Best Practices & Developments in Solventless Laminating

Printers and converters who integrate solventless laminating enjoy a competitive advantage by offering their customers a single source for flexible packaging. Thanks to recent advancements in laminating process technology, adhesive chemistry and equipment design, implementing a solventless laminating operation has never been easier. However, it's important that operators understand the basic principles and variables of the process to maximize production and reduce waste.

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Choosing the Right Adhesive

Factors that affect choosing the right adhesive for the job include the substrates that are going to be used, any regional regulatory considerations and requirements for chemical, product or UV resistance.

The correct adhesive means to analyze every aspect of the converting process, not just the adhesive price. The return on adhesive investment must take into consideration scrap rate and ability to run at competitive speeds.

USA food packaging regulations include Code of Regulations 21 CFR Part 175, which are indirect food additives for adhesives and components of coatings. Regulation 175.105 specifies adhesives for food containment applications up to 121 degrees Fahrenheit. This application is considered a general purpose adhesive system.

Regulation 177.1395 is for laminated structures used at temperatures between 120 and 250 Fahrenheit. This is considered medium performance adhesive systems, which are usually for hot fill applications, microwave and boiling bag applications.

Regulation 177.1390 pertains to laminated structures over 250 degrees Fahrenheit. These adhesive systems would be used for retort applications.

The adhesive system must be compatible with the ink. Otherwise, problems occur with poor appearance in printed areas, due to high retain solvent from ink or even incorrect adhesives. Impurities on the surface and high slip in the film can result in poor or no adhesion.

Poor adhesive heat and chemical resistance in the printed area is an indication that the mix ratio of the adhesive is off. Retain solvents or other high boiler additives in inks can also alter the cure.

Taking a closer look at retain solvent in lamination, one of the main factors that comes into play is the incomplete drying of inks. This is chain termination of the adhesive polymer resulting in the poor heat and chemical resistance. It will remain tacky, have low bond strength, and also residual odors.

Mixing

Most two component solventless adhesive systems require the

use of a mix meter dispensing unit to properly proportion the adhesive. The correct mixing ratios are available on technical data sheets provided by your supplier. Before laminating, make sure the mixing unit is calibrated. This is normally done gravimetrically by weighing the two components after they are pumped into two separate containers.

The adhesive mix ratio needs to be monitored on a regular basis. Most mix meter units have real-time monitoring with triggered alarms should the adhesive mix ratio exceed the allotted tolerance.

A turning point in the industry came 20 years ago when solventless lamination evolved into an easier to use technology with the development of new mechanic hardware for meter mixing dispensing of two component adhesives. The operator friendly system uses gear pumps, which enable digitally setting mixing ratios without any mechanical adjustments.

In this design, the two components are contained in reservoirs that are shielded from the moisture in the atmosphere. Moisture is a potential trigger of catalyzation. Nitrogen can be used as a neutral gas to refill the atmosphere above the adhesive in the reservoir whenever some early polymerization may be experienced.

A volumetric pump is used for this system therefore the mixing ratio needs to be moved from weight (the unit used in most adhesive TDS) to volume through the gravity weights. Gravity weights are normally listed because in different environmental conditions specifications may change for the adhesive.

A good mixer is equipped with three different levels of temperature control: the resin, the hardener, and the hose that delivers the adhesive to the laminator. It should be noted that Viscosity of even low temperature adhesives are influenced by small temperature variations. It is important to consider that even adhesives that are handled at low temperatures, (room temperature adhesives), are heavily influenced in viscosity by small variations of temperature.

Implications of poor adhesive mix

If the adhesive mix ratio is off, you'll have either an excess of hydroxyl or isocyanate. If there is excess hydroxyl, the adhesive will not cure properly and remain tacky; and, exhibit poor heat, chemical, and product resistance. Generally speaking you'll have low bond strength.

If there is excess isocyanate, it will take longer to cure, as the adhesive will be even more dependent on moisture to complete the curing. The adhesive will remain tacky until enough moisture has entered into the laminate. If it's MDI based, you could see some anti seal issues.

These systems are designed to handle chemicals in a liquid form with precision accuracy; therefore, following routine maintenance on the mixing system is critical.

Rolls

All the coating head rollers for solventless laminating are engineered, sized and surface finished to deposit the selected amount of adhesive precisely and evenly to the web. It should be noted that roll temperature and roll quality will impact the adhesive's appearance. Roll heaters should be set to appropriate temperatures for specific adhesive systems. Recommended starting points for temperatures for each adhesive system are found on the adhesive supplier's technical data sheets. Coating rolls cleaning is of paramount importance for the process. Any residual adhesive left uncleaned on a roll surface during a job changeover will cure and will result as an imperfection in the deposition of the adhesive for the next job.

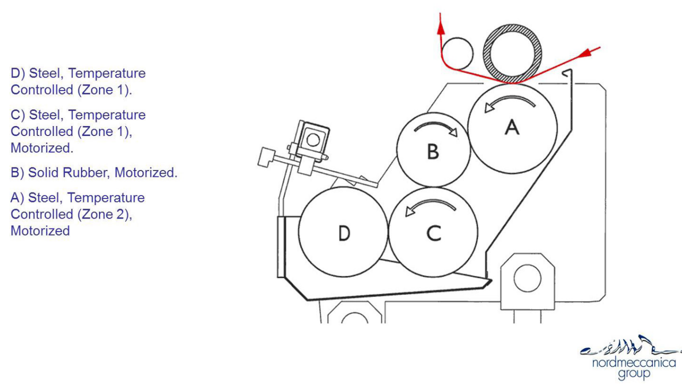
Controlling the coating weight (the thickness of the adhesive layer).

Technically, the aim of the coating head of a solventless laminator is to reduce the adhesive layer of a high viscosity, chemical compound to the order of magnitude of a metric microns (the range of about .04 mils).

As shown in figure 1, the process starts by dosing the adhesive between roller C and D. Both are chromed polished and temperature controlled to guarantee the maximum accuracy of Outside Diameter. The distance between the roller C and D is the first calibration of the coating weight.

The gap is adjustable and used in most application in the three mills in imperial setting (80 microns.) Rollers in the coating headturns at about 10 times the speed of the previous roller. If roller B turns 10 times faster than the roller C, the thickness of the layer carried by the roller C will be reduced by 10 times when passing to the roller B. The same will happen when passing through the roller A. That will allow you to go from an order of magnitude of around 80 micron at the gap between rollers C and D to an order of magnitude of about .80 micron, or from 3 mills to .03 at the coated layer. It is very difficult to reliably control the thickness of a chemical layer at production speed therefore proper engineering of the coating station is required.

Coating Unit (E.P. Pat. No. 0324892)



Engineering overcomes the technical difficulty of compensating the normal tolerance in accuracy of rotating mechanisms in regular mechanics. Roller B, specifically, is rubber covered and is the one that determines the coated width of the job that you are running.

That roller will need substitution and different undercuts at different web widths handled within the production process. This roller is the "weak link" in the station and needs to be superbly engineered as a solid roller in order to not trigger coating weight inaccuracy. Roller A, the final roller in the transmission chain, or the glue handling chain, turns at the machine speed and about 100 times faster than roller C.

Typical Coating Weights

Chart 1 shows typical coating weights that we recommend as a starting point based on the substrates that are being coated. For film to film laminations that are unprinted using lower coat weights of .8 to 1 pound per ream is sufficient. For printed substrates, increasing the coating weight slightly will make up for the difference of the surface area of the print.

For metalized films and foils, coating from 1 to 1.5 pounds per ream is appropriate, depending on graphics and ink coverage. For applications with paper to film or foil, we recommend higher coat weight. It also depends on the type of paper and the adhesive viscosity as well.

It is recommended to check the coat weight with fresh adhesive to avoid any buildup in the viscosity, and it's advisable to check the coat weight across the web to ensure the adhesive weight is uniform.

Nip Conditions & Tension Control

Nip conditions are very important when running solventless laminations. Just like the coating head rollers, they need to be clean and free of defects to prevent transfer to the final laminate.

Optimal appearance is achieved when using the hottest nip temperature possible based on substrates being laminated. A much lower temperature is used when laminating PE to PE film, as opposed to laminating PET to PE. The substrate dictates the nip temperature and excessive nip temperatures may lead to curling and tension control problems.

Tension control is important due to the low bond and sheer strength of the solventless adhesive. You want to balance the film elongation so that when the tension is removed there will not be any curling or tunneling.

Recommended Coating Weights

FILM/FILM LAMINATIONS

Unprinted	1.3-1.8 g/m2 (0.8-1.0 #/rm)
Printed	1.5-2.0 g/m2 (0.9-1.2 #/rm)
Printed film/metalized film	1.8-2.5 g/m2 (1.0-1.5 #/rm)*
Film/AF	1.8-2.5 g/m2 (1.0-1.5 #/rm)*

*Depends on graphic & ink coverage

PAPER/FILM, AF
2.0-5 g/m2 (1.2-3.0 #/rm) or higher*

*Depends on porosity of paper & adhesive viscosity

Solventless laminators are mechanically designed for a low friction web path with dynamic balance of the rollers. Maintenance in web handling is important. Bearings need to be monitored and replaced if they cause any friction. A bad idle roller can break the process and affect quality of the finished product.

A properly designed laminator for a two ply lamination should have up to six tension controlled zones, each one independently motorized with dancer rollers or load cells to ensure you have correct feedback from the system. The system will self adjust within the operator's settings to guarantee the proper outcome.

Web handling should be a closed-loop system and every single unwind needs to be motorized. Digital vector drives provide the best results while allowing to reduce the number of controls required. Compared to previous technologies, new laminators features a much simpler operator interface, a significantly reduced number of control buttons and are easier to operate.

Adhesive cure

The technical definition for adhesive cure is the disappearance of any free isocyanate over time, tracked via IR analysis. The converter's definition is how soon a laminate can be further processed. The adhesive must be fully cured to withstand slitting and pouching processes, and to be compliant for food safety.

Consult with your adhesive suppliers to identify cure times needed for safe food contact over federal and regional regulations. Generally speaking, adhesive cure depends on the adhesive type. Some adhesives are fast curing while others require a hot room.

Improper mixing ratios will impact adhesive cure. If the adhesive coating weight is excessively high, it may take longer for the adhesive to cure. Improper storage temperatures and conditions, also impact the cure time of your laminate. Ideally, you should cure the laminate at a consistent temperature all year round, if possible.

Corona treaters in the solventless laminating process

Corona treaters prepare film surfaces for bonding with solvent chemistry. Corona treaters clean, etch & functionalize surfaces to eliminate surface energy as a process variable. Industry best practice is to install treaters after the primary and secondary unwinds.

A corona treater power supply generates energy to a high voltage transformer, which boosts the energy to a higher value. That energy is sent on to the corona treater's electrode, which generates corona.

Do pre-treated films need to be treated?

Polyethylene films are inert with initial dyne levels of 30 or 32 and no polarity. Although polyethylene films are treated at the time of extrusion, they are unable to retain the dyne levels required for successful wetting. Dyne levels diminish due to migrating surface additives, contamination, humidity and time. Bump treating or re-treating films as part of the laminating process enables wetting out of the adhesive chemistry.

Measuring the effect of surface treating

Dyne levels are used to measure the effect of treatment. Dyne pens are ideal for a quick check when loading a roll of film on a laminator to verify which side has been pretreated. For a more accurate dyne reading, we recommend using dyne solutions with a cotton swab as outlined by ASTM method D2578. For more process control, follow the TAPPI method which calls for a Mayer Rod to meter the solutions over a larger area of film consistently.

Train your employees how to conduct these tests and interpret the results. Dyne level readings are subject to human interpretation and slight differences in results may not be significant enough to affect the success of your process. Always document your results so you can compare what's changed should you run into future problems. Remember, achieving a target dyne level does not guarantee adhesion. Dyne level is the measurement of wetting, not the measurement of adhesion.

How much treatment do I need?

Always use the least amount of corona treating required to consistently meet your application's dyne level target. Required power levels are based on the width of the treater station's electrodes, the speed you are running and your film's responsiveness to corona treating. If you run different speeds or different films, your treater can be designed to handle a range of applications.

Enercon recommends high definition corona with ceramic electrodes and a proprietary nonconductive ceramic ground roll. This combination treats both conductive and nonconductive films and provides the industry's best insurance against backside treatment, pinholing and film wrinkling.

To properly control the power output, use a power supply with watt density control. This technology adjusts the power output of the treater according to changes in line speed to ensure consistent treatment is applied. The power level needed for the primary and secondary films will not always be the same.

Installation considerations

Follow all the exhaust ducting recommendations when installing your corona treaters. Improper exhaust ducting reduces airflow and leads to problems including electrode overheating, excessive moisture and failure to remove ozone (a byproduct of corona treating.). Based on your locality you may be able to exhaust ozone into the atmosphere. Or, if local regulations require, you can add an Ozone Decomposer to break down the ozone in the exhaust prior to being released to the atmosphere.

Future improvements

Adhesive suppliers and equipment manufacturers are working to develop technologies that close the processing gap and increase the speed of curing while maintaining global compliance. Advances in these areas will greatly expand the uses of solventless laminating. Reducing curing time accelerates the speed to market for final packaging. With recent material and equipment developments it is now possible for six hours to bag making and one to two days, depending on the substrate, to full curing and safe food contact. Additional developments have been made for producing higher barrier structures with OPA and EVOH coex to avoid outgassing at higher speeds than previously achievable.

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