Project Overview

Issue and Opportunity
Current analog varnish application is inefficient in non-repeating printing of box patterns. During box construction, glue does not adhere well to varnished surfaces.

Objective
Develop a digital solution to selectively alter overprint varnished surfaces to strengthen adhesive interactions for box construction.

Background
What is overprint varnish (OPV)?
- INX KOTE Varnish: Polyurethane based film
- Increases durability and water resistance of paper products
- Improves product appearance

Why does glue not adhere well to varnish?
- In paper, glues work by wetting the surface and entangling itself with the fibers
- Varnish covers the paper, leaving a flat, nonporous, low surface energy surface

Industry Analog Solution Disadvantages
- Flood coating requires expensive adhesives
- Manually switching printing plates to apply different varnish patterns for spot coating is time consuming and labor intensive

Methods

Bench-Scale Experiments
1. Apply thin layer of varnish to paper
2. Mist surface with treatment chemical
3. Punch circular samples with die cutter
4. Glue samples together
5. Conduct qualitative adhesive test to determine mode of failure

Full-Scale Experiments
1. Fill printheads with treatment chemicals
2. Mount printhead to T-400 printer (Figure 2)
3. Perform peel test to determine adhesive strength

Use Thermal Inkjet Technology to Apply Chemical Treatments
The Young-Laplace relation states that for a small nozzle radius, a high driving pressure is required. This can be accounted for by decreasing fluid surface tension. When necessary, a dish soap surfactant was used. The following chemical treatments were tested:

- “Bonding Agent” (BA)
- Isopropyl alcohol solution (IPA)
- “Magi PF”
- Ammonium Hydroxide (NH₄OH)

Develop Quantitative Adhesive Test (Bench-Scale)
A qualitative adhesive peel test shows mode of failure. A successful chemical treatment will change mode of failure from adhesive to structural. Adhesive for peel test must cause:

- structural failure in Virgin-Virgin bonding (Figure 4)
- adhesive failure in OPV-OPV bonding (Figure 5)

The adhesive used was a specialty hot melt supplied by NW Adhesives.

Develop Quantitative Adhesive Test (Full-Scale)
A 180° peel test was implemented with the Chatillon CS225 Force Tester. This measured the force required to peel 5" of Scotch tape at a speed of 10" per minute from the paper surface.

Conclusions
- Bonding Agent and IPA solution treatments showed significant improvement in adhesive strength compared to untreated varnish surface.
- Magi and NH₄OH treatments did not improve upon untreated varnish.

Future Work
- Use force tester with NW Adhesive supplied glue to more accurately characterize adhesive strength.
- Determine cost per square meter for chemical treatments found to be significant with new force test.
- Test chemical treatment with different overprint varnishes.

Results
Using the Chatillon CS225 Force Tester, the following graph was produced for BA. It can be seen in Figure 7 that there is separation between the peel force of an untreated varnish surface to a BA treated varnish surface.

Figure 1. HP T400 Printing Press prints up to 3 meters wide as fast as 1000 fpm

Figure 2. Printhead mounting setup

Figure 4. Virgin-Virgin qualitative peel test resulted in structural failure

Figure 5. OPV-OPV qualitative peel test resulted in adhesive failure

Figure 7. Peel force vs. distance plot for BA past treatment compared to virgin and varnish paper

The following bar graph summarizes the average peel force for each chemical treatment tested. Light, medium, and heavy corresponds to amount of chemical applied.

Figure 8. Summarized average peel force data for each treatment. Error bars and shaded areas represent one standard deviation

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- NH₄OH - Applied Experiment; provided NH₄OH for surface tension measurements
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