IDENTIFICATION AND CAUSES OF "PUDDLING" AND "VOLCANOING" IN PUBLICATION GRAVURE PRINTING

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ABSTRACT

For the past several years the incidence of "puddling" and "volcanoing" has increased markedly. These print anomalies are characterized by small localized areas of excessively thick ink, which may also fracture and erupt while drying. These deficiencies are nearly always found in high density areas of the print.

In this paper it is shown that while the causes are related to solvent entrapment, these problems can be a function of solvent retention by the ink vehicle, solvent evaporation rate, paper absorbtivity, and ink/paper interactions.

Laboratory methods for observing and identifying these conditions and some suggested ways of minimizing them are presented.

INTRODUCTION

Solvent entrapment is a common printing deficiency which can often occur in high speed gravure printing. The effect of solvent entrapment varies greatly, ranging from an undesirable visual effect to complete film failure. It has been associated with a number of conditions, such as; incomplete drying of the ink film between stations, excessively high dryer temperatures, non-absorbent substrates,

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high ink coverage, poor ink/paper interactions and poor ink solvent release.

DISCUSSION

The drying mechanism of gravure printing is based on evaporation. A low viscosity ink is transferred from an engraved cell and deposited onto a specified stock which is either coated or uncoated. The ink in its liquid state is deposited in small cellular areas that flow laterally to form a continuous film in solid printed areas.

Puddling and volcanoing are two distinct printing deficiencies which sometimes occur simultaneously as a result of poor ink/paper interactions. Paper absorbtivity as well as ink composition will have an effect on both defects.

Uncoated substrates are printed with inks that produce low gloss finishes, which dry by initial absorption followed by evaporation. These inks are based on metal resinate binders and include fillers to minimize penetration. Coated papers utilize inks which produce high quality, glossy reproductions, and show relatively little initial ink absorption. The inks generally are based on metal resinates or other modified resins and contain no fillers. The substrates are heavily coated and are not absorbant to the same degree as uncoated papers. Evaporation of the solvent to effect drying is thus more likely to trap solvent between the sealed surface of the ink and partially penetrated paper coating. Most puddling and volcanoing occurs in coated paper applications because of this. On uncoated stock, the porous nature of the substrate provides a route for the easy escape of solvent vapors from the ink film, thus minimizing solvent entrapment.

Volcanoing is a direct result of excess solvent which is trapped in a localized area. (See photograph #1). A skin or seal is formed over the surface of the ink deposit, preventing total solvent release. The high vapor pressure of the retained solvent forces the skinned or sealed ink surface to rupture and results in a crater. Blended aliphatic/aromatic solvents, either virgin or recovered, lend themselves to increased volcanoing. The aliphatic content of blended solvents may vary from 20-80%, based on volume. (See photograph #2)

The initial evaporated solvent vapor from blended solvents will contain higher ratios of aliphatic solvents, whereas the remaining solvent is richer in aromatics. The aliphatic-rich solvent evaporated initially will form a skin on the surface. Aromatic rich solvent is then entrapped between the surface skin and the substrate. As a result of increased vapor pressure in the dryer, the entrapped solvent may cause volcanoing.

Puddling is a term used to describe the formation of ink pools on the paper surface. Puddling is usually found in printed areas with high ink densities. They can be easily detected by a darker ring which is formed around the pool of ink. This causes macro visual defects which give an appearance of overall worminess to the print. Puddles are isolated, circular, and dense ink deposits which vary in size but remain similar in appearance when viewed microscopically. (See photograph #3)

Puddling and volcanoing can be easily identified with the use of a microscope. With visual macro or low magnifications under 10X, the overall appearance can be described as: speckling, worminess and mottling. (See photograph #4).

A print which is suspected of puddling and volcanoing should be viewed at higher magnifications for correct assessment of the deficiency. (See photograph #5)

These defects may also be found in all process colors. They are detected mostly in red and blue printed areas because of their high visibility and predominance in solid tones.

Cell configuration also appears to have an effect on the tendency toward puddling and volcanoing. In our laboratory print tests, elongated Helio engraved cells contributed to these problems, probably due to their tendency to transfer more ink. Helio compressed cell configurations, however, produced little evidence of puddling or volcanoing. (See photograph #6)

Paper smoothness also appears to have an effect on puddling. Prominent paper fibers, and paper bundles increase the tendency for puddling by forcing large ink deposits to form in the depressed areas of the paper surface. As a result of this, the pooled ink may also volcano due to trapped solvent in this heavier localized area. (See photograph #7)

Due to variations in paper coating formulations, the tendency for puddling and volcanoing may vary with different paper manufacturers. A commercially produced print, which employed identical printing conditions and inks, changing only the substrate, produced wide variations in degree of puddling and volcanoing, due primarily to paper coating formulation differences. (See photograph #8)

To simulate the effect of the dryer in publication gravure printing, a freshly made laboratory print was subjected to heat using a hot air gun. The gun, which uses high heat to simulate excessive dryer temperatures on press, caused solvent entrapment in full tone areas. Due to immediate surface skinning, volcanoes resulted. This points out the need to avoid excessive dryer temperatures.

The photographs included in this paper will exhibit the overall appearances of puddling and volcanoing. Printing parameters, as previously discussed, may have a great influence on the previously stated condition. The direct and indirect causes for these conditions are usually complex and can be a function of more than one deficiency.

While these problems are not new to the gravure printing industry, the frequency of occurrence is increasing. It appears that increased ink density demands in the gravure industry will only increase the occurrence of these problems.

Various ways of alleviating these conditions have been tried. Below is a list of the most common methods currently utilized for minimizing them:

* Reduce dryer air temperatures and increase air volume. If possible, add air bars to increase air volume. Air volume is more important than the dryer air temperature. Minimizing solvent content prior to reaching the dryer will also reduce the tendency toward cratering.

* Reduce ink viscosity with toluene. This will increase the open-time of the ink, thereby minimizing surface sealing or skinning.

* Increase impression roller pressure once the ink viscosity has been reduced to maintain density.

* Carry the minimum amount of ink required to print an acceptable product. Areas with high ink coverage have a greater tendency to puddle and volcano.

* Select a substrate that insures proper ink/paper interactions. One of the most common causes for both puddling and volcanoing is excessively low absorbtivity of the paper coating. Using a simple laboratory press, make multiple trapped prints. Dry the print with a heat gun. If the substrate is prone to these defects, they will appear in the full tone areas.

* Ask the ink supplier to reformulate or modify the ink for better solvent release.

If the ink binder holds onto solvent too long, puddling and volcanoing may appear.

* Stronger inks could also minimize the effects of both conditions, as ink volume should be reduced by decreasing cell volume to transfer less ink.

* Higher screen lines to increase the number of cells/inch would be beneficial, as it would enable decreased cell depths. The cost may, however, be prohibitive in all cases.

The causes for puddling and volcanoing may be, for the most part, difficult to determine. Inspection of the printed material with a microscope usually provides clear evidence of these occurrences. We have established some suggested techniques for observing them.

Although a low powered microscope would usually be sufficient for assessing overall print quality, it is not effective in studying puddling and volcanoing. Below is a list of methods used for determining these conditions in printed gravure signatures.

SUGGESTED TECHNIQUES FOR DETERMINING "PUDDLING" & "VOLCANOING"

1.) The most effective tool is a high resolution research microscope with variable magnifications.

2.) The sample should be mounted flat on a glass slide with double-sided tape.

3.) A magnification range of 25-100X is usually optimum for observing these defects.

4.) Incident illumination using tungsten halogen lamps with fiber optics provides the best overall lighting technique. Occasional use of vertical brightfield or transmitted illumination is also helpful.

5.) Start by examining the color bars first, if available. These areas provide a complete tonal range and allow one to relate the problem to density level.

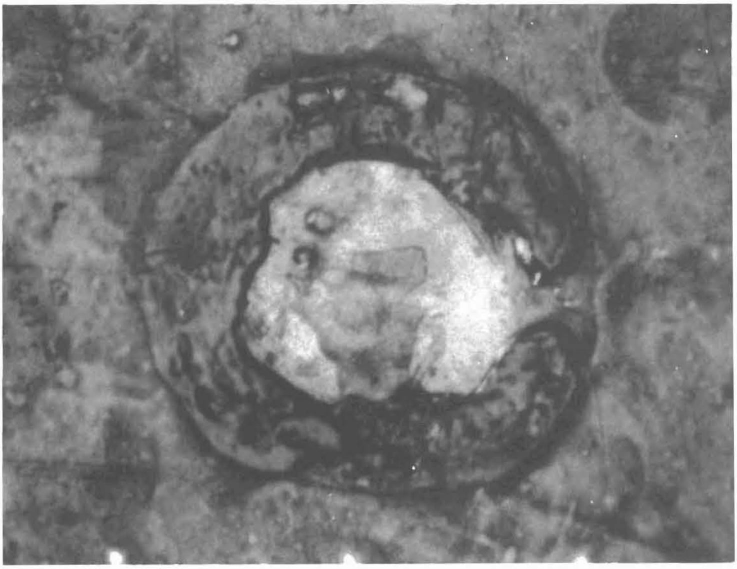
6.) Unprinted paper should also be examined, using grazing illumination, for the purpose of determining prominent paper fibers and paper bundles. Paper smoothness is important in publication gravure printing.

7.) It is always valuable when using incident illumination to inspect the print at both normal lighting angles and grazing illumination.

CONCLUSION

We have described two important and prevalent defects in gravure printing on coated stock and provided a methodology for easy detection. An attempt to outline the causes of these conditions and offer some suggestions for minimizing them was also made.

As ink and paper manufacturers improve their understanding of these problems, and as printers observe optimum operating conditions on press, the future incidence of these problems should decrease.



Photograph #1 "Volcano" 300X
High Resolution Photomicrograph
Vertical Brightfield Illumination

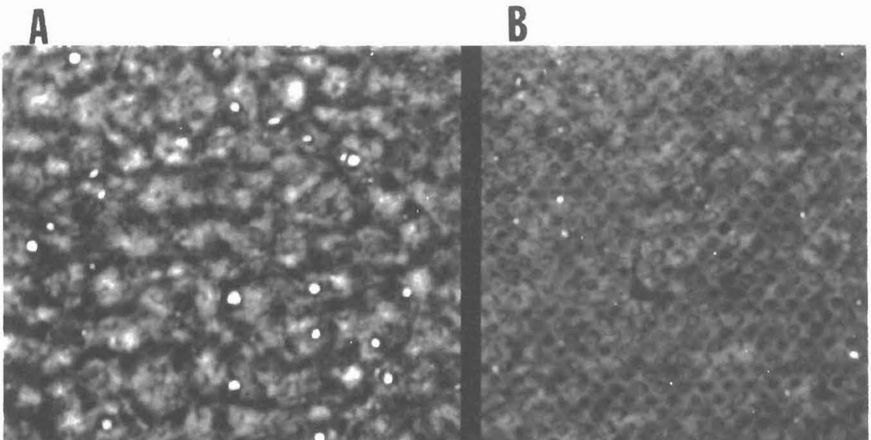
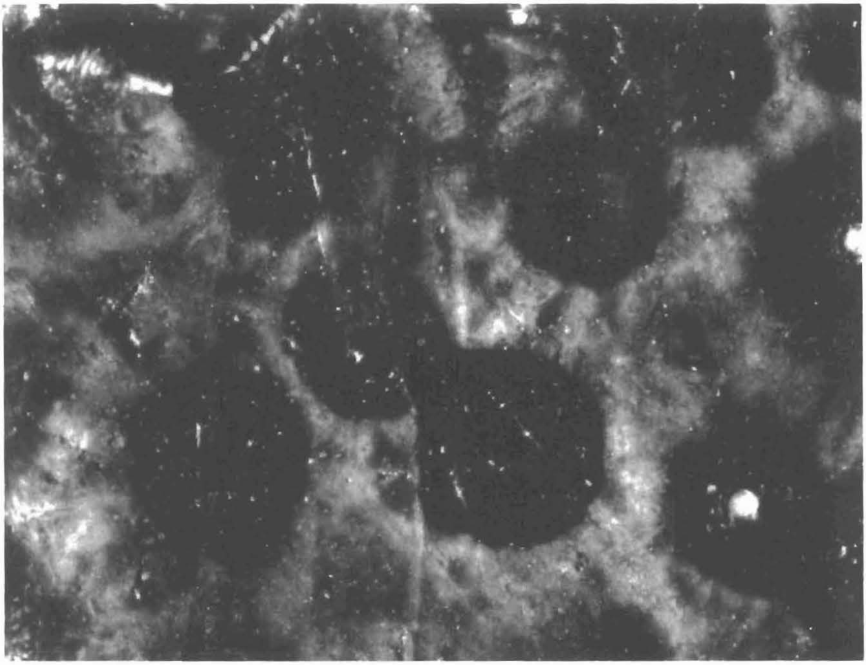
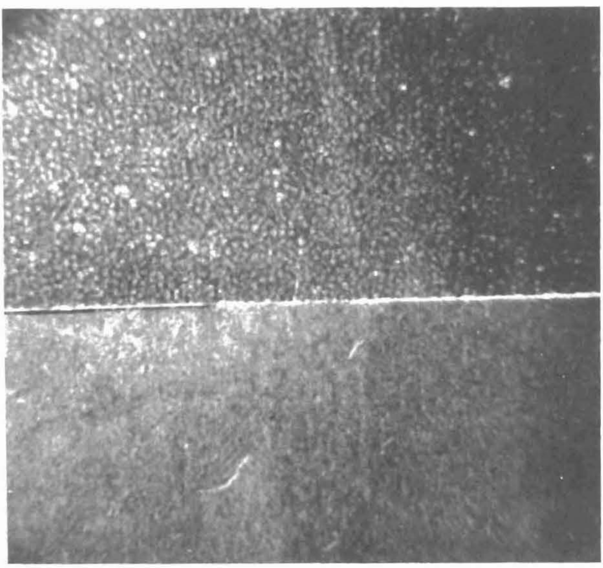


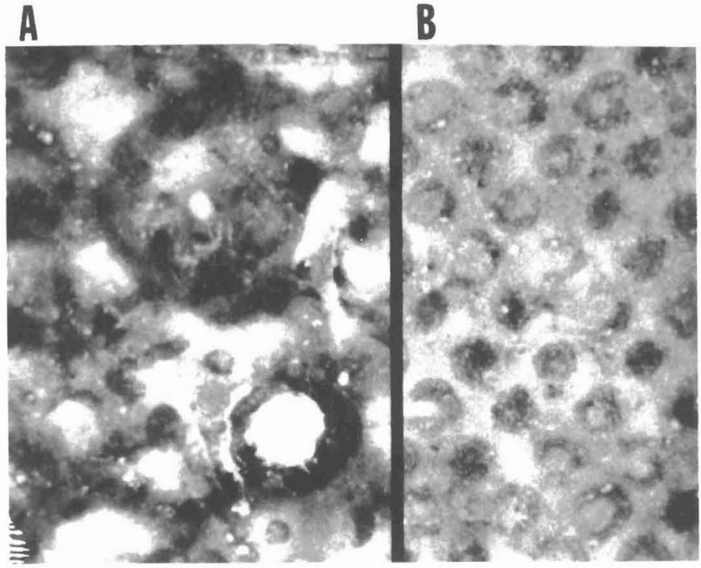
Photo #2 Side A Aliphatic/Aromatic Solvent Ink
Side B Aromatic Based Ink
High Resolution Photomicrograph Incident
Illumination 18.75X



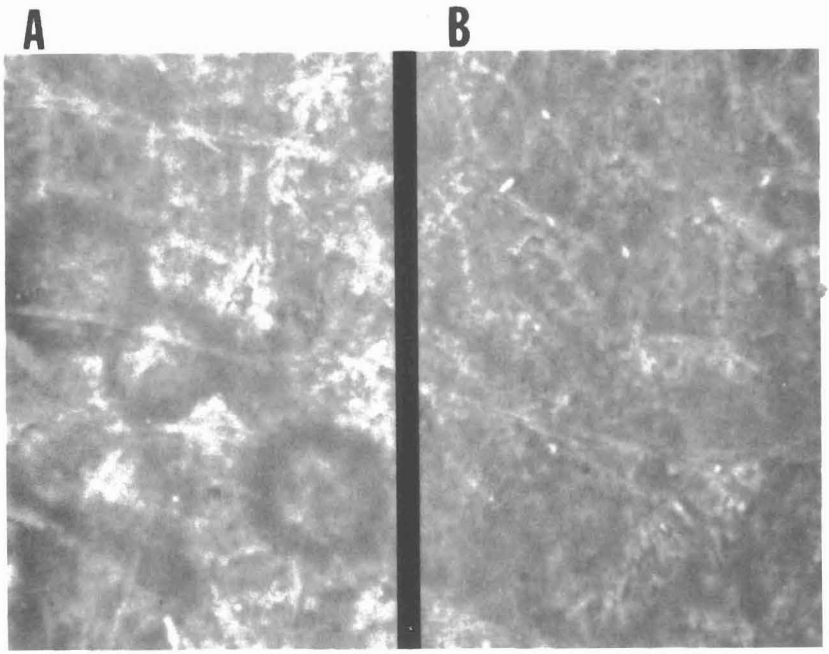
Photograph #3 "Puddling" 75X
High Resolution Photomicrograph Incident
Illumination



Photograph #4 Side A "Puddling" & "Volcanoing"
Side B Normal Print
Illumination 7.5X



Photograph #5 Side A "Puddling" & "Volcanoing"
Side B Normal Print
High Resolution Photomicrograph Incident Illumination 75X



Photograph #6 Side A Elongated Cell Configuration
Side B Compressed Cell Configuration
Incident Illumination 37.5X

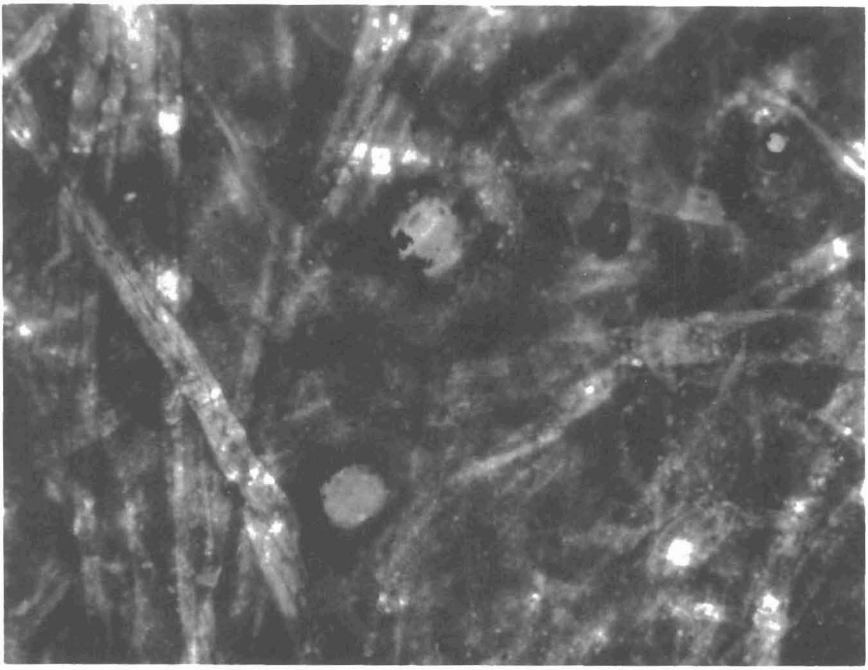
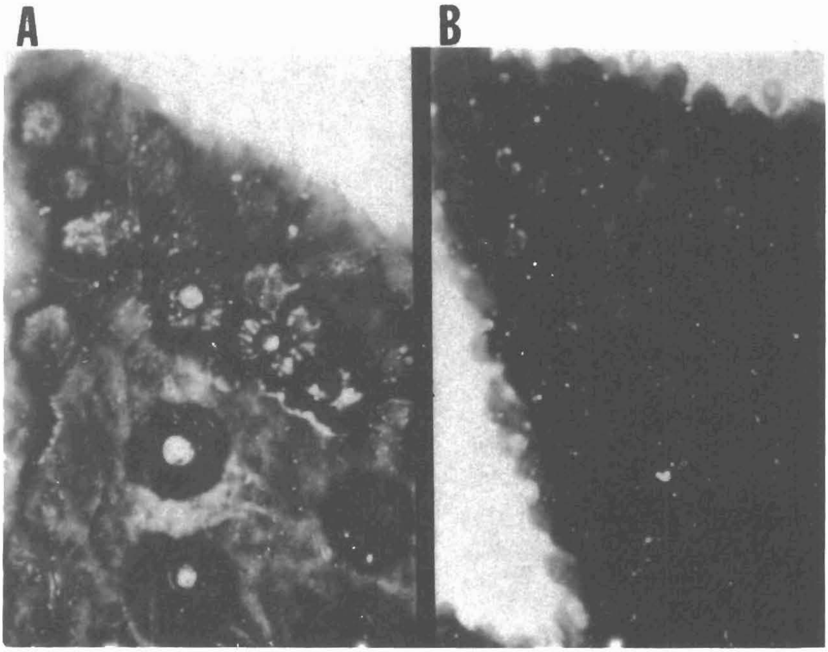


Photo #7 Paper Fibers Surrounding A "Volcano"
Incident Brightfield Illumination 75X



Photograph #8 Side A Substrate Test #1a
Side B Substrate Test #2a
Incident Illumination 37.5X