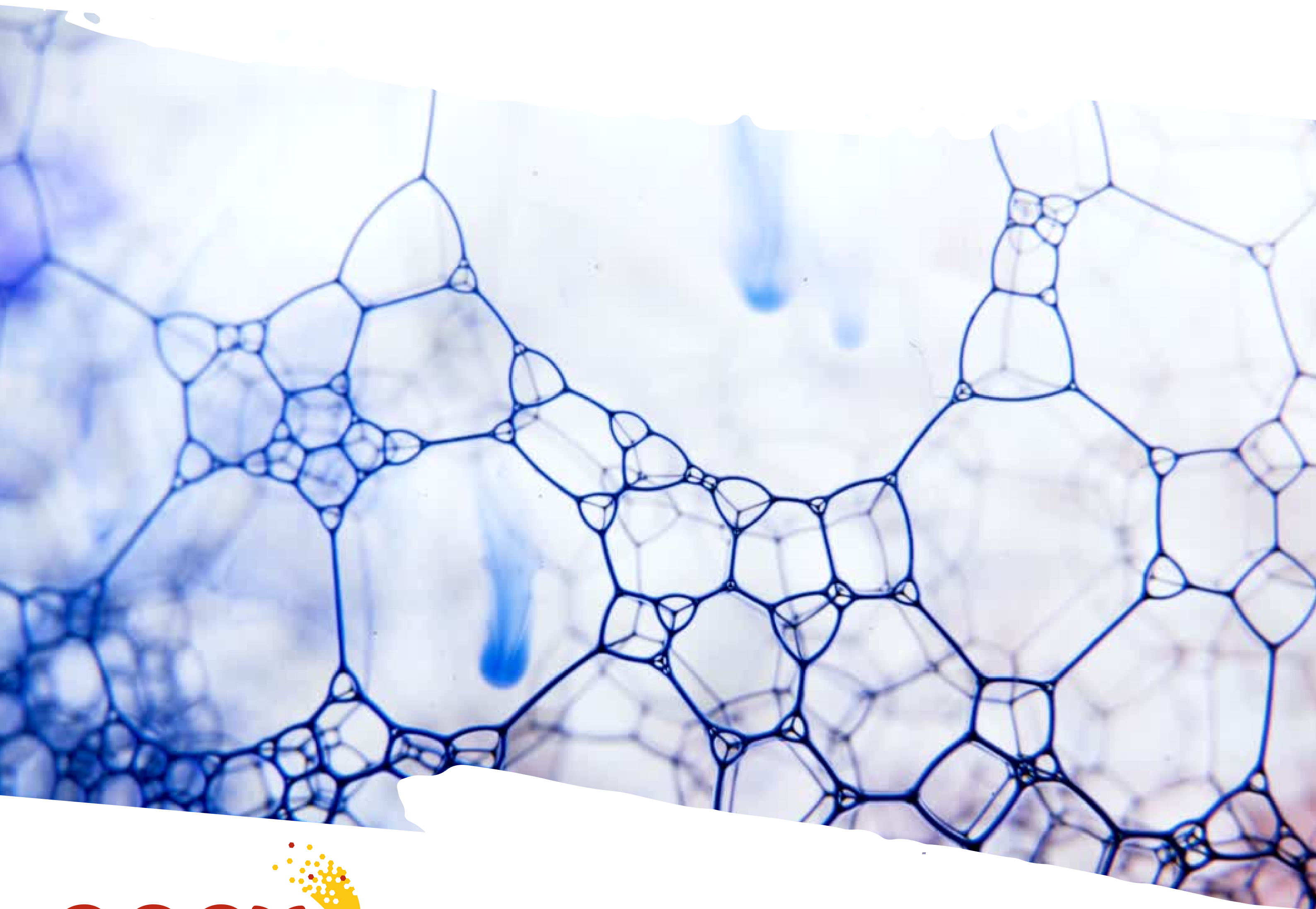
WATER-BASED INK FOAMING

GTT vs. Hexagonal

White Paper



apex International

SUMMARY

Over the past couple of decades, flexo printing has become one of the most essential printing technologies in use. It is particularly useful for printing packaging at very high speeds with high-quality image fidelity, ideal for food packaging and other products with short shelf lives.

However, there is a question around the productivity and efficiency achieved by the current flexo process, when you consider that the high investment cost of a printing press is only running and making saleable product 40 % of the time (meaning that 60% of the time it generates zero revenue).

The problem isn't in whether the machinery and technology are fast enough, but rather the difficulty in efficiently achieving the required print quality at a high speed. This requires a streamlined set up procedure and reduced downtime on a press normally associated with the flexo process. Currently, ink foaming is a silent problem, resulting in downtime that is experienced only when using water-based flexo ink.

When a printing press is in the stationary or idle position, and the water based ink is circulating around the ink system, it is not affected by foaming due to the closed inking system. It is only when the printing press is in full production that the micro-foaming will start to occur.

Micro-foaming can create ink circulation issues but is normally solved with chemical additions. However both aeration and the over addition of antifoam agents can create many print-related problems that produce waste products and additional downtime.

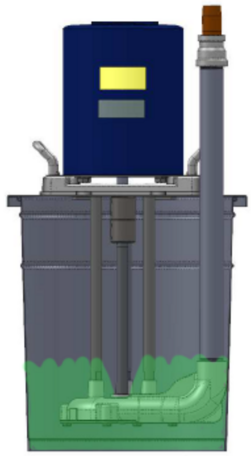
A possible solution is to adjust the print method, increasing the anilox volume. However, this results in a higher drying time, slower process speeds, higher ink costs and ultimately drives up print costs.

CAUSES

Ink in itself does not foam. It is only when it moves through the ink delivery system that it can start foaming. There are multiple reasons for this, however as stated above, micro-foaming can still occur even when the ink delivery system is devoid of any air leaks and using different pumping techniques.

Centrifugal Pumps

Centrifugal pumps include an impeller that rotates at a high speed to force the fluid toward the walls of the pump. Due to the impeller design, the liquid gets sucked in from the inlet and then thrown out of the outlet.

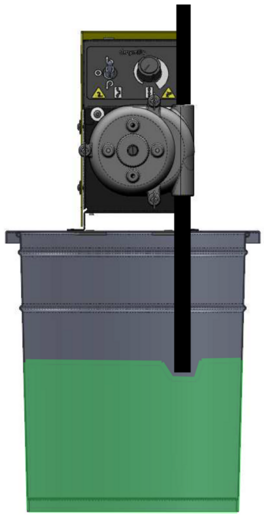


If the pump is top fed, the vortex sucks in air as well, causing turbulent flow of ink in the ink delivery system. Bottom feeding the centrifugal pump with an appropriate amount of clearance, and always remaining at high ink levels, can help avoid aeration in the system.

Diaphragm or Peristaltic Pump

Diaphragm or peristaltic pumps rely on tubing to suck ink from ink reservoirs and feed it into the ink delivery system. If the tube isn't long enough or the ink levels are low, air can get sucked into the tubing and disturb the flow of ink.

Making the tube long enough so that it sits deep into the reservoir is a great way to resolve this issue. Additionally, cutting the end of the tube in a V shape and always keeping ink levels high helps avoid air suction.



The way these pumps work is also a factor to consider when determining the causes of turbulent flow in an ink delivery system. Their working mechanism creates a pulsating rhythm, which, combined with obstructions in the piping system, can lead to micro foaming due to turbulent flow. Keeping the piping system simple can help encourage a calmer ink flow.

CAUSES

Ink return

Flexo printing is a process where ink is continuously running through the system. After each cycle it returns to the reservoir, making a closed loop. If the return line is too high up in the reservoir, the ink will come splashing down into the ink bucket, causing it to aerate.

The simplest solution is to keep the return line submerged in the reservoir so that it merges with the existing liquid, preventing splashing when ink is returned at high velocity.

Other sources

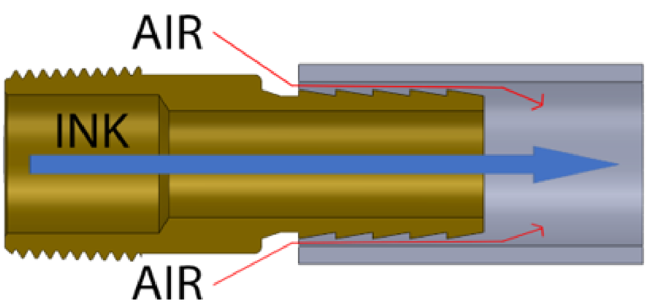
If the measures described above are taken, air in the ink delivery system can be greatly reduced or even eliminated. However, the ink circulation system isn't the only place that can allow air to enter. Aeration is also created in the ink delivery system doctor blade chamber/anilox and its components.

Common causes include:

- Worn out end seals on the press
- High pump pressure or velocity
- Nicks on the edges of the anilox

Shouldn't ink escape from the system if there are leaks in the piping?

No. Because of the high velocity of ink in the piping system, the Venturi Effect comes into play, sucking in air from the constriction. Hence, leaky pipes need to be replaced to prevent air entering the system.

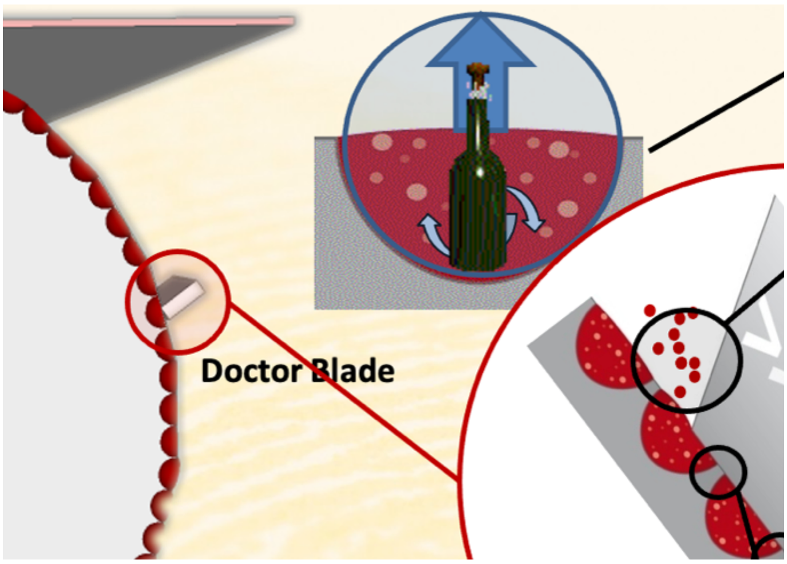


Micro pump situation

An anilox surface with its millions of cells is NEVER totally empty, the cells will always have either a liquid ink/coating or air inside the cells.

During print production the anilox cells transfer ink onto the printing plate which automatically allows air from the surrounding atmosphere to enter the cells. These cells, which are now part or fully filled with air, get forced into the doctor chamber with the rotational speed. The high-speed revolution of the anilox roll drags the air within the cells into the positive pressure within the doctor chamber.

The purpose of the doctor blade chamber is to remove the air from the cells and replace the air with the ink. This action creates micro-vortexes within the chamber which in turn cause micro air bubbles to form.



Due to the short space of time that the anilox surface is in contact with the doctor blade chamber, the air that is removed from the cells cannot escape from the chamber, causing micro foaming.

The effect is accentuated if:

- The press speed is higher
- The cell dimensions are bigger (which means a higher volume)

A DESIGN PROBLEM

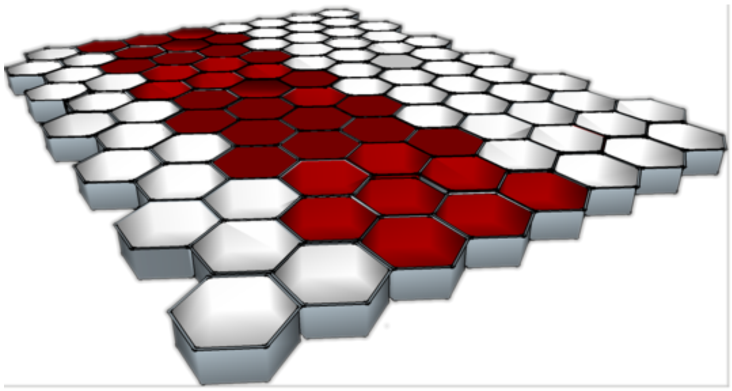
The anilox roll is one of the most important components of the flexo printing process because the anilox controls the amount of ink laid on the printing plate. The anilox roll or sleeve is typically coated in ceramic Cr_2/O_3 with microscopic hexagonal cells engraved in the surface.

The cells carry a measured amount of ink from the pressurized doctor chamber and transfer the ink or liquid onto the surface of the printing plate or directly to the substrate (in direct coating applications). How much ink is made available to be transferred depends on the size, number of cells, and geometry of the anilox engraving.

It has been established that even when you can ensure that there are no sources of air leaks or suction within the ink circulation system, the problem of aeration will still occur when the anilox roll and the doctor blade chamber interact during print production. The anilox roll rotates at high speeds, passing the enclosed doctor chamber that contains ink.

The initial filling of the anilox cells does not cause any issues, as once the surface is covered with ink it remains closed as it rotates, allowing the doctor blade to aquaplane over the surface of the anilox as it does so (this occurs when a printing press is in the idle position).

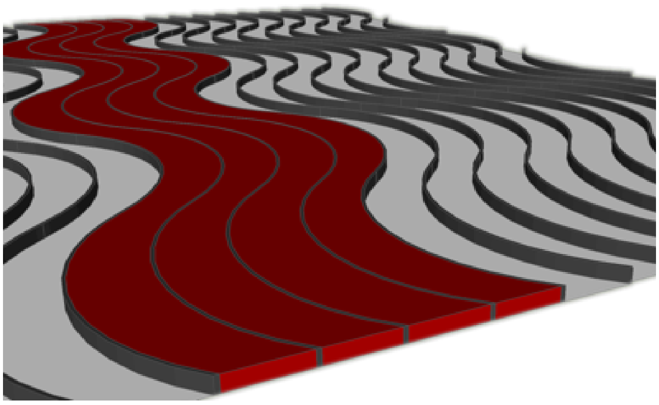
However, once a printing press is in production, the geometric structure on the surface of the anilox roll creates a constant micro pump situation.



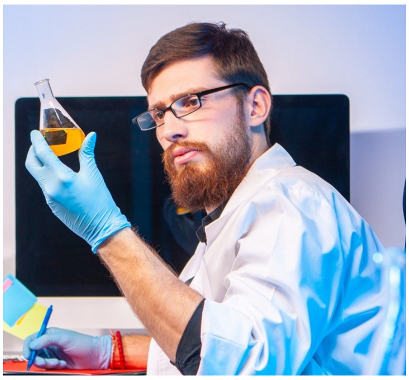
Aerated ink in the doctor blade chamber results in a combination of ink and air being deposited onto the printing plate surface. This creates problems that will affect the print quality and performance. For example pinholes appear on the surface that drastically reduce print quality, making it look duller.

To tackle the aeration at the root cause, Apex evaluated an open structure anilox engraving pattern which was designed to mitigate the formation of micro air bubbles.

Following many design ideas, Apex discovered that the GTT with its wave/channel engraving on the anilox surface (rather than the commonly available closed-cell structure) resulted in a significant improvement, and in many cases eliminated the aeration effect.



To test out this new innovation, Apex requested the services of an independent testing body, Technology Coaching BVBA.



Their job was to devise a testing methodology that could evaluate and compare the effect of Apex's innovative anilox roll design and traditional anilox roll engravings on foaming outcomes in water-based ink.

TEST SETUP

Technology Coaching BVBA was employed as part of a series of large-scale tests that would determine the quality and performance of the anilox roll. Additional test elements were assessed during the ink foaming test, notably ink transfer and color density which will be discussed in future articles. Here we focus only on the anilox aeration effect and how it was studied and compared.

The MPS EF430 web printing machine was used to conduct all tests to ensure uniform test conditions. The machine is ideal for evaluating the impact of the anilox engraving to ink aeration, as its ink metering system includes a doctor blade that controls how much ink gets deposited on the anilox roll as it rotates in the ink tray.

The ink delivery system to the ink tray also required further consideration. The system comprises feed and return piping to and from the ink tray to the ink reservoir. The piping was kept intentionally short with no restrictions to simulate an ideal piping system that provides no access to air.

Additionally, a peristaltic pump was used to drive ink through the piping so that ink flow remains laminar, minimising foaming during pulsation. Therefore, the interaction between the anilox surface and the doctor blade metering system remained the only source of foaming.

The ink used for the tests required no dilution. This helped mitigate possible dilution errors that would impact ink viscosity and pH, enabling ink to be used right out of the ink supply container.

The purpose of this test was to measure the inclusion of air in ink. But how do we evaluate that?

Evaluation Tools

It is a known fact that air occupies space, hence the inclusion of undissolved air in a medium should increase its volume. Since the density of a substance is dependent on its mass and volume and the cumulative mass of undissolved air in ink should be negligible compared to its cumulative volume, the density should decrease. Note that this is not the colour density of the ink but rather its physical density.

Knowing this fact made it easier to devise the ink foaming test, requiring available tools and instruments with high accuracy and precision.

Measuring the density of ink requires measuring its mass and volume. A scientific weighing scale was used with a precision correct to two decimal places or 0.01g. To measure the volume, a 50 ml pipette was used with a tolerance of 0.2%

How is ink density measured?

To measure the density, a small cup capable of storing at least 50ml of ink was placed on the scale. The scale was then zeroed. 50ml of ink was then sucked into the pipette, making sure to note the correct measurements.

The ink was then poured into the cup and the mass was recorded on the scale. Since the volume of the ink was already known as 50ml, dividing the recorded mass by the volume gives us the density in g/ml or equivalently g/cm3. G/cm3 is also equivalent to Kg/dm3, hence no additional conversion is required.

To get an accurate comparison between the two anilox engravings, the two anilox screens must have similar ink carrying capabilities. An Ink Film Thickness (IFT) Analyser was used to gather data about the two anilox rolls.

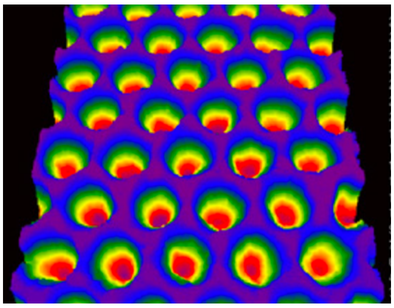
The instrument came with an MD digital USB microscope with a magnification factor of 1500, allowing microscopic images of the anilox engravings to be taken. The images were taken in 3 positions. The IFT Analyser then measured and calculated the specifications of the two screens. The table below summarises the results.

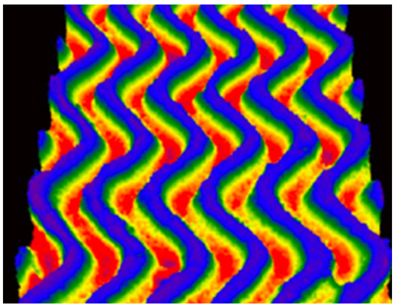
Measurement	Unit	GTT Anilox Engraving	60° Anilox Engraving
Screen	lpcm	GTT C 3.5	400
Volume	cm3/cm2	3.5	3.5
Depth	microns	9	12.3
Wall Thickness	microns	4	6
Opening	microns	17	19
Opening Depth	microns	1.88	1.55

Table 1: IFT analyser results for each anilox roll surface

The results showed that both anilox rolls carry the same volume, and therefore carry the same amount of ink to deposit on the printing plate, resulting in an ink film with the same thickness.

Fig 2: Images taken by IFT analyser



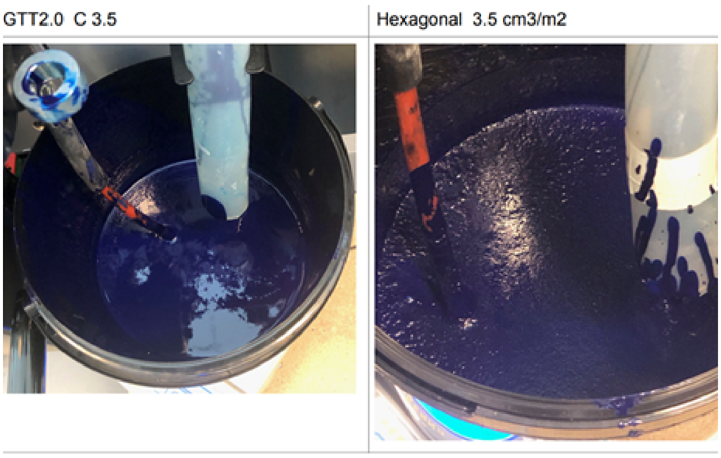


THE RESULTS

The following table shows the ink density results:

Screen Roll	Density Ink start KG/dm3	Density Ink end KG/dm3	Density Ink 24h KG/dm3
GTT 2.0 S	1.085	1.082	1.078
Hexagonal	1.081	1.048	1.078

Fig 3: Foaming in the GTT Anilox engraving reservoir as compared to the foaming in the cell based hexagonal engraving reservoir



The test results were taken at the following intervals:

- Before the start of the test
- At the end of the printing session
- 24 hours after the test had completed

1. The ink density Kg/dm3 of the ink used for both screen rolls at the beginning of the test fresh ink for each anilox is almost identical.

2. The ink density Kg/dm3 of the ink measured after the print test demonstrated that the ink density when measured resulted in a drop of 0.033 for the H60, whereas the GTT only had a drop of 0.003.

3. When the two inks were collected and stored in a calm environment for 24 hours without circulation, on remeasuring the ink density had stabilised at 1.078 for both inks.

CONCLUSION

The tests as conducted were designed to create the ideal ink circulation situation so that the ink foam reported was likely only the result of the different screen-roll screenings and not influenced by the ink metering system.

It is safe to conclude from the tests done that the ink foaming is significantly less, or even none, for the GTT2.0 S screen roll compared to the hexagonal screen roll, where both screen rolls had the same ink film thickness (volume) on the surface of the screen roll.

So, what does this mean for printers?

This means that when a GTT anilox is used with water-based ink in flexo printing, making manual chemical additions is unnecessary.

Avoiding chemical additions results in:

- Better print quality
- Less production waste
- Less ink waste (due to press returns containing an unknown number of additives)
- Higher profits