How much really transfers?

Beyond viscosity – flexo applied coatings and ink transfer fluid rheology

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Rheology is defined as the science of the deformation and flow of matter. It is a science that studies the nature of how matter flows. For flexographic printers, having a basic understanding of ink and coating flow properties and how they flow is important to a predictable experience in the press room – and can assist in troubleshooting complex problems.

Knowing the viscosity of the ink or coating is important to achieving good, consistent results. But beyond the viscosity numbers are the transfer properties of the fluid itself – or what are called the rheology properties of the material. This article explores the rheology dynamics of fluids being transferred in the ›anilox surface-transfer zone‹ environment of a printing/coating press.

Over the years, coating roller surface technology has been greatly limited in its accuracy and predictability on press, making it more of an art than a science in the production process. This guess work on press continues to frustrate coating development engineers and chemists when attempting to transfer lab results into the production environment an all too frequently a long and often uncompromising process.

The cause of this unpredictability can, for the most part, be traced to a misunderstanding of the fluid transfer dynamics for any given printing/coating application. The result is typically created by certain assumptions being made when attempting to reproduce laboratory results on press, causing downtime and lost quality on the press.

Defining the challenges:

Coatings have long been used to enhance the surface properties of a given substrate or material. In printing or coating the web or sheet typically applies functional properties to the substrate ranging from moisture holdout, enhanced smoothness, chemical resistances, gloss, scuff resistances, slip resisters and any number of other properties.

During the development phase of these coatings, the laboratories will place a given quantity of the test materials on the test substrates which are being used. Once the right chemistry has been determined to achieve the desired result, determining the amount needed for application becomes the next question. This »amount needed« to achieve the functional properties desired is typically measured in pounds per ream or kilograms per ream. These numbers become the targeted results on press.

Several challenges present themselves as the functional properties achieved in the lab are translated on to the press in this fashion. The first pitfall to avoid is to ensure that the laboratory measure for success is the same as will be used on the press. For instance, is kilogram per square meter (k/sqm) used and calculated with a specific sample size?

Second, when calculating what anilox or coating roller volume is needed to achieve target application levels, be sure that the calculation considers the transfer fluid dynamics involved in the coating application. This is perhaps the biggest mistake made in this process of determining the right volume to order for a particular coating application. For many years it was little understood until research in the mid 90's, sponsored by *Harper Corporation*, was launched to answer questions in this area, chartered to explore coating applications and the optimization efforts being investigated to improve anilox surface technologies.

Prior to this time, most people believed that the volume required on an anilox roller surface for coatings and inks, was the actual amount that transferred to the plate (or substrate in the case of gravure type coating stations) and subsequently to the substrate. Research found that not only was this not the case, but only 23–25% of the anilox volume actually reached the substrate in 99% of the fluids tested, inks included! This result was determined after testing hundreds of fluid application systems. *Figure 1* shows the logic of the transferred fluid film being reduced to 25% of the original thickness available.

Therefore, if the calculated volume of »x« is needed to obtain the colour or functional property of a coating on substrate, then the volume on the anilox roll surface would need to be »x« multiplied by four. This represents the volume needed on the coating roller when using flexo transfer conditions.

Visualizing the rheology dynamics:

Like many discoveries, simple theories created from observation proved to be what was imagined to be happening on a microscopic level in the highly dynamic transfer zones between anilox and plate and from plate to substrate. One such example was the observation that a sim-

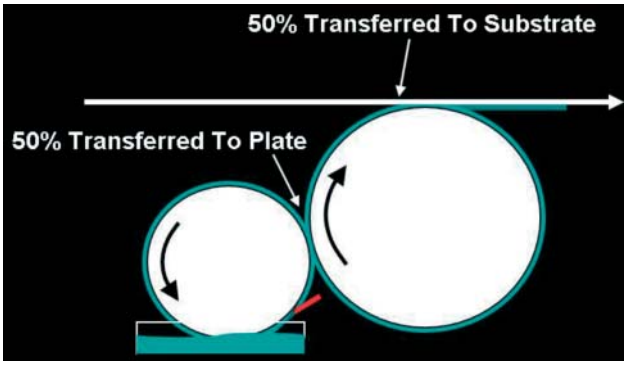

Figure 1:
Testing has proven at 23–25% of an anilox roll volume actually gets to the substrate, with half transferring from anilox to plate, and then half of this to the substrate.

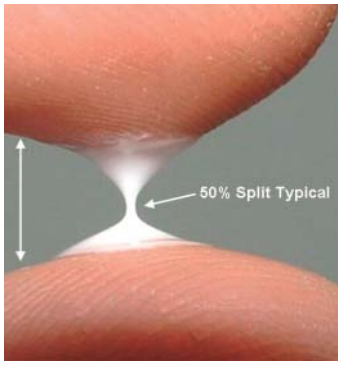

Figure 2:
Research proved that a 50% split in fluid films results between most all transfer rollers and plate surfaces.

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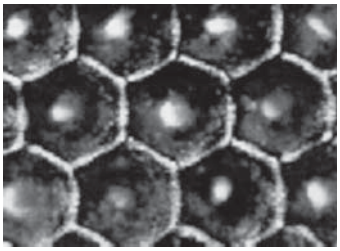

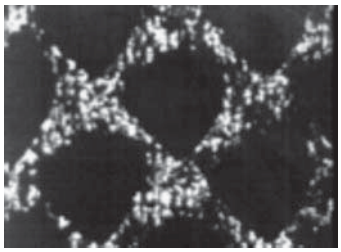

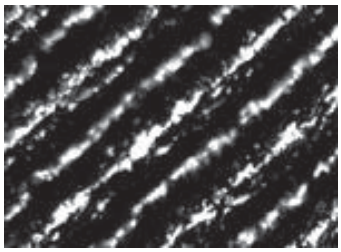

From left: Quadrangular engravings found best for thick film.

60 degree engravings found best for thin film coating.

Tri-helical engravings found best for thick film.

ple adhesive placed on one finger and then touched with another and then separated. As noted in *figure 2*, the dynamic of the fluid is to actually split – with 50% of the fluid actually remaining on the originating surface. This splitting phenomenon is something that was believed to be happening on a microscopic level with all fluids being transferred between two surfaces. Subsequent research proved this to be the case.

Additionally, this explains why the dynamic flow of a fluid or its rheology offers good reasoning as to why the surface energy of a surface, as measured in dynes, has little overall effect in the printing & coating processes. This reasoning comes from analyzing the dynamic transfer forces shown in figure 2, regardless of the surfaces involved. Research has proved the only requirement needed is sufficient surface energy to attract or create a functional transfer bond with the fluid involved. Thus dynes have their place of influence in printing, but only in extreme cases. One such example is when highly bloomed poly substrate surfaces are used, where ink is repelled due to the waxes/oils migrating to the exterior layers of the film, thus reducing the dyne level required to facilitate ink transfer to its surface.

Optimizing coating predictability:

Coating application success begins in the laboratory with chemistry that is easy to apply and manage at press side. While press type simulation would be best it's not practical for most printers. The best systems available today are those such as the coating application device developed by *HarperScientific.com*, called the *Echocel Coating Jr. Proofer*.

Unlike the typical Meyers rods or blade metering tools, these newly created coating proofing devices provide a laser engraved anilox surface along with a blade metering action that will best simulate what is happening in the press. These systems are far more scientific than the older technologies that have zero correlation to press mechanics (see *figure 4*).

Regardless of what testing device is used in, or during, the development phase, at minimum it should have reproducible results

tested and documented under laboratory conditions. This laboratory testing will provide some minimum and maximum application tolerances for the production management and quality control. Surprisingly, this is seen all too many times not to be the case – with only one target number going to production and many hours of downtime created as a result.

Second, spend the required time to develop the right anilox surface configuration. Developing coating specifications for press conditions requires several mathematical calculations to achieve the expected results. These calculations become the determining factors in the surface selection for any given application. Depending on the thickness and solids content of the coating needed, there could be up to three different cell geometries selected. These would include the 60 degree hexagon, a tri-helical or the 45 degree quadrangular pattern. Each has proven to be ideal for thin or thick coatings as well as considering the solids content of the materials.

Thick or thin film coatings differ in specification dramatically, covering a range of the following applications:

- Laminations
- Overprint Varnishes
- Colour Coatings
- Adhesives
- Silicon Release Coatings
- Security Coatings
- Blister Card Coatings
- Specialty Coatings

Each of these requires different application techniques that the anilox supplier should be able to guarantee results – allowing for the accuracy of the information provided in developing their specification. The supplier should have a specification form that covers all the needed information for developing these specifications.

In some cases a banded anilox roller may be needed to achieve high confidence in the final stages of production development. If the coating is totally new in application or functional performance, this testing is suggested as performance properties or the material's rheology may be quite different from what has been tried before. While this can initially be expensive and time consuming, it can pay great returns in avoiding many hours of downtime and even project failure. If the innovation has potential marketplace advantages, then banded roll testing should be considered as part of the developmental cost.

In summary, coatings applied in the flexographic press provide good benefit to the customers – and when done with science in mind, can be a very profitable undertaking by any manufacturing team. It should be treated as a special manufacturing capability, realizing few do it successfully on a consistent basis. Education and planning – with a fundamental understanding of the application dynamics is the key to success. And like printing, the right suppliers of the coatings and the anilox rollers are paramount. ■

Proofing systems developed that simulate press conditions are important to achieving in-press success. Picture shows a system developed by HarperScientific.com Photos: Harper.