The Performance of Spray Dampening Systems in Commercial Printing Applications

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Abstract: Data is presented on the performance of web and sheetfed presses, equipped with spray dampeners in commercial applications under both production and test conditions. The press configurations reported on include separate dampening roller trains and ink train dampening. The scope of the data encompasses print quality measurements; quantitative assessments of ghosting; the effects of various fountain solutions, papers, and inks; water consumption vis-à-vis conventional dampeners; and the subjective appraisals of press operators. Other operational parameters addressed include water window and performance when printing on narrow webs and sheets.

Introduction

Spray dampeners have gained widespread acceptance and success with both newspaper and forms printers as a result of the advances made in design over the past 15 years. This is evidenced by the fact that there are currently over 30,000 spray dampeners of all manufacturers in operation today, primarily on newspaper and forms presses. In addition, almost all buyers of new double-width newspaper presses opt for spray dampening. Encouraged by this acceptance, a number of commercial web printers have equipped their presses with spray dampening systems and realized comparable success. The primary purpose of this paper is to present information on how spray dampeners have performed in this latter and relatively new application. In doing so, it is hoped that the reader will gain some additional insight into the interaction of ink and water and that some long-held negative perceptions of spray dampening will be dispelled.

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Commercial printing is defined here as printing with heatset inks in the case of web presses, and printing on coated stock in the case of sheetfed presses. The performance data reported on below was obtained from both types of presses, under both production and test conditions. Accordingly, separate sections have been included on each type press. These two main sections are preceded by one containing background information on history, limitations of early designs, and the features of current designs that account for their main advantages. The last section comprises a brief summary.

Background Information

The idea of using some type of atomizing nozzle to apply fountain solution to a lithographic press dates back to at least the 1930s (Grembecki, 1940, Larsen, 1939, and Schultz, 1935). Nevertheless, the first design adopted on a significant scale, on forms presses, was not developed until the late 1960s (Smith, 1972). Although a variety of other designs followed, spray dampeners did not prove immediately popular because of the problems that stemmed from the use of gum arabic and the low fluid delivery pressures employed (separate jets of high pressure air were used to atomize the fountain solution that was metered out at low pressure). That is, gum left in the system at shutdown dried up and plugged the fluid delivery system on subsequent startups.

The turnaround in acceptance of spray dampening systems began with the introduction of two design features: the use of relatively high pressure single-fluid nozzles and the adoption of a control scheme in which average flow rate is controlled by periodically pulsing the opening of the valves that control flow through the nozzles (Schwartz and Yamagata, 1984). Thus, all of the current spray systems operate at a constant fluid pressure in the range of about 40–100 pounds/square inch, and control average flowrate by varying the relative amount of time the nozzle control valves are open and closed. The adoption of these two designs features did not immediately result in complete success—because of water marks and banding. To explain the reasons for these shortcomings, it is first necessary to review the principles of operation.

Figure 1(a) illustrates the principle of a modern pulsed spray dampener (MacPhee, 1998). The key element is a spraybar consisting of an array of uniformly spaced atomizing nozzles and control valve assemblies. Each nozzle produces an oval spray pattern with a flow distribution that is relatively flat except near the ends, where it falls off quite rapidly, as shown in Figure 1(b). For this reason, the spray patterns of adjacent nozzles must overlap to produce a uniform flow distribution across the press. The trapezoidal shape of the nozzle distribution curves results in a more forgiving requirement on nozzle spacing to the roller. It also requires the spray patterns of the end nozzles to extend beyond the width of the printing area to insure flow uniformity at the edges of the plate. Thus, there is overspray at the ends. Overspray also occurs because a small

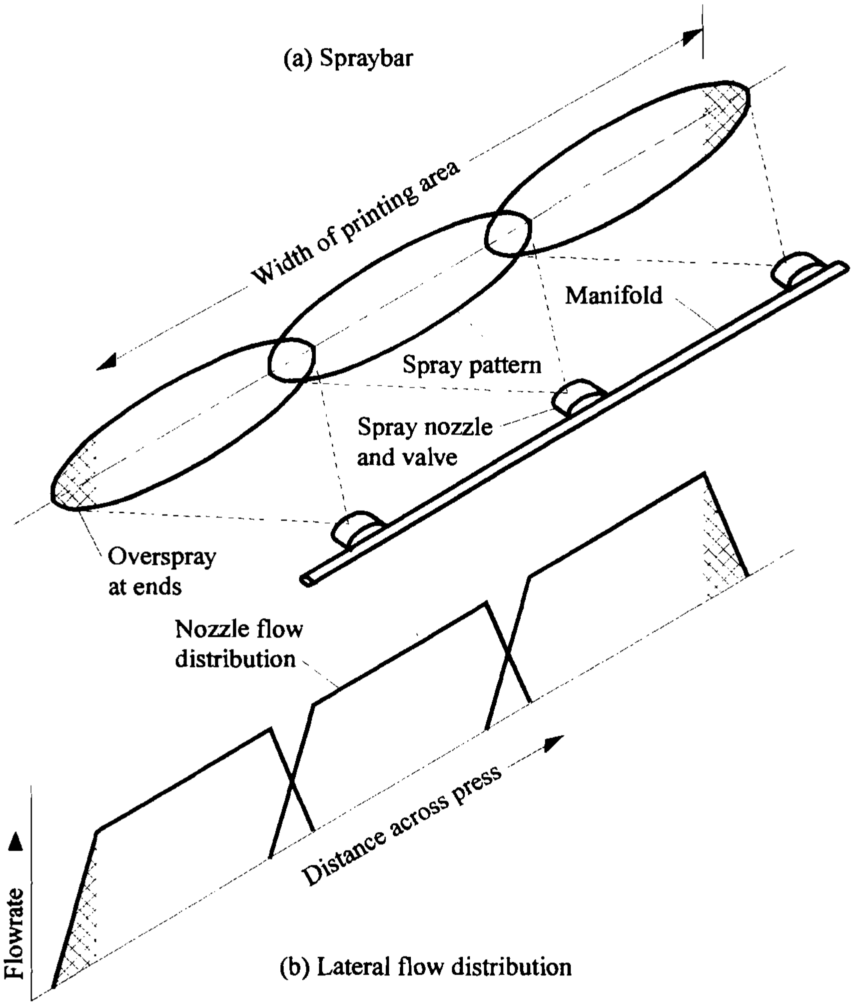
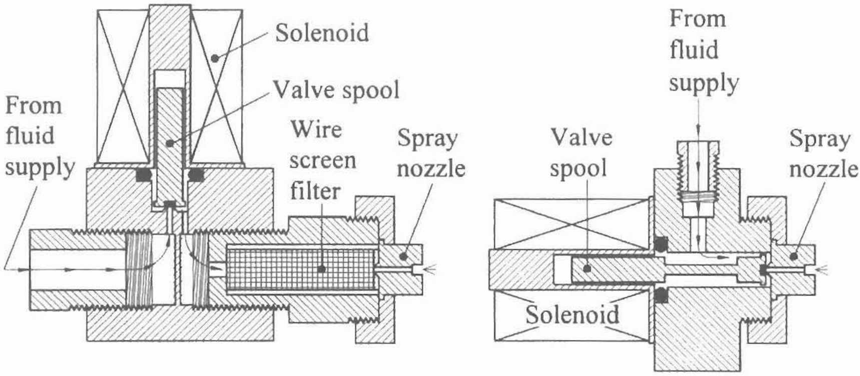


Figure 1 Nozzle arrangement used to produce uniform flow distribution across the press. To achieve ideal distribution shown in (b) nozzles patterns must be accurately matched.

fraction of the atomized particles are scattered when they strike the target roller. Thus, the spraybar must be enclosed so that the overspray can be contained, collected, and drained away.

The first of the two shortcomings initially encountered with this concept, water marks, arose because the early designs of the nozzle control valves were such that a relatively large volume of fluid was stored downstream of the valve



(a) Early valve design (b) Current valve design

Figure 2 In early valve design, shown in (a), a large volume of fluid was stored downstream of valve spool in area occupied by cylindrical wire screen filter. Leakage of this fluid through nozzle opening, during valve closure, led to formation of a drop at nozzle exit. Current design, shown in (b), eliminates storage volume and attendant problem.

closure point, as shown in Figure 2(a). During the period of valve closure, some of this fluid leaked out to form a drop. Thus, when the valve opened the drop was propelled along with the stream of atomized particles to produce a water mark on the print. Although this did not pose a major problem when printing on uncoated stock it added to the perception that water marks were synonymous with spray dampening. The solution to this problem was the relatively new valve design (Hultberg, and Hansson, 1991) shown in Figure 2(b).

The second shortcoming encountered, banding, arose because the high pressure nozzles first used were commercial grade and thus were not matched, either in terms of flow pattern or flowrate. Consequently, and contrary to the ideal shown in Figure 1(b), the total flow pattern was seldom, if ever, flat at the overlap of adjacent spray patterns. Thus, depending on nozzle mismatch, either too much or too little water would be fed midway between nozzles. Consequently, if water feedrate was not carefully controlled, either light or dark bands would appear on the print. Again, this was a problem that could be coped with when printing on uncoated stock because of the greater margin in ink/water balance. It did pose a bar, however, to printing on coated stock with higher tack inks. The solution here was to carefully match nozzles during manufacture, a relatively straightforward yet expensive procedure.

Since the early 1990s a significant number of precision pulsed spray dampening systems—those that incorporate both matched nozzles and properly designed valves—have been placed in service. The following is a list of the more important advantages that have been realized by their users:

1. Higher print quality.
2. Lower ink consumption.
3. Less fanout.
4. Lower dryer temperatures when used on commercial web presses.
5. Fewer problems in running narrow webs.
6. Lower makeready waste and faster makeready times.
7. No need for sock on dampening form roller (vis-à-vis a brush dampener).
8. No dirty circulators to clean.
9. No need to use an alcohol substitute when used on commercial presses.

The reasons why most of these advantages have accrued stem from three key features as follows:

• Water feedrate can be adjusted in the across-press direction. This means that excess water does not have to be fed in zones that have lower demands than that of the zone with the maximum demand. As a net result, less water is fed to the plate. This accounts for the first five of the above advantages.
• It is an easy matter to momentarily increase water feedrate at startup, thus reducing time to clean up. This accounts for the 6th and 7th advantages.
• A closed fountain solution supply system can be used to eliminate feedback of ink and paper dust into the system. This accounts for the last advantage.

Perhaps the only connection between the above features and advantages that is not obvious is that of less ink consumption accruing from less water fed to the plate. Because the initial reports of printers to this effect were viewed with skepticism, a test was decided upon to check the effect. In this test, run on March 22, 1990, two consecutive runs were made on the Goss Community press at RIT. This press was selected because one couple had been equipped with a four-nozzle spraybar that supplied water to the chrome roller in the non-integrated dampening system.

The form used consisted of a typical newspaper page on the right with a measured coverage of 12.5 percent, and a number of test patterns on the lefthand page with a measured coverage of 32.4 percent. In the first run water was set at just above the scum level. This resulted in water settings of 60 and 60 on the lefthand page with the heavy coverage, compared to 50 and 50 on the righthand page with the lighter coverage. In the second run water feedrate was increased 60 percent uniformly across the press and ink feed was also increased, so as to achieve the same solid print density as in the first run. Each run comprised 4000 impressions and sample signatures were pulled every 100 impressions. In addition both water and ink consumption were measured, the latter using a method (MacPhee and Lind, 1991) found to be reliable. The measured results, given in Table I (MacPhee, 1990) show that ink usage increased 10 percent as a result of the 60 percent increase in water during the second run. This lends credence to documented savings by printers that have ranged from 3—20 percent over a one year period. This test also provided a demonstration of the first key feature set forth above: variable water settings in the across-press direction.

Another very useful feature of spray dampening systems, not listed above, is that the control system can be designed to provide a real-time readout of the absolute amount of water that is being supplied to each zone. This information is useful in a number of different ways. For example, deviations from the norm provide early warning. of press malfunctions such as a change in roller setting. In addition water settings can be recorded and used subsequently to preset water and thus speed makeready on rerun jobs. Readouts are also very useful in assessing the effects of using different inks, papers, and fountain solution.

Table I Data on tests run to assess effect of water feedrate on ink consumption. Black news ink was printed on 30 inch wide, 28 pound newsprint on Community press unit equipped with spray dampener. Density and dot gain data were measured on signatures pulled every 100 impressions.

		Run 1	Run 2
Length of run	(impressions)	4,000	4,000
	(minutes:seconds)	11:25	11:25
Press speed	(impressions per hour)	21,000	21,000
	(feet per minute)	667	667
Fountain solution usage	(gallons per hour)	0.57	0.90
	(microns)*	0.19	0.30
Ink usage	(ounces)	25.5	28.0
	(gms/m^2 of image area)	1.82	2.00
Ink mileage	(pages per pound of ink)	5,020	4,570
Solid density (with paper)	(mean value)	1.15	1.16
	(standard deviation)	0.015	0.012
Paper density	(mean value)	0.20	0.20
	(standard deviation)	0.007	0.005
Midtone dot gain	(mean value, percent)	42.3	42.3
	(standard deviation, percent)	0.35	0.6

*Thickness of equivalent sheet of water leaving the press.

Performance on Commercial Web Presses

As of this writing, a total of 35 heatset web presses, most of which are four-color, have been equipped with spray dampeners of the type described in this paper. Interviews with this group of printers were an important source of the advantages listed above. From these interviews, it was also discerned that the advantages most important (or perhaps most evident) to this group are faster makeready, far fewer problems in running narrow webs, higher print quality, elimination of alcohol substitutes and better control of water. Except for one set of data on ink consumption, none of the information obtained was supported by data. To address this lack of quantitative information two actions were taken.

First, a number of the above printers were called and asked to record the water settings on the jobs being run at the time. Figure 3 charts the actual such water settings on the upper units of a 36 inch-wide heatset press. For this width press, each spraybar has four nozzles that divide each dampener into four feed zones. It can be seen in Figure 3 that on no unit did the pressman judge that the required water settings should be uniform across the press.

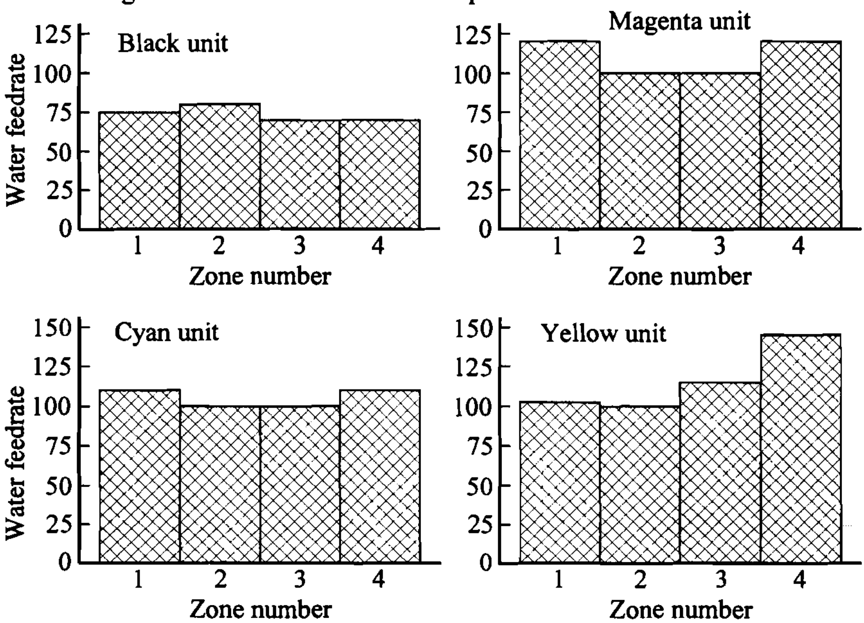


Figure 3 Actual water feed settings on the upper units of a 38 inch-wide heatset press, recorded while running a typical job.

More specifically, in the upper black unit, the feedrate in Zone 2, having the highest demand, was 14% greater than in Zones 3 and 4, having the lowest demand. What this means is that if a brush or film type dampener were being used, water feedrate would be set to satisfy the maximum demand of Zone 2. Consequently, 14% more water would be fed to Zones 3 and 4 because water feedrate is uniform in the across-press directions in such dampeners.

Similarly, for the press in Figure 3, the use of a brush or film type dampener would result in 10% more water being fed to Zones 2 and 3 in the upper cyan unit, 20% more in Zones 2 and 3 of the upper magenta, and 45% more in Zone 2 of the upper yellow. Thus it can be seen here that the use of a spray dampener resulted in less water being fed to the plate in every unit.

A second example is provided by the recordings from a 66 inch-wide press, charted in Figure 4. Because a narrower (50 inch-wide) web was being run, the pressman reduced feedrate in the end Zones 1 and 8. Examination of active Zones 2-7 shows that the active zones having the lowest demand would be oversupplied with water had a brush or film type dampener been used. Specifically, 32% more water than necessary would have been fed to Zone 5 on the upper black unit, 50% more to Zone 5 in the upper cyan, 23% more to Zone 7 in the upper magenta, and 33% more in Zone 3 of the upper yellow.

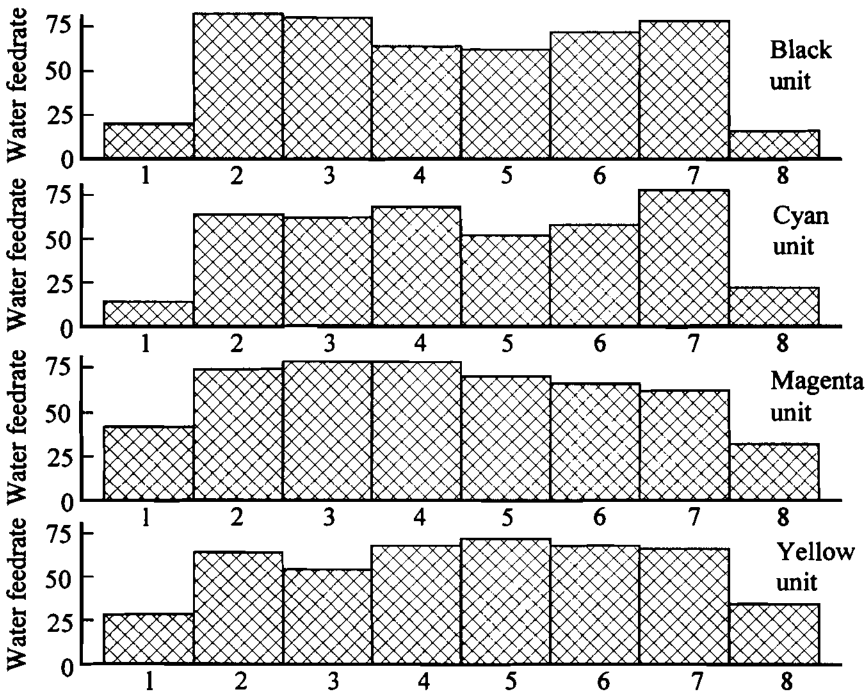


Figure 4 Actual water feed settings on the upper units of a 66 inch-wide heatset press, recorded while running a typical job. Width of web was 50 inches.

The data in Figure 4 also illustrates why fewer problems are encountered in running narrow webs on spray-dampener equipped presses—water feedrate can be reduced at the ends where less water is consumed.

The second action taken to obtain quantitative information on heatset presses was to participate in a cooperative test program involving International Paper, GATF, and Baldwin, run on the Harris M-110 press at GATF. This press is equipped with Duotrol dampeners. A total of five printing tests were carried out in December, 1997 using the same GATF four-color test form, the same heatset inks, and both coated and uncoated Number 3, 60-pound stocks. In three of the tests, the four upper units on the press were temporarily equipped with spray dampeners that applied water to a string of three dampening rollers, all running at press speed. The results of detailed measurements of print quality will be given in a paper to be presented at the GATF Research Conference in October, 1998. At present, however, it can be stated that there was no discernible change in print quality when spray dampening was used, nor was there any evidence of water marks or banding.

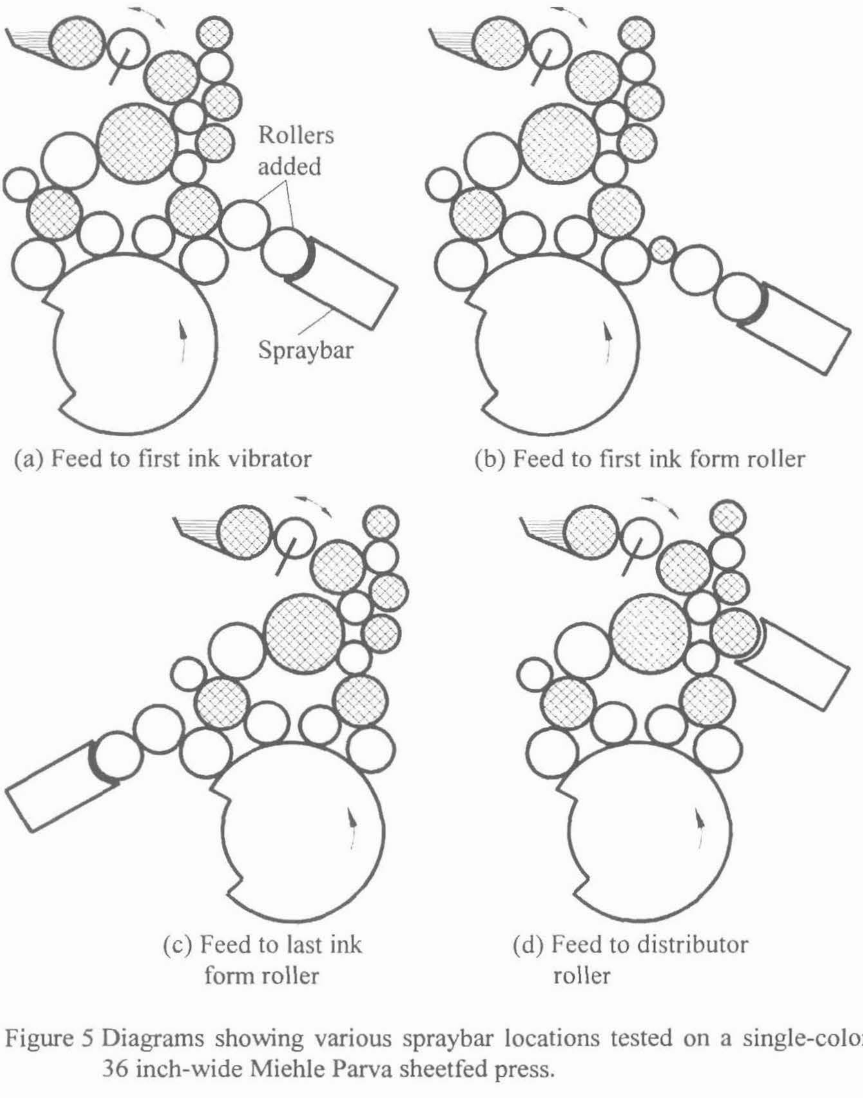
Performance on Sheetfed Presses

Operation of spray dampeners on sheetfed presses has been extremely limited to date. From a research standpoint, however, it proved more interesting because fountain solution was sprayed directly into the inking system. This so-called ink train dampening scheme was selected with the objective of achieving improved performance, in accordance with the theory proposed by Fadner (Fadner, 1996). Specifically, the sought for improvements were drier printing, elimination of the need for alcohol or alcohol substitutes, and elimination of problems with dampening rollers. Printing tests were first carried out on a single-color 28 inch wide Miehle sheetfed press located in Baldwin's R&D laboratory. These were sufficiently encouraging that it was decided to install a spray dampener on a single-color 35 inch wide Miehle press located in a nearby printing plant. The system was used by the printer for a period of 20 months, and was only removed when the press was sold.

The initial tests, run on the R&D press, showed that the promise of drier printing and the elimination of dependence on alcohol/alcohol substitutes was indeed realized. Measurements of water consumption ranged from 22 to 37 percent less with the spray dampener, compared to printing with the ductor type dampener. Specifically, in two tests with the ductor-type dampener, water consumption was 775 and 800 cc per 5000 impressions. This compares with the range of 597—805 cc per 5000 impressions measured at an earlier date on the same model press equipped with a Dahlgren Dampener (MacPhee, 1985). In eight tests using the spray dampener, water consumption ranged from 489 to 605 cc per 5000 impressions.

It was also discovered that performance of the spray dampener was insensitive to the type of fountain solution used. A traditional gum and etch mix worked just as well as one with alcohol or an alcohol substitute. Beyond that, the press operator liked the system because he could makeready so quickly.

This good news was negated by two drawbacks: Water settings were extremely critical with an almost non-existent margin, and ghosting was so bad as to be unacceptable. It was not known, however, to what extent this behavior could be attributed to the unusual inking system design on this press, wherein each form roller contacts a separate vibrating roller. For this reason, and because of the demonstrated advantages, a local printer agreed to a trial installation on a 35 inch wide Miehle sheetfed press that had an inking system of a more common design, i.e., one vibrator over each pair of form rollers, as shown in Figure 5.



(a) Feed to first ink vibrator

(b) Feed to first ink form roller

(c) Feed to last ink form roller

(d) Feed to distributor roller

Figure 5 Diagrams showing various spraybar locations tested on a single-color 36 inch-wide Miehle Parva sheetfed press.

Experience was good on this second installation when running live jobs because the work was mostly light coverage, i.e. book work or text. The printer found the system to be advantageous for the following reasons:

1. Makereadies were faster.
2 The press could be made ready at a lower speed, thereby reducing makeready waste.
3. On one occasion, involving a long run of 100,000 impressions, it was possible to use a less skilled duplicator operator to tend the press.
4. Narrow sheets could be run without the need for water stops.
5. The printer observed that printing was drier, based on the appearance of the plate.
6. Dot fidelity was comparable to that achieved with the existing conventional dampener, as shown in Figure 6.

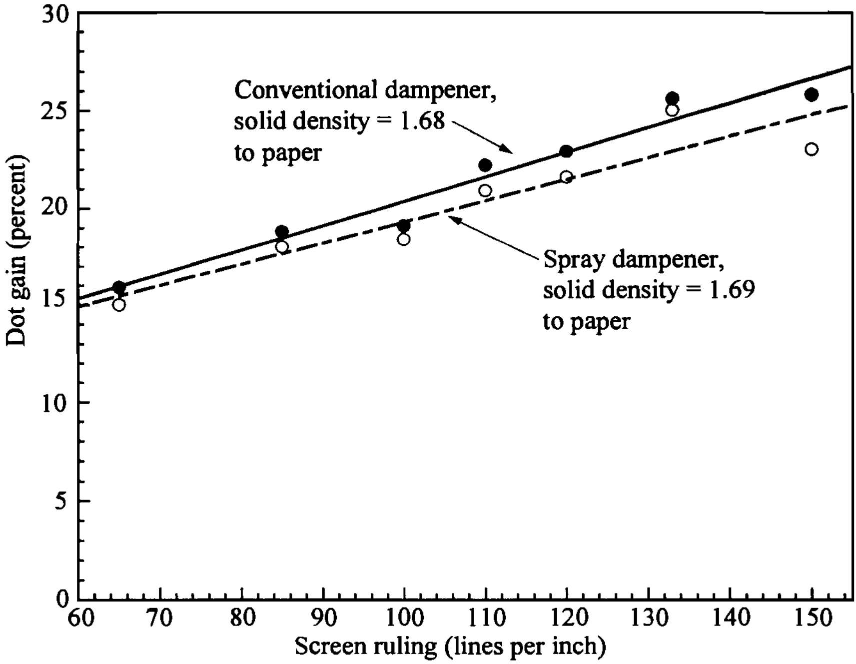


Figure 6 Midtone dot gain versus screen ruling for two different dampeners on a sheetfed press, using magenta ink and coated paper.

Nevertheless, when initial tests were run using the form shown in Figure 7 (coverage of 37 percent), the same two problems were encountered, i.e. an almost non-existent margin in water feedrate and unacceptable ghosting. For this reason, a broad-based series of tests were embarked upon with the objective of eliminating these drawbacks. Performance was assessed by measuring the

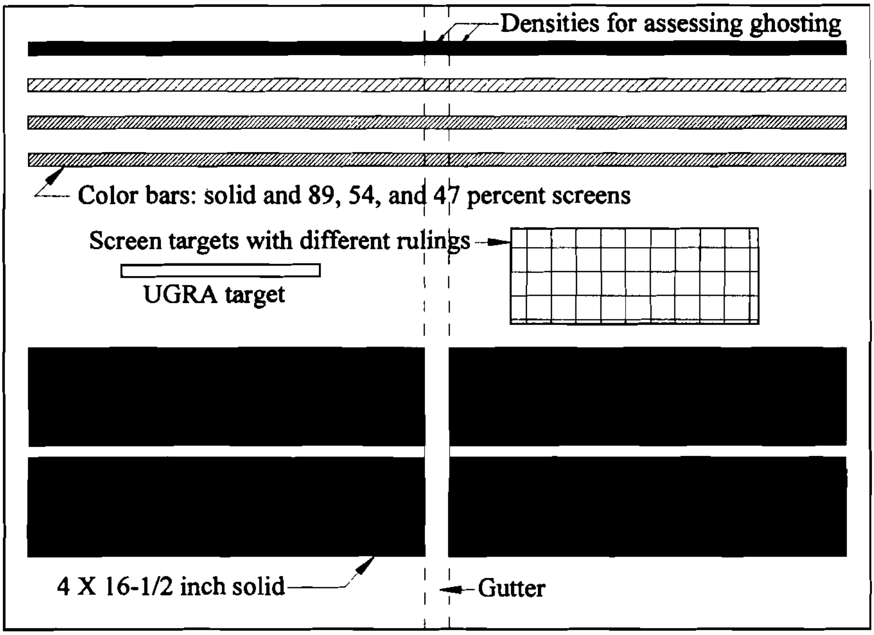


Figure 7 Form used in tests run on 36 inch-wide Miehle Parva sheetfed press.

magnitude of the starvation ghosting that occurred along the solid color bar that extended across the top of the test form, as shown in Figure 7. This ghosting resulted from the gutter between the large solids at the bottom of the form. During the course of this test program, the following variables were explored:

- Color of ink
- Inking system roller arrangement
- Ink coverage
- Water feed point
- Solid ink density
- Paper
- Ink formulation
- Fountain solution
- Plate surface

Most of the tests were run using magenta ink on the theory that it is more likely to exhibit a water problem. The alternate color tested, cyan, was chosen because it is one of the worst insofar as ghosting is concerned. The inking system was modified, as shown in Figure 8, so that all of the ink was delivered to the first two ink form rollers—known as a 50/50/0/0 configuration, versus the as-designed 33/33/17/17 configuration in Figure 5. Ink coverage was varied from 22 to 53 percent by running test forms with two, four (as in Figure 7), and six 4

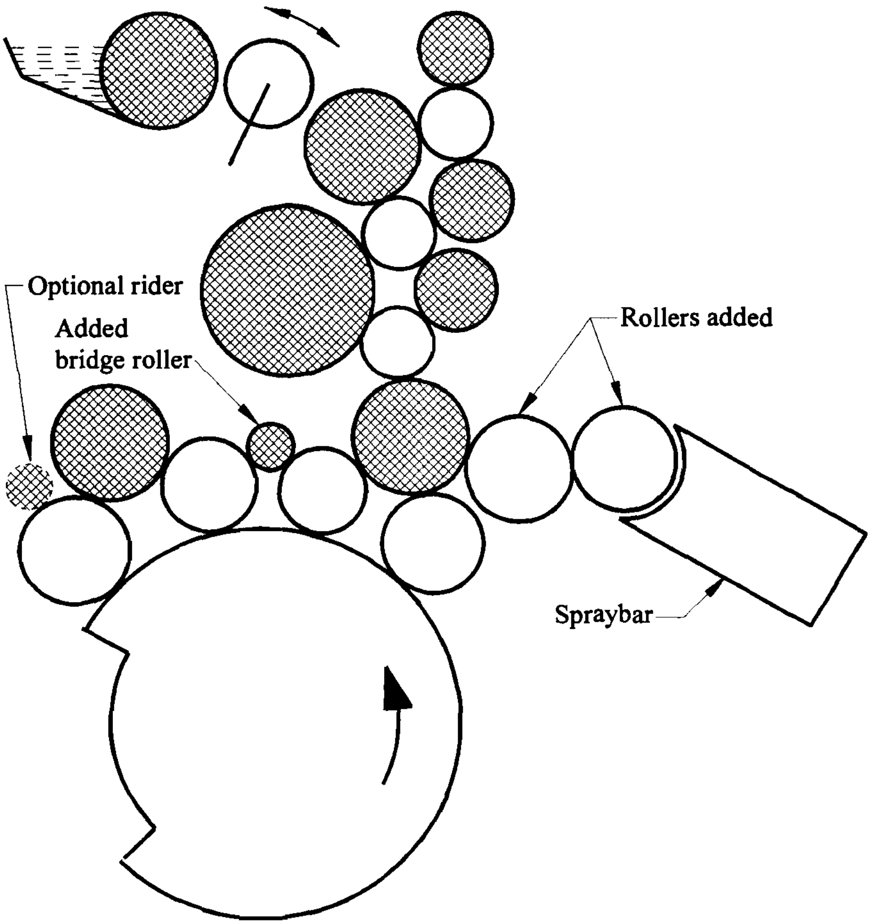


Figure 8 Roller diagram showing modified inking system roller arrangement tested on 36 inch-wide Miehle Parva sheetfed press.

X 16 1/2 inch solids. Four different water feed points, shown in Figure 5, were also checked. While most of the tests were run on 80 pound Number 3 coated stock, 60 pound offset (uncoated) stock was also tried. The affect of ink formulation was checked by running five different inks, including three specially formulated to stabilize the water-in- ink emulsion. Although not reported in detail here, ink-water combinations with widely different water pickups were also tried, as were five different fountain solutions. Measurements were made of the effect of adding alcohol to a traditional gum and etch fountain solution. Finally, a Presstek PEARLgold™ beta production plate was tested to explore if its very smooth non-image surface would have a beneficial effect.

Table II Effect of some system variables on starvation ghosting on sheetfed press with ink train dampening. Measure of ghosting is provided by density difference across gutter. None of the density differences listed are considered acceptable. Letters in feed point column refer to diagrams in Figure 5.

Variable		Feed point	Nom. density	Dens. differ.
Ink color (37% coverage)	Cyan	(a)	1.53	0.28
	Magenta	(a)	1.57	0.13
Inking system (magenta and 37% coverage)	Standard	(a)	1.57	0.13
	Modified	(a)	1.54	0.19
Ink coverage (w cyan)	22 percent	(a)	1.47	0.08
	37 percent	(a)	1.53	0.28
	53 percent	(a)	1.55	0.33
Water feed point (w cyan, and 53% coverage)	1st ink form roller	(b)	1.44	0.20
	4th ink form roller	(c)	1.45	0.20
	Vibrator above 1st ink form roller	(a)	1.55	0.33
	2nd distributor above 1st vibrator	(d)	1.13	0.53*
Print density (w cyan and 37% coverage)	Low density **	(b)	1.35	0.16
	Medium density **	(b)	1.55	0.13
	High density **	(b)	1.75	0.11
Paper (w cyan and 37% coverage)	Coated **	(b)	1.28	0.17
	Uncoated	(b)	1.28	0.03
	Coated **	(b)	1.46	0.14
	Uncoated	(b)	1.46	0.03
Isopropyl alcohol (20%) added to fountain solution (w cyan and 37% coverage)	No alcohol **	(b)	1.44	0.15
	With alcohol	(b)	1.44	0.08
	No alcohol **	(b)	2.05	0.07
	With alcohol	(b)	2.05	0.04

* This compares with an estimate of 0.22 for feedpoint at 1st ink form roller and same nominal density.

** From Figure 9.

The results of most of these tests are either listed in Table II or plotted in Figure 9. They show that fountain solution, inker configuration, plate, and ink formulation, had a negligible effect on ghosting. They also show that ghosting

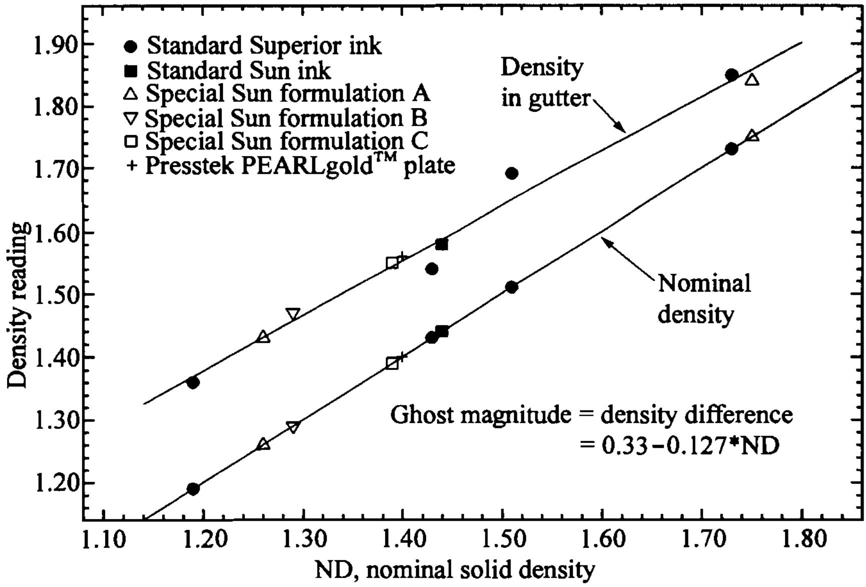


Figure 9 Effect of solid density, ink formulation, and experimental plate on magnitude of ghosting. All data is from sheets printed with cyan ink and 37 percent ink coverage.

was lessened by magenta ink (versus cyan), decreasing ink coverage, higher solid density, and uncoated paper (versus coated). In addition, locating the water feedpoint at either the first or last ink form roller resulted in less ghosting compared to locations further upstream of the plate. Although adding alcohol to the fountain solution also reduced ghost magnitude, it is questionable as to whether the change is statistically significant. Most important of all, however, no way was found to reduce ghosting to an acceptable level on a press of traditional design, using ink train dampening, when printing heavy coverage forms.

Summary

1. To date, 35 commercial web presses, meaning heatset presses, have been equipped with spray dampeners of the type described in this paper. In all installations, water is supplied to a separate train of dampening rollers.

2. Qualitative assessments of spray dampeners in these applications by printers have been favorable., based primarily on the realization of five advantages: faster makereadies, far fewer problems in running narrow webs, higher print quality, no need for alcohol substitutes and better control of water. Four of these advantages are attributed to the ability to adjust water in the across-press direction, which results in not having to overfeed zones of low water demand.

3. Data in the form of water feed settings recorded while printing live jobs provide confirmation that the ability to adjust water in the across-press direction is of practical importance, and does result in less water being fed to the plate. Measurements of the quality of prints on cover stock produced during tests run on a heatset press equipped with both non-integrated film-type and spray dampeners demonstrated that print quality is comparable when spray dampening is used.

4. Experience to date with spray dampeners on sheetfed presses has been limited to an installation on an R&D press, and a 20-month-long installation on a single -color 36 inch wide press in a printing plant where it was used in production. In both installations, water was fed to one of the inking system rollers, i.e., ink train dampening was used.

5. In comparison to the conventional dampening system on the sheetfed press, the spray (ink train) dampener was enormously successful when printing light coverage forms. Specifically, it was easier to operate, printed drier, i.e. used less water, did not require water stops when printing narrow sheets, and produced comparable print quality. In addition, alcohol or an alcohol substitute did not have to be added to the fountain solution. There were, however, two serious drawbacks when printing forms with heavy coverage: a vanishingly small margin in water feedrate, and excessive ghosting.

6. Extensive tests aimed at alleviating these drawbacks of ink train dampening were carried out on the sheetfed press. The variables explored included ink, fountain solution, paper, plates, location of water feedpoint in the inker, inker roller arrangement, ink coverage on the form, ink color, and solid ink density.

7. The net result of all the tests run on the two sheetfed presses was that no way was found to reduce ghosting to an acceptable level on a press of traditional design, using ink train dampening, when printing heavy coverage forms. Nevertheless, based on experience with commercial web presses, there is every reason to believe that a spray dampener employing separate dampening rollers on a sheetfed press would achieve the same favorable performance as realized on commercial web presses.

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