



Drying on a High Speed Inkjet Press

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Overview

- HP has developed high speed commercial-scale inkjet presses currently in use at a number of customer sites
- Books printed under extreme conditions (e.g. high humidity, high picture density, lightweight paper) display waviness, decreasing customer satisfaction
- Objective: reduce book waviness through optimization of inkjet press printing parameters and application of fundamental engineering principles

Background

- Paper consists of cellulose fibers (see Figure 1) treated with various coatings to improve durability and performance

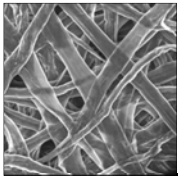


Figure 1. Microscopic view of paper structure

- High levels of tension, significant application of moisture to paper, and aggressive drying during printing cause non-uniform expansion of the cellulose fibers and can lead to permanent deformities recognized as waviness
- Literature regarding the waviness phenomenon reveals unclear and often contradictory results for common strategies to reduce waviness

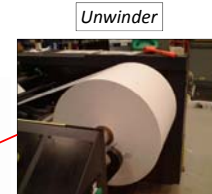


Print Zone 2



Print Zone 1

Dryer 1



Unwinder



The T300 Press

Experimental

- DOE-style experiment altering printing press parameters (Table 1); 23 variations created consisting of 3 repeating test patterns

DOE Variable	High Value	Low Value	Units
Dryer 1 Airbar Velocity	14000	10000	fpm
Dryer 1 Air Temperature	270	330	°F
Dryer 2 Airbar Velocity	14000	10000	fpm
Dryer 2 Air Temperature	270	330	°F
Moisturizer Loading	2	0	gsm
Tension Level	35	20	lb
Tension Profile	Stepped	Flat	-

Table 1. Original DOE book variables and values. Tension Profile refers to differing (stepped) or constant (flat) tension on the paper through the different printing processes

- Uniform moisture application across pages (ink and bonding agent) during printing: even expansion across pages
- Dryer effects: High Temp 1, Low Temp 2 vs. Low Temp 1, High Temp 2
- Laser profilometry (Figure 2): quantitative measurement of waviness (Figure 3)



Figure 2. Laser profilometer

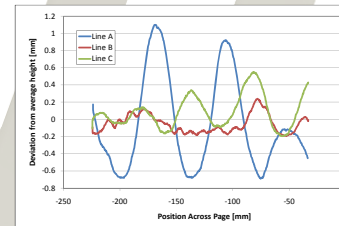


Figure 3. Example of laser profilometry results for DOE books. Lines A, B, and C refer to scans along the bottom, middle, and top of a page, respectively

Results and Discussion

- DOE Analysis: most tested printing press parameters had negligible effect on waviness
- First dryer temperature correlated directly with waviness (DOE); further experiments show inconclusive results
- Higher paper moisture content (post-printing) correlated significantly with less waviness (Figure 4)

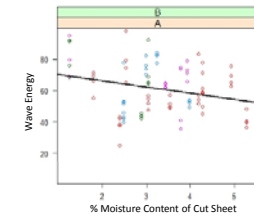


Figure 4. Example plot of wave energy (higher wave energy = more book waviness) as a function of % moisture content of the printed paper.

- High levels of uniform moisture application reduced waviness. Measured by laser profilometry (Figure 5) and human grading (Figure 6)

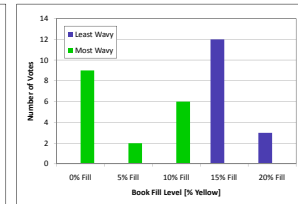
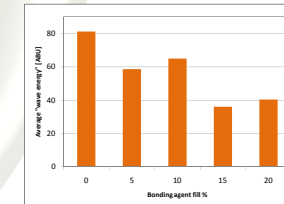


Figure 5. Laser profilometry results for uniform bonding agent application experiments.

Figure 6. Human polling results for uniform bonding agent application experiments.

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References

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