Making Your Legacy Coater/Laminator Work

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Abstract:

While companies consolidate facilities, legacy equipment continues to get passed down to unsuspecting process engineers. Drawings of the machine's components don't exist and operators are being asked to produce products that the machine was never designed to produce. "Magical" one-of-a-kind rollers are discovered to work while all others resembling them fail to perform no matter how similar they might appear. With no money and anxious managers waiting for miracles, what is the answer?

This paper will discuss critical issues needed to be considered when attempting to press a legacy coater/laminator into service to successfully produce new and different products for your company.

Introduction:

In order to be successful in transforming a legacy coater/laminator into a machine that will be producing new products, there are some questions that need to be asked and answered.

1. What are the processing parameters required for producing the "new" product?
2. What was the legacy machine designed to produce and at what rates?
3. What process limitations did the existing equipment have with its original products?
4. What are the economics involved with a "successful" transformation, or how much is management willing to invest in the project?

What Does the "New" Product Require?

In any successful upgrade project, a full understanding of the process requirements for the desired product must clearly be understood. If that knowledge does not reside within the company then it is advisable to speak with experts in the field of your new product. The process requirements of laminating heavy gauge craft paper to an adhesive coated backing liner are quite different than those needed to successfully laminate 0.5 mil optically clear films. If it is not clearly known what type of web handling and laminating setup is needed, the project is likely to fail or waste a lot of money trying to eventually get to a process that doesn't quite meet the expectations. The machine control parameters for different web thicknesses and materials vary dramatically. The rigidity and repeatability requirements for process equipment (laminator or coating applicator head) are as varied as the products themselves.

Slot die coating (Solvent, Emulsion, or Hotmelt) can offer precise thin coatings with relatively low mess and ease of product change. Hotmelt die coating is especially attractive in today's environmentally friendly climate due to its lack of VOC's and its lack of energy needed for driving off liquids or creating cross-links. While the technology is mature, thinner products produced at faster rates are making the process of successful die coating more and more difficult to achieve. Slot die coating works great as long as all of the process details are in place.

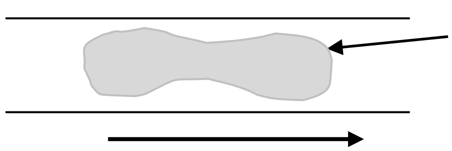
Laminating:

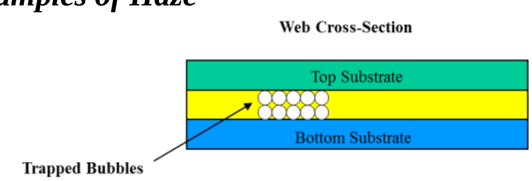
Laminating is one of the most common web processes. Process requirements for laminates are directly related to the product itself. As mentioned previously, some laminates are much more difficult to process than others. Optically transparent laminates of all types are very popular but difficult to properly produce. Because of their transparency, any little defect produced by the machine or lamination process is immediately visible.

Many older laminating machines were not designed with transparent products in mind. The laminate products the machines were originally designed for were much thicker and heavier gauged. These products typically did not stretch, i.e. heavy face paper and were produced at slower rates (150 – 500 fpm). All that was required was that the two webs needed to come together relatively straight and that they could be joined by a relatively simple laminating station with one soft roll and one hard roll.

With laminating webs as thin as ¼ mil and line speeds as fast as 3000 fpm, successful laminators need to be concerned with accurate web handling, repeatable mechanical action, and well designed, geometrically accurate laminating rollers. In the case of transparent laminations, a further complication is introduced by entrained air which leads to haze or opacity in the otherwise clear lamination.

Examples of Haze





One of the best ways to beat haze (trapped air in the lamination), is to keep it from being trapped in the first place.   Conventional laminating wisdom would say that a soft roll cover that produces a large footprint in the laminating nip should prevent the boundary layer air (the air next to the substrates) from being drawn into the lamination. The only thing the large footprint accomplishes is to lower the unit area force in the nip by spreading the load out over a larger surface area. This lower force in turn allows air to sneak through the nip and produce haze.

A harder cover with a higher durometer (80 -100 Shore A) acts more like a dam in the laminating nip. All of the force from the nip is concentrated along a narrow laminating foot print thereby increasing the unit area force which in turn prevents any air from migrating into the lamination and thus produces a transparent lamination.

While in many cases a harder cover produces a superior laminate, processing considerations have to be kept in mind. Harder elastomeric covers plastically deform (dent or mark) easier than their softer counterparts. Harder covers have to be produced to exacting geometries because they don't displace or squish like soft covers to compensate for lack of geometric precision. As long as it is know what process details have to be accounted for, process design considerations can be made. For instance, the laminator can be retro-fitted with a splice-bump option so that the splice does not mark the roll. Also, since roller geometry is so critical, it is important to use a vender who can produce and accurately measure the finished shape of the roll to make sure that it meets the exacting tolerances needed.

If roller geometry is not matched to the process requirement, several defects can be experienced. The more common defects include:

- Regions of Haze or Opacity in Otherwise Transparent Laminations
- Wrinkles
- Creases
- Web Curling
- Out of Spec Coat Weight
- Poor Web Handling/Re-Winding

These defects can be eliminated if the roller geometry is correct for the process.
Sometimes the proper shape for the job is a convexly crowned roll. Sometimes it needs to be a concavely crowned roll. Finally, sometimes it may mean the roll has to be cylindrically straight.

Slot Die Coating:

In slot die coating there are several key details that have to be followed in order for a successful coating to be produced. For transparent coatings on thin webs (≤ 1 mil.) die coating works well when these critical parameters are addressed:

- Die geometry
    - Feed Gap Variation ≤ 0.001"
    - Lip Step Variation ≤ 0.001"
- Accurate Die Positioning to the Backup Roll
    - Repeatable and controllable Die-to-Backup Roll Gap
    - Coating Angle of Attack Rotation about the Feed Gap
- Precision Backup Roll
    - Concentricity ≤ 0.0005
    - Cylindricity ≤ 0.001

Most of the time, these critical parameters can only be met with newly designed dies, rebuilt or redesigned die stations, and re-worked or newly built backup rolls

The good news is that these improvements are all modular and relatively easy to integrate into your legacy piece of equipment. Slot die manufacturing has improved dramatically over the last several years. Standard designs have made it relatively easy to clean, maintain and accurately assemble the dies to the precision that is required by these demanding products. There are several manufacturers to choose from and they are very helpful in guiding you through the process of selecting the appropriate die for your application.

Proper die positioning is one of the most overlooked, and important details that must be correct for die coating to be successful. It is imperative that the feed gap between the die lips meets the backing roll in a tangential form and that any attack angle rotation be carried out around that feed gap interface. While most people would say that they understand this fact, a lot of machine builders get it wrong. When evaluating the capabilities of a legacy die coating station, verify that the die is positioned properly and that the angle of attack rotates around the feed gap. Any other scenario will drastically reduce, if not prevent, your chances of producing the desired coating.

Finally, backup roll geometry is everything in thin, slot die coated films. The thickness of the coating is directly proportional to the distance between the die lip and the backing roll. If run out exists in the backing roll, it will translate directly into MD (machine direction) coat weight variation. In the same way, if the diameter of the roller varies across the working face (diameter changes of more than 0.001") it will cause CW (cross-web) coating variations.

In order to mitigate MD variation, a bearing and bearing housing re-design may be required. Many older machines were not designed with the type of repeatable accuracy needed for the modern demanding products (Concentricity $\leq$ 0.0005). A bearing housing re-design can also facilitate quick roller changes for product width variation. Once again, if you know what types of products you want produced on your machine, smart modular upgrades can benefit multiple manufacturing goals.

What was the legacy machine designed to produce and at what rates?

When looking at upgrading or pressing back into service any type of machine, a clear understanding of its original capabilities must be understood. The following questions should be asked and answered:

- What is the maximum web width than can be handled?
- What is the maximum line speed with the existing drives?
- How many BTU's of oven capacity is available if ovens are needed?
- What type of web processing was performed on the machine?
  - Laminating
  - Coating
    - Roll
    - Gravure
    - Blade Coating
    - Slot Die (solvent, emulsion, or hot melt)

- What type of web was handled?
  - Paper
  - Plastic
  - Foil

These answers will help form the understanding of what the processes the machine can perform and to what level. If the original machine ran at line speeds of 150 – 500 fpm and it is determined the upgraded line should run at 1000 – 1500 fpm, then new drives and tension zones will have to be added. Fortunately, drive and tension technology advancement makes it a modular project to upgrade the machine.

Moving from a reverse roll coater to a hot melt slot die requires new equipment stations. Even in the case where the proposed product change is moving from solvent die coating to hot melt die coating, the thicknesses of the coatings and substrates involved may require that the die station needs to be reworked so that it can meet the positioning needs of the thin constructions.

What Process Limitations Already Exist?

It is important to understand what processing problems, if any, already exist on the piece of equipment. For instance if it is know that the machine always creases or steers the web to the right or left in one section of the machine, then that problem has to be addressed before anything else is attempted. This example could be caused by several different individual or combined reasons. Maybe the machine is out of alignment or the geometry on the rollers in the line is incorrect.

It is very frustrating for a process engineer to "inherit" a piece of equipment that has strange idiosyncrasies that are not documented but known by everyone who has ever run the machine. It is not uncommon to have a "magic" process roll that exists for a given line. This special process roll has the honor of being the only roll to work in a given position even though there is a large inventory of rollers that appear to be identical. While it seems mysterious, usually the answer is quite simple. In many cases the good roll varies from the others in some very subtle but important ways.

For example, in a laminating station, a successful lamination is produced when the window film is transparent and no defects or haze is visible. It is known by the operators and the engineer that **Roll #1** works beautifully and produces that illusive clear lamination. When it is time to regrind **Roll #1** and **Roll #2** which has been freshly ground to the same specifications as **Roll #1** is placed in the machine, the line produces haze in the center of the web. The rollers had the same OD, the same rubber compound, the same durometer, and the cores had the same geometries. What's the deal? Is the roll grinder a liar who exaggerated the inspection report? Maybe. Is there another explanation? Absolutely!

Here is a possible explanation:

1. Both rolls have a working face of 90.00 in. and a core O.D. of 8.00 in.
2. Both rolls have a bearing centerline distance of 100.00 in.

3. Both rolls are made out of steel.
4. Both rolls are covered in 80 durometer shore A Nitrile.
5. Both rolls see a loading of 20 PLI in the laminator and have a parabolic crown of 0.015" on the diameter.

When trying to solve this puzzle, we need to try to understand what the defective roll is telling us through its processing. As mentioned above, the most common source of haze is trapped air between the substrates. The "bad" roll let air into the lamination and the "good" roll did not. The bad roll let air get through the center of the laminating nip. How is this possible? It was crowned like the good roll to match the bending load in the nip. Or was it?

Because no drawings exist for rolls in this machine location, we must do some digging. The operators made an interesting observation. They said **Roll #1**, the good roll, seemed to weigh more than **Roll #2**. Through further analysis with a UTC (ultrasonic thickness gage), it was discovered that the good roll had a core wall thickness of 1.0 inch. The other roll was measured with the UTC and discovered to have a wall thickness of 0.375 inch. This difference in wall thicknesses, when processed through roll deflection calculations, produces different amounts of roll bending. For the magic roll (Roll #1), its core defection worked out to approximately **0.0075** in. on the radius or **0.015** in. on the diameter. The other roll's deflection calculated out to **0.013** in. on the radius or **0.026** in. on the diameter. This difference in core bending is more than enough to allow air to enter the lamination in the center of the product and cause the haze.

It is not uncommon for machine owners to receive OEM rollers when the machine is first purchased and then have other sources fabricate new rollers as spares when needed. Depending on the age of the machine, several different sources could have been used to provide the additionally needed rollers. Over time it is not unusual to have a collection of process rollers that may look the same but in fact are constructed very different from one another. For instance, if it is decided for convenience sake to lighten the weight of a roll and it is fabricated out of aluminum instead of steel, then the change in material and it's physical properties will change the way the roller will behave in the process. The construction of the roll body directly affects the performance of any process in which it is utilized. Many well-meaning engineers or fabricators design and build roll bodies without fully understanding how their choice of materials can change the way a process functions. Whenever considering fabricating spare rollers or upgrading their capabilities, it is critical that you work with someone who is qualified to properly design the roll bodies to work properly with the process demands.

How much is management willing to invest in the project?

As with any project, it is critical to understand up front the amount of money management is willing to spend on the project. Obviously, the amount of money is not infinite otherwise a piece of legacy equipment would not be considered as a solution. One of the benefits of utilizing a piece of equipment that already exists is the ability incrementally upgrade the process or processing capabilities through modular improvement as money is available. Existing process modules can be upgraded or replaced as the machine or product requirements evolve.

Relatively inexpensive improvements can be made to the existing line which in turn can expand the machine's capabilities. Some of these improvements include:

- Machine alignment
- Mechanical improvements to the laminating station
- Process Roller Evaluation
- Process Roller Cover Selection and Refurbishment
- Bearing/Bearing Housing Redesign and Replacement
- Die Station Mechanical Evaluation and Overhaul

As the machine becomes more useful and profitable through the less expensive upgrades, the company can then make the decision to take on more costly upgrades such as new process modules, drive and tension zone modernization, overall machine control and monitoring systems as well as oven improvements. In this way a legacy coater/laminator can evolve into an effective tool for processing modern products.

Conclusion:

Current economic times have forced many companies to do more with fewer resources. Knowledgeable personnel are retiring or being let go leaving, in many cases, a lack of understanding about existing legacy coaters and laminators. Companies are forced to produce new products with new requirements or else go out of business. Without the large amounts of capital needed to purchase new processing lines, there is a way to methodically move forward and survive with the equipment that is in hand.

In order to be successful in this endeavor, it is critical to understand the capabilities of the existing equipment, determine the process requirements of the product that is proposed to be produced and finally develop a plan on how to modify the current equipment to meet those process requirements. In a nutshell you have to learn where you have been and discover the path to where you want to go. To help discover this path it may require working with knowledgeable people in the industry.