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Project Summary

Waste Reduction Evaluation of Soy-Based Ink at a Sheet-Fed Offset Printer

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This Waste Reduction and Innovative Technology Evaluation project focused on the use of soy-based inks as a substitute for petroleum-based inks in sheet-fed offset printing. The goal of the study was to evaluate the waste reduction and economic effects of using soy-based inks in place of the petroleum-based inks traditionally used in sheet-fed offset printing. The main potential environmental benefits claimed for soy-based inks are that they are a renewable resource and emit less amounts of volatile hydrocarbons during the printing process. No published studies verify the claim of reduced air emissions or quantify other environmental aspects of using soy-based inks such as the amount of liquid wastes generated and cleaners required. Other reported benefits of soy-based inks are that they are biodegradable in landfills and are more conducive to cleanup with degradable and less toxic cleaners than are petroleum-based inks.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the program demonstration that is fully documented in a separate report (see ordering information at back).

Introduction

The impetus for developing soy-based inks initially came from the oil shortages of the 1970's that threatened the supply of petroleum-based chemicals. Now, increased emphasis on improving worker safety and reducing environmental emissions is motivating the printing industry to seek cleaner technologies. In the 1980s, soy-based inks were first used in offset web presses for printing newspapers, mainly for presumed environmental benefits. In the late 1980s, soy-ink formulations were marketed for sheet-fed offset presses.

Sheet-fed soy inks are defined as those that have a minimum of 20% soy oil by volume. The soy oil replaces petroleum oils in the ink vehicle and varnish components. Use of the soy oil affects color, drying, and other operating characteristics of the inks. Soy-based inks used in sheet-fed presses still contain at least 10% petroleum oils. Research is continuing to increase the proportion of soy and other vegetable-based oils in these ink formulations while maintaining satisfactory printing characteristics.

The Office of Printing Services (OPS) at the University of Illinois is the operating partner in this study. They are considered a medium size, in-plant printer and gross about $4.5 million annually. They agreed to enter into this cooperative project because of their commitment to active research participation and out of a desire to be a model environmentally aware print shop. They were one of the first sheet-fed offset presses in the United States to use soy-based inks.

Approach

Data for this study was collected during a full-scale print run on a Miller TP104 Plus* six-color press in July 1992 at the OPS. The print job evaluated was a 4400 sheet, six-color, work-and-turn. Only four of the six colors were included in the study because the type of ink used for two colors was not changed between the runs. All inks included in the study were manufactured by the same company, Handschy, Inc. of Bellwood, IL.* In-plant measurements consisted of weighing the containers of inks, blanket cleaners, and roller cleaners used during makeready and printing at each press unit before and after each print run. Cleanup rags were weighed before and after each print run. Wastes in the wash-up trays were weighed at each press unit at the end of each run. Samples of each type and color of ink and each cleaner used were analyzed at the same temperature as the press for total solids and volatile content at the Hazardous Waste Research and Information Center's (HWRIC) Hazardous Materials Laboratory.

The operators at OPS use the same cleaners for both petroleum-based and soy-based inks. They had previously tried aqueous and less volatile organic cleaners and had not found any satisfactory substitutes. Problems identified with some of the cleaners they tested were that they required more labor, dried much slower, and sometimes left a film on the presses that had to be removed in an additional step.

Results

Ink Use

During the two print runs studied, makeready for the petroleum-based ink run was considerably more involved than that for the soy-based run. This was caused by excess moisture in the original batch of paper and not by differences in the inks. This difference in the two runs affected ink and blanket cleaner usage and waste paper generated. The excess moisture in the paper caused it to curl and wrinkle during feeding into the press. This problem was not a result of the type of ink being used for that run but because the paper had been stored in high humidity conditions before the first run. Because of this, about 25% more pages were printed using petroleum-based inks, which makes a comparison of inks and cleaners used and waste generated between the two runs difficult. These differences were compensated for to the extent possible in evaluating results of in-plant measurements.

The study results showed that the petroleum-based ink run required larger quantities of three of the four colors of ink than did the soy-based ink print run (Table 1). The amount shown in the g/100 sheets printed column compensate for the difference in the number of sheets printed during makeready. The % difference column compares the amount of petroleum-based ink used with the amount of soy-based ink used. For these specific print jobs, in total, approximately 17% more petroleum-based inks were used on a per sheet printed basis.

Cleaner Use

The amount of blanket cleaners used is shown in Table 2. Almost 46% more blanket cleaners were used during the petroleum ink run (3,455.4g compared with 2,368.0g). Some of this difference can be attributed to the larger amount of blanket cleaners used during the longer makeready that occurred during this run. The amount of blanket cleaner used during makeready was not recorded separately from that used during press cleaning at the end of the print run. The amount of additional cleaners used for that purpose during the printing run could not be directly measured; it would not necessarily be directly proportional to the amount of paper printed. Therefore, an equivalent comparison can not be made between the amount of blanket cleaners used for each print run.

At the end of each printing run, roller cleaners were used to clean up the presses. Their use was not affected by differences in makeready, but there was a difference in the way the presses were cleaned at the end of the two runs. At the end of the petroleum ink run, the ink in two of the stations was not changed. Also, since the same colors were used in the next run, each ink station was not cleaned as thoroughly as it was at the end of the second run with soy inks. The amounts of each roller cleaner used for each color and type of ink are shown in Table 3. Overall, about 30% more roller cleaners were used for the soy inks. This was expected since the stations were cleaned more thoroughly at the end of the soy-based ink run. Both inks appeared to require approximately the same amount of cleaners and effort to remove from the presses. On average in typical practice,

Table 1. *Quantity Inks Used*

Ink Color	*Ink Type*	*Ink Used (g)*	*Ink Used (g)/100 Sheets*	*% Difference*
Black	*Petroleum*	*241.8*	*3.8*	*19*
	Soy	*162.7*	*3.2*	
Blue	*Petroleum*	*124.8*	*2.0*	*25*
	Soy	*79.5*	*1.6*	
Red	*Petroleum*	*109.7*	*1.7*	*0*
	Soy	*87.1*	*1.7*	
Yellow	*Petroleum*			
	Soy	*85.8*	*1.4*	*27*
		53.6	*1.1*	

Table 2. *Quantity (g) of Blanket Cleaners Used*

Ink Type	*Cleaner Name*	*Cleaner Used (g)*
Petroleum	*V120*	*1768.7*
	Clean Quick	*1686.7*
Soy	*V120*	*1141.2*
	Clean Quick	*1226.8*

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Table 3. *Quantity of Roller Cleaners Used at Each Color Station*

Ink Color	Ink Type	RBP #1(g)	RBP #2(g)	MIX(g)
Black	Petroleum	40.1	31.0	12.4
	Soy	78.8	43.5	27.9
Blue	Petroleum	44.8	34.5	33.8
	Soy	75.7	56.2	52.1
Red	Petroleum	29.5	75.8	19.5
	Soy	97.9	19.7	24.9
Yellow	Petroleum	35.1	96.6	61.5
	Soy	40.3	84.9	71.5

the amount of cleaner used for the two inks would be expected to be about the same.

At the end of the petroleum-based ink run, 663.8 g of ink and cleaner mixed waste was in the washup trays. By comparison, there was 604.5 g at the end of the soy-based ink run. This approximately 10% difference can be attributed to the extended makeready at the beginning of the petroleum-based ink run. On average in typical practice, the amount of cleaner usage for the two inks would be expected to be the same.

Volatile Components

All inks had less than 6% volatile components, and there were significantly less volatile components in the soy-based inks than in the petroleum-based inks. The petroleum-based inks had an average of about 4.6% volatile components compared with an average of about 0.8% for the soy-based inks. Thus, on average, the soy-based inks only had about 17% of the amount of volatiles as the petroleum-based inks. The cleaners contained more than 97% volatile components except for one roller cleaner that contained about 88%.

Based on these laboratory results and on the amount of inks and cleaners used (Tables 1 and 2), the amounts of solids and volatiles in the inks and cleaners were calculated (Table 4). The amounts of volatiles were used to estimate the total mass of air emissions. Over 90% of the liquid wastes originated from the inks. As for the volatiles, over 99% originated from the cleaners in both cases.

Because of the difficulty of directly measuring the amount of emissions from the many sources on the press, the printed papers, and the waste containers, a worst case assumption was made that air emissions were equal to the volatile content of the materials used. Thus, for the petroleum-based ink run, 3,930.15 g were calculated to be evaporated compared with 3,004.30 g for the soy-based ink run. This was about 31% more emissions. As described above, even after adjusting for differences in makeready, about 17% more petroleum-based ink was used. In addition, the petroleum-based inks had a higher volatile content (4.6% compared with 0.77%). Just in terms of ink used, there were 0.39 g/sheets of volatile emissions from the petroleum inks compared to 0.23 g/100 sheets for the soy inks. This is about 70% more emissions to the air for an equivalent amount of printing with petroleum inks.

As shown in Table 4, the mass of volatiles estimated to be emitted from the inks is less than 1.0% of the total mass estimated to be emitted from the inks and cleaners. Since most of the air emissions were from the cleaners, less than 1% overall reduction in air emissions resulted from using the soy-based inks. The longer the print run the greater the reduction in volatile emissions from using soy inks.

Liquid Components

The two main liquid wastes from the printing press were from washup trays and inks and cleaners on used rags. None of these materials were spilled during the two runs. To clean the various rollers and blankets, several rags were saturated with each cleaner and were used to wipe down the press. As a result, the rags contained some highly volatile inks and cleaners. An undeterminable portion of these cleaners and inks ended up in the washup trays. Rather than determining the rapidly changing amount of liquids on the rags immediately at the end of the print run, the rags were dried and the amount of dried solids on the rags was weighed. About 60% more solids were on the rags used to clean the presses after the petroleum ink run. Since more inks and cleaners were used in that run, apparently much of these materials ended up on the cleanup rags.

The amount of liquids in the washup trays from this study was measured directly at the end of the print runs. Almost 10% more liquids were generated in the washup trays after the petroleum ink run. This liquid was a mixture of inks and various cleaners. The amount of each ink and each cleaner that ended up in these trays and the rags (less the amount evaporated and on printed product) could not be directly measured.

The amount of each cleaner used to saturate the rags was not metered out precisely by the press operators so that differences between the two runs in the amounts used were mostly the result of operator variability when they poured cleaners on the rags and not the results of the type of ink being cleaned. We observed no reason for there to be a consistent difference in the amount of liquid wastes generated by the two types of inks studied. Differences resulted from operator variability, extended makeready during the petroleum ink run, and more thorough cleaning conducted at the end of the soy ink run. It can not be concluded that one ink generated more liquid wastes than the other.

Table 4. *Solid and Volatile Contents of Inks and Cleaners Used (g)*

Parameter	Petroleum Print Run	Soy Print Run
Ink Solids	537.17	371.36
Cleaner Solids	64.78	48.64
Total Solids	**601.95**	**420.00**
Ink Volatiles	24.93	11.54
Cleaner Volatiles	3905.22	2992.76
Total Volatiles	**3930.15**	**3004.30**

Solid Waste

During makeready for the petroleum-based ink run, 1375 waste sheets were generated. The reverse side of 100 waste sheets were reused during makeready for the soy-based ink print run. This is the amount of solid waste generated directly during these print runs. No other containers of solid wastes were observed. Additional solid waste that may be generated in printing include trimmings and excess number of pages printed to compensate for losses that may occur during folding, binding and any other final preparation steps. Because the soy inks generally spread further (by an average of about 17%), less used ink containers may be generated with those inks. The amount of the other solid wastes would be unaffected by the type of ink used. In this case, the difference in makeready waste resulted from moisture in the paper at the beginning of the print run and not from difficulty with using the inks.

Press alignment and ink metering was automated for the press used in this study. Based on observations of manually operated presses at this and other facilities, automation or efficient press set-up, rather than the choice of ink, results in less solid waste being generated during printing. Once operators are familiar with the use of either the petroleum or soy inks, then the amount of solid waste generated during makeready will not be noticeably different. In both cases, more waste paper might be generated on some jobs because of difficulties in obtaining acceptable colors or other print quality factors. In this regard, neither ink appears to have a clear advantage over the other.

Costs

The main cost factor considered was that of raw materials. No equipment expenditures were required by OPS to switch from using petroleum to soy inks. There was a difference in the amount of labor involved in the two print runs but that was due to the problems with paper at the beginning of the first run and the fact that cleanup was more rigorous at the end of the second run. Neither of these differences was due to the type of ink being used. The operating conditions of the press, such as temperature and speed, were the same for each ink so there was no difference in overall rate of production or utilities used because of the type of ink used. Insurance, monitoring requirements, reporting and recordkeeping, and permit requirements are the same for each type of ink. Any differences in future costs for remediation or property damage would be minimal. Employee health costs would slightly favor the use of soy-based inks because of reduced employee exposure to breathing released chemicals. All the quantified cost factors are for the Miller TP 104 press only and not for the entire facility at OPS.

The purchase prices of raw materials (inks, cleaners, and paper) for this print job are approximately the same for both types of ink. Generally soy inks cost about 10% more. The average purchase price for both the soy inks and petroleum inks is about $8.00/lb (or $0.018g). Actual costs, depending on the color, range from about $4.00 to $12.00/lb. Costs do vary, however, when the amount of materials used for petroleum inks is compared with the amount of materials for soy inks. On an equivalent basis of ink used during printing and typical makeready, the overall cost savings in ink used for the soy-based ink print run was estimated to be $1.17. This cost difference is not a major factor in ink selection. Higher costs are involved in printing including labor, materials such as paper, equipment amortization, and utilities. The portion of total printing costs allocated to inks is usually very small.
When adjusted to the amount of acceptable product printed, the difference between cleaner costs for the petroleum and soy-based ink runs for this print job was only 5 cents. This difference would be greater if the cleaning after the petroleum-based ink run had been more thorough. Because the same cleaners were used for both inks and on average there would be no difference between the two inks in the amount of cleaner needed, costs for cleaning would not be expected to differ.

Discussion

Overall, about 17% less soy ink compared with petroleum ink was used for the print job studied. Because less amounts of volatile hydrocarbons are emitted from the soy-based inks, air emissions were less. Since the inks and cleaners continuously evaporate during use and the waste inks and cleaners end up mixed together in washup trays and on the cleanup rags, it was difficult to determine the proportion that evaporated during the actual printing process. Ultimately, most if not all of the volatiles in the inks and cleaners will either evaporate, be discharged to the water (such as from a commercial laundry) or be containerized and sent to a landfill. Some of these emissions will occur at the print shop, some perhaps after shipment of the printed product, and some at waste management facilities. The proportion of volatilization that will occur in any one place will vary depending on how the waste materials are managed. For comparison purposes, it was assumed in this study that all the air emissions occurred at the print shop.

An important factor that influences the amount of waste generated per unit of production is the length of the print run. Some uses of ink (and resulting wastes generated) in the printing process are fairly consistent among print jobs. For instance, the amount of ink required to coat the rollers and plates for each revolution is relatively consistent. A certain amount of waste is expected for every print job, but a higher proportion of waste is produced per raw material input on shorter print jobs, such as the one monitored here. With longer print jobs, a greater percentage of the ink used would be applied to acceptable product.

To most printers, there are little or no perceived differences in the cost of using soy-based inks because the raw material cost is slightly higher or equivalent to petroleum-based inks. The cost difference is more than offset by the fact that the soy inks spread almost 20% further and do not release as much volatile organic chemicals. Less tangible benefits of using soy inks (company image as being environmentally friendly, improved employee relations due to a perceived healthier working environment, and customer preference for products) are major factors considered by printers. If customer response to product quality is negative, printers will not adopt a new ink. At OPS, their experience has been that customers find the quality of the product to be acceptable, and many prefer to have their job printed with soy-based inks.

A company also must consider the willingness of its workers to switch to and use soy inks and the time it takes for operators to become skilled in using these inks. Understandably there may be some excess waste generated during such a change. At OPS, there was some initial resistance to the new inks. Formulations of soy inks in sheet-fed offset presses were new. In the past few years, these formulations have improved and the press operators at OPS have gained the experience necessary to produce high quality images. Presently, the employees prefer to use soy-based inks on this particular press. A major reason for this is that the soy inks are very similar to petroleum-based inks to work with and clean from presses. If an alternative cleaner was used that took the operators longer or required more effort for the soy inks then there would be considerable resistance and cost.

In addition to using soy-based inks, there are other strategies printers can use to reduce wastes from the sheet-fed offset printing. Since most emissions were from use of the cleaners, these emissions could be reduced if aqueous or less volatile cleaners were used. The press operators at OPS have not found any of the alternative products they tried to be acceptable. It should be kept in mind that the use of less volatile cleaners may increase liquid wastes.

Another strategy to reduce waste would be to reduce the use of cleaners and inks. This can be done in two ways; both may involve additional capital for equipment. One way is to recover or reuse waste inks and cleaners. Installing a solvent still to recover chemicals from the washup tray wastes and possibly reusing those chemicals in formulating cleaners might be feasible. Some large printers have reportedly adopted this approach.

A second way to reduce cleaner and ink usage would be to purchase automatic blanket washers and ink roller train systems. Literature from one manufacturer of this equipment claims that as little as 220 to 275 mL of cleaning solvent can be used during a print run when the automated systems are in use. Although this would not eliminate the need for hand cleaning, it could greatly reduce the amount of cleaner used and, thus, the emissions from the cleaners. It could also reduce employee exposure to potentially harmful substances. An automatic blanket washer could reduce cleaner use by up to 90%. It should be noted that on some presses where these systems have been installed the operators actually increased use of the cleaners because, even during a print run, the blankets can be cleaned without stopping the press. Automatic ink handling systems allow this type of press to be operated with about 80% less ink in the fountain.

The automatic blanket washer and ink handling systems also reduce makeready and cleanup times, saving the press crew time and exposure to volatile compounds. At OPS, it was estimated that such a system would have a payback of about 3 yr. Most cost savings would be expected in the cost of cleaners and in reduced cleanup time.

Overall, soy inks have some environmental and other advantages for sheet-fed offset printers. The main environmental advantage with soy inks is that they release less than 20% of the mass of volatile organic chemicals compared to petroleum inks. The soy inks also spread about 15% further, which offsets the small difference in cost that currently exists. Reportedly, recycling of soy ink printed paper also has some advantages. In this study all other factors including makeready time, appearance of printed product, and cleanup effort were essentially equivalent between the two types of inks.

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The complete report, entitled "Waste Reduction Evaluation of Soy-Based Inks at a Sheet-Fed Offset Printer," (Order No. PB95-100046/AS; Cost: $17.50, subject to change) will be available only from:
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