UV Silicone and Emulsion Adhesive Tandem Coating

In the last few years, the label industry has continued to grow. The pace of growth has slowed from double-digit expansion to a growth rate of five to seven percent in 1998. The growth rate continues to be better than most industries, however, a variety of factors have brought about a cost reduction emphasis not seen before in this business.

With the financial crisis in Asia and other parts of the world, a deflationary cycle started in many business areas including the labeling industry. The market had been expanding so rapidly that many new companies entered into the market. Later the growth slowed and a surplus of capacity was now in the market. In order to fill more production lines, pricing became more competitive. Export demand slowed dramatically and commodity raw materials reductions add to the spiral.

The market consolidations and capacity pressures have brought about a strong restriction in capital expenditures and an increased need for production efficiency. Backward integration in many companies has helped them to remain competitive.

UV silicones have participated in the backward integration and expansion of capacities. There has been a lot of interest in UV silicone coating and adhesive coating in tandem. The lower cost to add UV capacity makes this a practical solution for many companies. The machines take up less space and require lower capital investment than other curing processes. High production speeds have been realized for UV silicones in recent years. Recent trials have proven that for most practical applications, the UV silicone would not be the bottleneck in the process.

RC Silicones, manufactured by Th. Goldschmidt AG, allow great flexibility with tandem processing. The RC Silicones allow a manufacturer to use a wide variety of substrates and adhesives. This combination, as well as fast cure speeds and no post-cure allows a company to design a process with tandem coating in mind.

Goldschmidt Chemical Corporation is the United States subsidiary for Th. Goldschmidt AG. Goldschmidt is a large manufacturer of specialty silicones with a global presence. These products are used in a variety of interesting specialty applications as surfactants and coatings. Goldschmidt is a subsidiary of VIAG and SKW, both German holding companies. Goldschmidt's corporate offices are based in Essen, Germany.

The RC Silicones are silicone acrylates. The acrylate chemistry cures by a free radical mechanism. Free radical curing has many advantages over other curing mechanisms. The reaction that takes place is very fast, anchors well, and has no post cure. This mechanism produces a very consistent result.

Substrate compatibility is another key issue when looking at UV Silicones. Since the free radical system cures without a nonionic catalyst, there is no potential for poisoning the reaction. This allows a company to use any substrate they wish. There is no need for special coatings on films or papers. RC Silicones have even been coated directly onto a metallized surface. This allows the end user to keep costs down for special treatments that are not needed.

Adhesive compatibility is greatly improved over earlier versions of UV Silicones. The newest RC Silicone polymers are compatible with an even broader range of adhesives. The RC Silicones have improved recently in regard to aging characteristics as well. Release ranges can be tailored to the needs of the final product requirements since the range of release is quite broad with these polymers. It is incorrect to assume that any silicone will work with all adhesives so one must be prepared to prescreen the adhesives.

Historically, the UV silicones have been the slow point in the process. However, it has recently been proven that this is no longer true. Easy release formulations are typically the slowest curing products. It has been proven that easy release products from Goldschmidt can run at a rate of 200 fpm per 100
Watts/inch of lamp power. For example, a 600 Watt/in. lamp allows the RC Silicones to cure at speeds greater than 1200 fpm.

Black Clawson recently renovated their Research & Technical Center. This renovation allowed for the possibility of testing this tandem coating process. Prospective companies can come to this pilot facility and try many different coating configurations for both silicone and adhesive in-line on the only OEM tandem production coating facility in the Northern hemisphere.

The BLACK CLAWSON RESEARCH & TECHNICAL CENTER

The Tandem coating line at the Black Clawson Research and Development Center can accommodate over 50 different coating methods. The line consists of two separate lab lines known as the Pilot Line and the Production Line. The Pilot line can run 18 inch wide materials up to 3000 FPM. The web path is comprised of the following:
- Single position unwind
- Pull roll/corona treater
- Series 3000 Cartridge Coater
- Fusion UV System
- Modular three zone, fifteen foot Black Clawson Dryer
- Edge guide
- Cooling/lamination section
- Single position rewind

When operating in the tandem mode, the coated substrate passes over the edge guide through the wall into the Production Lab.

The Production line can handle 36-inch wide material up to 3000 FPM. The web path is:
- Turret unwind
- Pull roll
- Edge guide
- Series 4000 Cartridge Coater
- Sixty foot, six zone floatation dryer by Black Clawson including quick change nozzles
- Edge guide/cooling roll section
- Steamex™ remoistuizer
- Cooling roll section
- Laminator
- Turret winder with patented stationary knife

When operating in the tandem mode the web enters the Production lab on the second floor and then is lowered to the first floor. The web then passes under the Production coater, to the pull roll, to the edge guide, to the coater and then up to the dryers, the rest of the path is the same.

For this tandem lab trial, the Pilot coater configuration was the Differential Offset Gravure Coater. The backing roll was chrome plated, the applicator roll was a 65 shore ‘A’ millible urethane rubber covered roll and the Gravure roll was a 200 QCH pattern with a volume of 7.0 BCM. The gravure ratio was 25 % of linespeed and applied a coatweight of .7 pounds per 3000 square feet. The silicone was supplied to the
gravure roll by an enclosed applicator. The applicator speed was 98% of line speed. The Production coater configuration was Reverse Gravure. The backing roll was a 70 shore 'A' rubber roll and the gravure was a 62 Tri Helical pattern. The volume of the gravure is 39.3 BCM which produced a coatweight of 11 pounds per 3000 square feet. The gravure roll was run at 120% of line speed in the reverse direction to the web. The adhesive was supplied to the gravure by an enclosed applicator.

When considering running tandem coating trials at “The Black Clawson Research & Technical Center” you have the choice of a multitude of coating modes. The R&D center has all the coater modes you need to produce a top quality product. To coat 100% solid silicone the Differential Offset Gravure or the 5 Roll Transfer coaters are available. To coat emulsion or solvent-based silicones, the Direct Gravure, Reverse Gravure or Mayer Rod coaters are available. For the PSA coating you may choose between the Direct Die, Reverse Roll, Direct Gravure, Reverse Gravure or the Mayer Rod coaters.

The UV capabilities for the Black Clawson line are supplied by Fusion UV. During the recent renovation at Black Clawson, Fusion worked to include nitrogen inerting capabilities on the unit there. Before that time, it had been impractical to test the RC silicone acrylate system there.

Black Clawson’s Pilot Lab has recently upgraded their primary UV curing system. The Model DRW-220QNH system supplied by Fusion UV Systems, Inc. now provides the capability to cure coatings in air or in an inert environment. The coated web is isolated from the air-cooled UV lamps by quartz plates. The quartz also acts to minimize the volume of space that must be inerted. Nitrogen gas of high purity is used to displace the atmospheric oxygen in the curing chamber to a residual level of <50 ppm.

The UV unit contains four Fusion model F600 microwave powered lamp systems. The modular designed electrodeless UV lamps are configured into two rows with two UV lamps in each row. As each lamp is 10 inches (25 cm) wide, this configuration allows for uniform cure across the entire 18 inch web width.

For the purposes of this study, 13 mm diameter “H” bulbs were used in each F600 lamp. These medium pressure, mercury sources provide the required short-wave UV energy that is necessary to initiate the photo-polymerization of the silicone coating. Due to the reduced quartz surface area, these small diameter bulbs are relatively low emitters of IR energy. Water-cooled base plates are incorporated into curing chamber design to minimize the build-up of heat that can damage the web. The light containment structure, or lightshield is designed to be safely operated within the potential solvent environment.

In light of the new capabilities available at Black Clawson, a trial plan was presented to Black Clawson by Goldschmidt. The plan was developed with a confidential global producer of pressure sensitive products. This would include a joint development plan to prove that the tandem coating of UV silicones and emulsion adhesives was not only possible but also practical.
The trials were designed to test a range of parameters including release level, adhesives, substrates, and face stock. The machine was set up to best handle the variability that was desired. Only one row of bulbs in the Fusion unit were utilized. The machine speed was kept constant at 400 fpm. This speed was limited due to adhesive drying capacity.

Silicones were chosen to give four different release levels. They will be referred to as easy, medium, controlled, and tight. Further information can be provided on the exact silicone formulations by request.

Substrates for the release liner were three general types. The substrates chosen were polypropylene, polyester, and super calendered kraft. The polypropylene chosen was a standard oriented grade. The 25 and 36 micron polyesters were uncoated. The super calendered kraft was a standard 42# sheet with no special treatments. The substrate manufacturers will not be revealed. It should be noted that all substrates were standard grades with no special surface treatments or additives.

There were two adhesives chosen for the trials. They were supplied by a major manufacturer. The adhesives will be referred to as A and B. The two adhesives were both clear drying acrylic dispersions. Any further details are considered proprietary.

The face stocks were uncoated films as well. Both polyester and polypropylene were used as face stocks. The polypropylenes used for the trial runs were either clear or white.

The silicone coating was done on a three roll offset gravure coating station. The rolls chosen allowed for the proper coat weights and variations needed for the trial. Target coat weights were chosen based upon the substrate used. This information is shown in the data tables.

Adhesives were applied with a reverse gravure coater. This was also chosen to allow for proper coverage based on the adhesive viscosities and the desired coatweight.

During the trials, minimal testing was conducted. The tests performed were to measure coatweight, coating quality, cure, and quick adhesive compatibility checks. For the SCK, a dye stain was performed to ensure coating quality. All liner samples were tested with a “loop tack” test. Anchorage and adhesive compatibility were checked manually.

After the trials, all samples were tested for release properties. The release levels were measured using a TLMI tester and Tesa 7475 standardized tape. The materials were heat aged at 40 degrees Celsius at varying intervals from one to seven days. Coatweights and quick subsequent adhesion tests were also performed.

TEST RESULTS and CONCLUSIONS

In general, all of the test results came out as expected. The trials successfully exhibited the possibility of tandem coating using the RC Silicones as the release agent. Aging was seen to be flat in all cases. Any variability in release levels can be attributed to differences in substrate stiffness.

In the first graph (Easy Release), the silicone formulation graphed was the easy release formula. The silicone formula is referred to as Si-3 in the legend. All of the filmic substrates behaved similarly with releases in the 5-10 gram range. The two samples of 42# SCK exhibited a higher release, partly due to the roughness of the substrate surface when compared to film. Stiffness of the substrates also contributed to the variability in release. It can be concluded that there was no a silicone/adhesive reaction in the samples. All of these samples gave very smooth releases.

In the second graph (Controlled Release), the silicone formulations were for medium and controlled release levels. The Si-1 formulation represents the controlled formulation. The Si-2 formulation represents the medium formulation. Again, the results indicate the same conclusions as the easy release formulation.
Aging can be considered fairly flat and indicate no silicone/adhesive reactions. Testing once again indicated smooth releases.

In the third graph (Tight Release), the silicone formulation was for a tight release. This trial run was done at the end of the run using the substrates, adhesives, and face materials that were on the machine. This was not a planned sample but it was decided to add it at that time. The release level was relatively smooth and stable. The tight release formula is called Si-4 in the legend. Again, there was no interaction between the silicone and the adhesive.

The samples from all trials will continue to be aged at room temperature and will be periodically tested for aging. To date, release for all samples remains stable.

It can be concluded that Goldschmidt UV Silicones can be used successfully in tandem coating operations with acrylic dispersion adhesives. These trials show that the tandem process is viable. With Black Clawson's pilot line and the new inerted UV from Fusion, there is now a location for testing this process with Goldschmidt's UV Silicones.

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