5	28	35	28	35
6	37	45	36	45
7	40	47	40	48
8	56	62	53	57
9	65	67	64	68
10	68	75	74	77
11	81	86	80	83
12	92	91	89	90
13	95	94	95	95

Figure 6. Comparison of Percent Equivalent Dot

Figure 7 shows the 85-line screen halftone prints from an ANPA test plate. Comparing the halftone print of Ink E with that of Ink B, or the halftone print of Ink E with that of Ink C, it was seen that the lower viscosity or the lower pigmented inks gave cleaner halftone reproduction. Dirtiness of halftones, where ink is printed in areas which should not be printed, is referred to as "fill-in," and can be readily observed on the prints. Note especially the forward creases of the lady's dress in the halftone prints.

Figure 7. Cleanliness of Halftones

Smoothness of Solids

Figure 8 shows portions of prints from the solid area of a Letterflex Systems test plate. Comparing the solid areas of Inks E, D, and C which contained 15.0 percent carbon black, but had different viscosities; i.e. 8, 10, and 12 seconds respectively, or comparing the solid area of Ink E and B which contained different carbon black concentrations (15.0 and 17.0 percent respectively), but had the same 8.0 second viscosity, it was seen that the solid area became not only denser but smoother with higher viscosity or higher carbon black concentration.

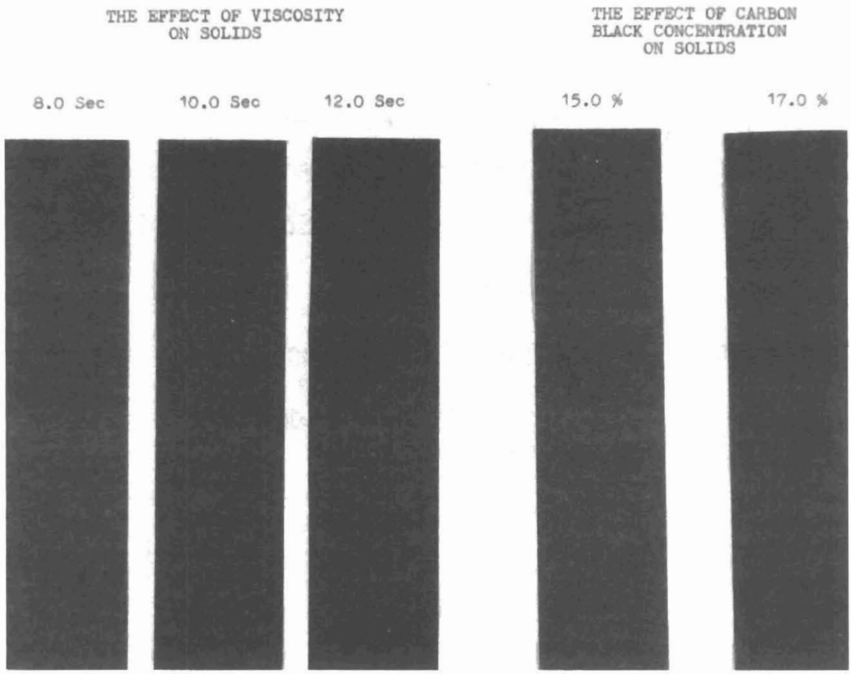


Figure 8. Comparison of Solids

Contrast

There was more "snap" or contrast of prints with increased carbon black concentration or increased viscosity. This is related to the density of the print which increases with increased carbon black concentration and viscosity. As the density increases, more difference or "contrast" is observed between the printed and unprinted areas of the substrate. A comparison of gray-scale densities for Inks B, E, and C is shown in the plot of Figure 9.

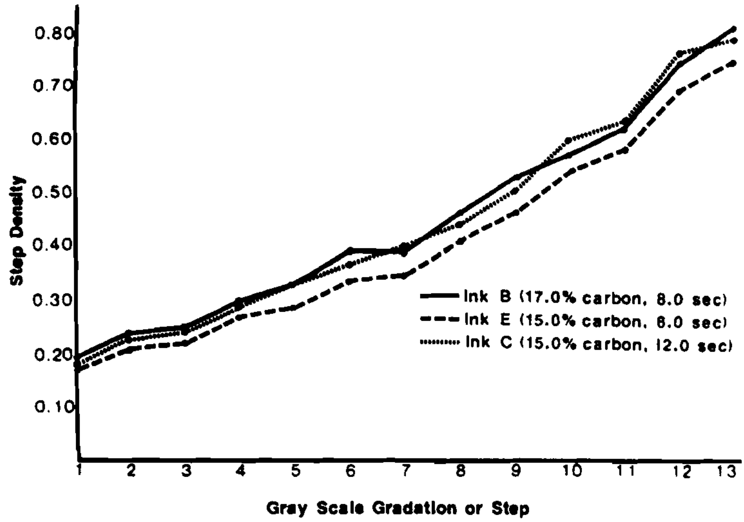


Figure 9. Comparison of Gray Scale Densities

Discussion

In our study it was possible to see certain trends with increasing carbon black concentration or with increasing viscosity (Figure 10), since the basic components and vehicles were the same for all inks.

Print Characteristics	Increasing Viscosity	Increasing Carbon Black
Density	Increases	Increases
Dot Gain	Increases	Increases
Halftone Cleanliness	Decreases	Decreases
Solid Smoothness	Increases	Increases
Contrast	Increases	Increases

Figure 10. Summary

It was also possible to select the best combination of carbon black concentration and viscosity for this ink system. The best combination for this ink system, though, would not necessarily be the best for another ink system. For example, as changes are made within the vehicle of an ink, its characteristics and, therefore, its printability can change.

Other factors which affect ink performance include (a) tack, how sticky the ink is; (b) yield value, how long it takes an ink to start flowing; (c) thixotropy, the degree of sheer thinning of an ink; (d) ink body, how puffy, short, or lengthy it is; and (e) ink wetting, which is related to the surface tension of not only the ink, but the anilox, plate, and substrate as well.

Conclusion

We see, then, that ink performance can be changed by certain adjustments in viscosity or carbon black concentration, but the effects from these adjustments might be minimal in comparison to other adjustments such as changes within the ink vehicle itself. And, it should be kept in mind that the best carbon black/viscosity relationship established for one ink system cannot be expected to give the best printing results for another system.

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