Waterless and Conventional Offset Lithography: A Realistic Technical Comparison

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Abstract: Comparisons of waterless and conventional offset lithography have been presented numerous times, including several TAGA publications. Nevertheless, the printing community still has not reconciled the obvious benefits of waterless printing: less waste, higher productivity, more consistent quality and environmental friendliness with the lack of commercial growth, especially in the US. Various myths have arisen to explain this contradiction. This study will demystify the issues concerning waterless printing and explain the seeming contradictions based upon controlled comparison studies. The improvements in "make ready to color"; the greater consistency throughout a print run will be described. Also, the characteristics of conventional printing, especially with digital plates, which minimize the advantages of the waterless process, will be discussed. Finally, the potential for "closed loop" press controls with digital waterless plates will be shown.

Introduction

At least one pundit characterizes waterless printing the same way he characterizes the generation of electricity with fusion power, that is, both are always just a few years from wide-spread commercialization, but they never get here. While the status of fusion energy is outside the scope of this paper, the status of waterless printing is very much the subject of this paper.

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Without belaboring the history, the comment above does bear some semblance of a truism. Waterless printing has been around for over thirty years. First viable technologies arose in 1970 (Curtin, US 3,511,178). Introduction of a truly commercial product occurred later in the 1970s (with 3M's Driography). New patents led to a renaissance in waterless printing technology, the commercialization of a line of negative and positive plates by Toray (later in the 1980s) culminating in a GATF Intertech Award given to the overall waterless system concept in 1992. Commercial growth was significant in the following few years. Nevertheless, in the year 1999 total production of signatures by waterless offset was probably static or even decreased versus a few years before.

We will explore the reasons for the historical trends in some depth using data; point out the advantages and disadvantages of waterless printing which come out of the data and highlight the factors which might drive waterless in the future. It is not the intent of this paper to try to predict the future but to present factual evidence and let the reader conclude whether the benefits of waterless would outweigh the disadvantages under future scenarios.

Waterless offset printing is characterized both by what it typically involves and what it doesn't. Waterless offset as the name implies does rely on an offset blanket to transfer the image to paper. Unlike conventional offset it does not involve the use of water (or fountain solution) to differentiate image from non-image areas. Waterless offset does use a printing plate to capture the image from another medium whether film or a digital file. Like conventional offset fairly complex inking systems can be employed to deliver the ink to the printing plate on press. Unlike conventional lithographic plates waterless plates have silicone "rubber" non-image areas for ink rejection instead of water-loving (usually aluminum oxide or gelatin) areas for ink rejection. Waterless offset inks can be considered more like conventional offset inks than not, ie can be called paste inks of relatively high tack and viscosity (versus, for example gravure, flexo or ink jet inks). However, waterless inks generally have lower tack and higher viscosity than conventional offset inks and usually a temperature window where their rheology is optimum for printing.

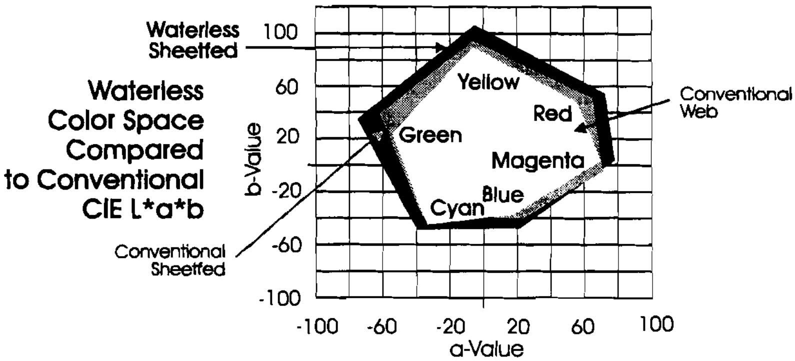
Waterless offset presses can look remarkably like conventional presses (with temperature control technology provided by built-in or add-on components). Or they can look somewhat different with special "short inking" systems. Waterless offset can be printed on most any paper stock as well as many non-porous media. Let us see how many of the purported advantages and disadvantages can be documented.

First Case Study

Wong, et.al. (1995) described an extensive study of waterless versus conventional offset on M90 heatset web presses in a commercial installation. They reported that average ink densities over six press samples were:

Waterless: black=1.70, cyan=1.35, magenta=1.45, yellow=1.32
Conventional: black=1.63, cyan=1.19, magenta=1.35, yellow=1.10.
This led to potential wider color space for the waterless. In fact, as shown on figure 1 the maximum possible color space for waterless does, without the effects of water, exceed that for conventional because of the higher saturation possible without the effects of water.

Figure 1. Waterless Color Space Compared to Conventional Litho



Wong reported significantly less dot gain to paper, especially for stochastic screens, and better print contrast. Ink consumption at the same densities were found to be 2.9% greater for waterless though comparing to visual match (since conventional prints to higher dot gain) required 14.5% more ink for waterless.

While it is always risky to draw too many conclusions from one study let us assume the general conclusions as valid: plate-to-paper waterless prints sharper to better contrast and less dot gain. The print buyer tends to prefer higher ink densities thus leading to higher ink consumption for waterless.

Second Case Study

In a report on waterless offset lithography, Lindqvist, et.al. (1999) reported several separate studies funded by the Nordic Industrial Fund. In one study, waterless printing performance was compared with conventional inks on a 4+4 web press printing on nine different papers. The results included findings of significant heating of the blankets during their runs (often going from 20C-34C) despite the cooling of the inking rollers. For this reason the web could not achieve maximum speed of 40,000 rph. Nevertheless the waterless inks printed well with dot gain reductions (approx. 6%) and generally higher ink densities. As in Wong's study, waterless showed (over a range of papers) ability to print sharper, and to higher densities. The Nordic study reported significantly shorter times to reach density at start-up. Waterless was more competent on matte finished papers, fewer differences were found on high gloss papers. And they found that printing waterless caused papers to follow the blankets longer causing web flutter, potentially leading to smearing or even paper breaks.

In a second study carried out by the Nordic fund, waterless inks were compared to conventional offset inks. The results confirmed that waterless inks usually are of higher viscosity and lower tack than conventional inks for the same presses and generally have higher polarity, usually more acidic. But most interestingly variations in waterless inks were so great that, "the differences between the waterless inks may be as large as the differences between a waterless ink and a conventional ink."

In a third study, overall environmental impacts of waterless versus conventional offset printing are compared. Looking at 12 different environmental factors, the two systems were found to have identical impacts based on all prepress factors, but waterless showed 30% less impact on press. The reductions accrue due to faster to color for waterless at startup and the elimination of fountain solutions and their accompanying impacts on VOC and water treatment facilities.

Third Case Study

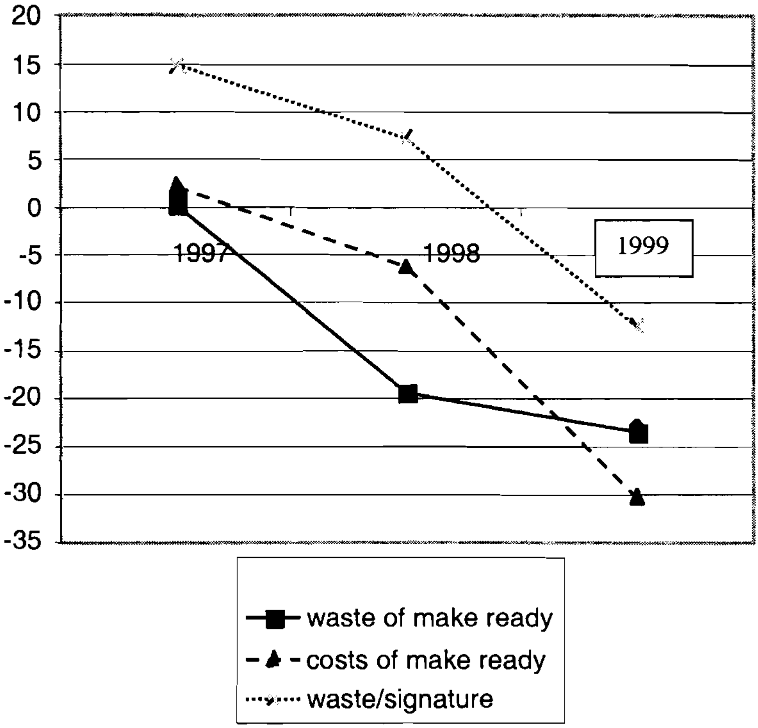
In perhaps the most complete and through study comparing waterless to conventional printing, Art LeFebvre (2000) reported on documentation provided by Kurt Zuckschwerdt of AVD Goldach on its three year study of waterless versus conventional printing on two virtually identical web presses. Table 1 summarizes some of the key findings.

Table 1. Percentage difference of printing on dry web versus wet web

Element	1997	1998	1999
Manufacturing Hours	-31.3	-11.6	24.6
Maintenance	-14.9	-1.4	-1.15
Copies	-12.2	29.4	58.5
Costs/1000copies	2.6	-17.1	-12.3
make-ready time	-22.1	-22.8	-37.5
waste of make ready	0.42	-19.5	-23.5
costs of make ready	2.3	-6.3	-30.3
waste/signature	14.9	7.3	-12.4

To better appreciate the changes over the 1997-1999 time period, the results for three key factors are plotted in the figure 2 below.

Figure 2. Waterless/Conventional Performance (Web presses at AVD)



The data show first of all the pattern over three years on like time periods. The year 1997 corresponds to the first experiences with waterless web printing. The relative percentages compare the printing performance on the wet vs. the dry press. In these data there is the crux of the waterless versus conventional printing issue. In 1997 the waterless performance was generally worse than the conventional wet press. The make ready time was already clearly less (by >20%) but the total waste per signature was 15% more, even the costs of make ready were higher. Overall, the difficulties in learning to properly run a waterless web press combined with real deficiencies in the original equipment and consumables led to poorer overall performance for waterless. AVD persevered and gradually developed understanding of the process and instituted changes in their procedures, equipment and materials. In the third year, 1999, the waterless press was achieving better performance numbers, e.g., almost 40% greater manufacturing hours, >58% more sheets produced, at 12% lower costs per 1000 copies. Clearly much of the advantage is in make ready where cost advantages of 30% are found. In short, once the process is optimized, the performance level is characterized by significantly higher throughput (due to much shorter make-readies) less wastes overall and faster job turnarounds.

Fourth Case Study

Similar results as AVD is provided by a waterless printer in the UK (Beacon Press) whose reported data is summarized on following tables.

Table 2. Press performance at Beacon Press (Waterless versus Conventional)

Paper waste:	29.7% less
Copies produced:	31.6% more
Cost per 1,000 copies:	13% less
Profits:	10% more
IPA (Alcohol) used:	79% less

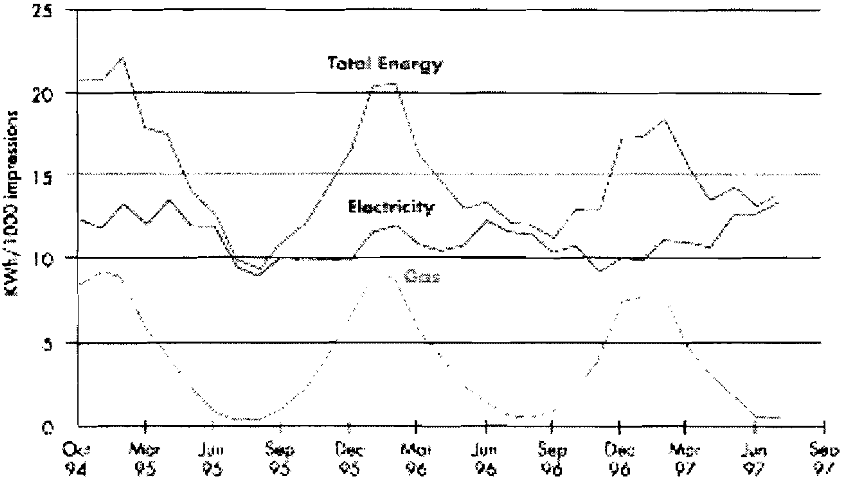
Table 3. Time in minutes for various stages on a typical print job

Process Step	Conventional	Waterless
Preparation	6.7	5.8
Registration/make-ready	38.9	34.7
Production	51.5	44.2
Press Adjustments	22.3	16.5
Others	5.8	6.8
Total	125.2	108

The tables show the same sort of productivity savings as AVD reported regarding paper waste, copies produced and cost of production.

The Figure 3 below shows that energy consumption in the total printing process did not change despite the need for water-cooling equipment for their presses.

Figure 3. Energy Consumption by Beacon Press Before and After Conversion of its Presses to Waterless in November 1995



Fifth Case Study

In a study at RIT (Chung, et.al. 1995) waterless and conventional jobs were printed on the same press. They looked at a sheetfed press printing commercial type signatures on good quality paper stock. They reported that differences in dot gain or visual appearance were not detectable between the waterless and conventional prints. The table 4 below captures the dot gain data from these tests. They attributed the limited differences to the excellent temperature control provided for both technologies during the tests.

Table 4. Dot gain comparison (Overall SD=3 %)

	Waterless	Conventional
Black	25.3	23.9
Cyan	19.1	19.7
Magenta	20.8	20.5
Yellow	19.1	20.3

Advantages of Digital (Conventional) Offset Plate Technologies

One issue that impacts the question of waterless versus conventional lithography greatly is that of digital plates. That is, many of the benefits attributable to waterless can be achieved by use of digital plates. Yeich (1999) reported surveys of printers who switched to digital plates; the compilation was from GATF Technology Report #13. Based on the respondents digital plates as a concept provided the following attributes and system benefits (with estimated score from 1-5 where 5 means excellent)

Table 5. Attributes and Benefits of CTP plates

Attributes	
Sharp print quality	4.4
Easy to maintain ink/water balance	3.8
Run length	3.8
System benefits	
Reduced press make-ready time	4.2
Improved image quality	4.2
Increased throughput	3.5
Reduced environmental impact	3.0

Overall, therefore, the digital plate concept brings a perceived significant set of benefits and attributes which waterless brings, especially in sharp print quality, easy press running, including reduced make ready, greater throughput and reduced environmental impacts.

Summary

From the five case studies and the commentary on digital plates we can extract some advantages and disadvantages of waterless offset versus conventional offset printing. Lindqvist (1999) emphasizes many of these.

Advantages

- -Larger color space for waterless.
- -Improved productivity due to faster make-ready. (Lindqvist points out this is only advantageous if a printer's sales force can generate more jobs for the extra press availability)
- -Less paper waste and ancillary costs associated with waste.
- -Waterless does not use alcohol.
- -On most presses waterless prints with lower dot gain; sharper printing.
- -Though not discussed in the case studies waterless can be more easily used to print metal decorating and plastic packaging.

Disadvantages

-Though not expressly addressed in case studies, waterless printing has high prices for consumables.
-For either analog or digital offset printing, till very recently, there was a single plate supplier.
-Though the Beacon press data disputes this; many printers expect higher energy costs in running waterless.
-There is a need for capital investment in efficient press cooling systems and new plate processing equipment.
-As is clearly shown by the AVD data, there is a very long learning curve for a printer to achieve the productivity advantages of waterless.
-Dot gain curves; one needs to adjust for lower dot gain to avoid washed out tints; generally waterless consumes more ink.

Besides these lists of advantages and disadvantages there are several of what we shall call considerations. For example, if one accepts that press cooling is a benefit for all offset printing, then one will obtain superior conventional quality printing (as described by Chung) but also incurs the potentially higher operating costs that might be a negative for waterless printing. During transitions, printers often find the print qualities on the two systems are too different to switch jobs last minute from one press to another causing inflexibility.

Lindqvist highlights a crucial but little discussed aspect during the transition to waterless printing, "The shorter make-ready times and, in certain cases, the need for *fewer pressmen* (emphasis mine) must be explained in a reasonable manner...if the introduction is a no-choice arrangement, the productivity gain may easily evaporate."

The Impacts of CTP on Printing

The reported dramatic positive acceptance of conventional digital plates (as described by Yeich) suggests that many of the benefits of waterless are achievable by use of digital plates. Based on published figures digital plate sales now dwarf waterless plate sales. So, the issue might be whether the availability of 3 digital waterless plate suppliers might rejuvenate waterless usage by providing benefits of both waterless and digital plates.

So, therefore, we can now review the explanations for waterless printing's slow acceptance. It undoubtedly shows a long learning curve to achieve the benefits. Benefits predominately accrue in productivity which can be easily compromised by lack of efficient sales organizations or poor pressroom management. Printers must provide capital upfront for waterless. Best practice with digital plates and temperature-controlled presses provide many of the print quality advantages of waterless. Environmental benefits more typically accrue to the society at large (through less forest and chemical resources used) that are not easily legislated at the point source. The impacts of these factors into the future will likely depend on what scenario one proposes. One proposed significant additional justification for digital waterless printing is the capability to implement closed loop press controls. That is, if one prints with a "single fluid" the print densities become a single-valued result of ink application (assuming excellent temperature controls). In conventional lithography for any desired density there is a multitude of ink/water settings capable of printing to that density. Combining the single-valuedness with a digital input file should enable pre-setting ink application to suit the image. This should make possible even more rapid make-readies to color and closed-loop color control throughout the entire print run.

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