

COATING LINES FOR BARRIER COAT MATERIALS

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ABSTRACT

Coating lines for barrier dispersion materials must be designed to optimize throughput and minimize consumption of expensive raw materials. The information necessary to specify coating lines is discussed and applied to two lines at opposite ends of the technology spectrum.

DESIGN CRITERIA AND SPECIFICATIONS

The important factors that form the basis for design of a coating line for barrier coat materials include:

- A. Tonnage required from the line, which usually sets the width and speed of the coating line on the basis of one, two or three shifts per day.
- B. Diameter and width of incoming rolls.
- C. Caliper and tension range of base stocks to be run.
- D. Base stock parameters: smoothness, porosity, basis weight, furnish and percentage of recycled material.
- E. Grade structure to be produced by tonnage and width.
- F. Requirement for other coating and converting operations in line in addition to polymer dispersion coatings.

The above information facilitates generation basic design specifications for the line. A typical specification might include the following:

Roll Face Width:	2.54 M
Maximum Web Width:	2.5 M
Design Speed:	450 MPM
Base Paper:	Recycled and Virgin Paperboard and Linerboard
Basis Weight Range of Uncoated Paper:	125 - 450 GSM
Tension Range:	50 - 200 Kg

Drying Capacity:

Operating Speed:	450 MPM
Base Web Basis Weight:	125 GSM
Incoming Base Web Moisture:	6%
Outgoing Base Web Moisture:	6%
First Coater Coat Weight:	1.75 GSM at 15% solids or 12 GSM at 60% solids
Second Coater Coat Weight:	12 GSM at 60% solids
Third Coater Coat Weight:	17 GSM at 50% solids
Fourth Coater Coat Weight:	12 GSM at 60% solids

Unwind and Rewind:

Maximum roll diameter:	1.5 M
Core diameter:	100 mm I.D.
Minimum diameter for new roll to be spliced in:	610 mm
Edges:	Slit trimmed (incoming)
Slitter:	5 knives (optional outgoing)

Web Cooling Sections:

Web temperature exiting last coater dryer:	87o C
Web temperature exiting cooling zone:	40o C

Calenders:

Type: First Position:	Two-Nip , (one hard, one soft) after 1st coating station
Second Position:	Single Soft Nip after last coating station
Incoming Smoothness:	300 - 450 Sheffield
Outgoing Smoothness:	40 - 70 Sheffield (using both calenders)

Components of the coating line are chosen to meet the design specification.

UNWIND STANDS

It is essential that the base stock be fed into the coater at uniform speed and tension, minimizing the potential for missed splices and web breaks. There two basic types of unwind available for continuous coating lines: the accumulator splicer type unwind and the continuous turret type unwind.

The accumulator type unwind (See Figure 1) has speed (350 to 500 MPM) and grade limitations (usually can only run papers over 80 gsm at speeds above 150 MPM). This is the type of unwind found on most corrugating machines. Its principal limitation is that it uses web tension and the accumulator to accelerate the new roll up to speed from a dead stop. It must do so gently enough so that the paper is not broken, yet quickly enough that the accumulator does not run out of storage.

The turret type unwind (Figure 2) accelerates the new roll to speed prior to making a taped transfer to the expiring roll at line speed. These machines have a higher degree of reliability and can handle high speeds and low basis weights with ease. Their primary disadvantage is in cost, which is 3 to 5 times that of the accumulator type.

WINDERS

The coated product must be wound at uniform tension to produce good quality rolls. Several equipment choices are available. The least complicated equipment to use is called a horizontal surface winder (Figure 3). It consists of a driven drum pneumatically loaded against a mandrel, onto which the paper is wound.

Horizontal surface winders are relatively inexpensive, but have limitations on the width of rolls that can be wound on small diameter paper cores. Typically, if finished rolls must ship on 75 or 100 mm I.D. cores, it is common to wind the roll on large diameter steel cores (greater than 200 mm diameter) and then take them off line to be slit and rewound onto smaller paper cores.

Multi-drum surface winders have been developed to allow winding large diameter wide rolls on small diameter cores. They work by fully supporting the winding roll against the weight of gravity as it winds to full diameter. Though more expensive, they allow each roll to be slit in line and shipped directly to the customer without rewinding.

With the choices of unwind and rewind equipment made, attention is turned to selecting components to complete a coating line that will manufacture the finished products desired by customers. Potential equipment choices often come down to a financial decision, based on the tonnage to be produced on the machine. In general, lines below 20 to 30,000 tonnes per year should concentrate only on the highest value added parts of the process. On larger tonnage lines (40,000 tonnes per year and larger), it usually makes sense to add additional equipment that permits the use of lower quality base stock and/or coating chemistry, since sufficient volume exists to make the added cost economically attractive.

COATING STATIONS

While a number of different types of coating equipment have been used to apply barrier dispersion coatings, two appear to stand out as the tools of choice for most barrier coating lines: the air loaded rod coater (Figure 4) and the air knife coater.

The rod coater applies an excess of coating to the web with an applicator roll prior to metering. The web is supported by an elastomer covered backing roll as it passes through a nip created by loading a rotating rod against the backing roll.

The rod on the coater shown in Figure 4 is held in a precisely machined plastic holder element, which is free to float in a retainer slot. It is pushed against the backing roll by a flexible air bladder whose pressure can be adjusted from 0.2 to 2.0 bar.

The backing roll is driven by its own variable speed drive, and follows line speed. The applicator roll is driven at a percentage of line speed. The rod is driven at a speed between 15 and 300 RPM.

For a given coating formulation, coat weight is dependent on four factors: paper absorbency, applicator roll speed, rod size, and air bladder pressure.

The rod size determines the coat weight range that the coater will operate over. Smooth rods between 5 mm and 50 mm in diameter provide coat weights of between 2 and 25 GSM, with a wide variety of coatings. Much heavier coatings can be achieved by using wire wound or grooved rods rather than smooth rods.

A rod coater utilizing a smooth rod is a leveling coater. The coating that is applied tends to fill in the low spots of the paper. Depending on the paper roughness, this tends to leave far less coating on the high spots than in the low spots.

A rod coater utilizing a wire wound rod meters volumetrically so that the same amount of coating flows out on any part of the web. The coating flow coats the fibers, roughly following the web contour. This type of rod provides more even coating thickness, but the surface smoothness is not as good as with the smooth rod.

The air knife coater (Figure 5) has many similarities to the rod coater. They use the same method of excess application. Both do their metering against a backing roll. The air knife coater uses a jet of moderate to high velocity air to blow off the excess coating. The air jet shears the liquid film, and removes the excess as liquid, spray, or mist. This excess is then collected in a blow off containment system.

The air knife coater provides a contour coating. It applies a coating that follows the web irregularities leaving an even coating thickness. It randomizes the coating being applied which tends to

minimize pattern. The air knife is used when it is important for coatings to have good coverage with very even thickness. It is an excellent coater for applications requiring optical uniformity.

CALENDERING

The calendering process is a mechanical method used to transform the properties of paper from one characteristic state to another. Calendering is accomplished by passing a web between all or part of a complement of rolls stacked vertically, with loads applied on each journal. Calendering reduces the caliper of the web and increases the density of the web by compacting, which occurs in the nip. Calendering can also improve the uniformity of the web surface. Increases in gloss and smoothness can also be obtained by calendering.

Calendering of base stock can improve coating holdout. The choice of type and intensity of calendering depends on the properties of the base stock and the coating method(s) to be used.

HARD NIP CALENDERING

"Hard nip calendering" applies to the use of cast iron rolls, with chilled, hardened surfaces or inert, non resilient surface materials. A hard nip calender produces uniform caliper. The coated linerboard web has a basic formation characteristic defined by density variation, manifesting itself as high and low areas across the web. A conventional hard nip calender affects only the high or denser areas and leaves the low, less dense portions untouched. This can create areas of variable absorption, resulting in print mottle. When hard nip calendering is applied to base stock, the areas of variable absorption can lead to non uniform coating holdout. Because a hard nip calender provides uniform caliper, it aids in building a level roll.

SOFT NIP CALENDERING

A soft nip calender, in its simplest form, consists of a smooth, highly polished hot roll or molding drum and a resilient pressure roll which forms a nip loaded by a suitable system. The hot roll may be chrome plated or unchromed and ground to a very smooth surface finish. It is heated by steam, oil or other controllable means to temperatures ranging from 95 to 300o C. The press roll is a rubber covered internally cooled roll. Pressure roll surface hardness ranges from 5 to 30 P&J. Pneumatic or hydraulic loading systems provide operating nip pressures from 90 to 350 kg/cm. The web is processed in such a way that it is pulled out of the finishing nip directly away from the hot roll surface so there is minimal opportunity for the coating to adhere to the surface. A soft nip calenders to uniform density, finishing all areas of the coated web evenly. Soft nip calendered linerboard prints with cleaner half tone fidelity and uniform solids. Calendering with a soft nip tends to align the pigment particles, which aids in developing gloss. It improves snap, that is the differential between web gloss and print gloss. Soft nip calendered linerboard has much more uniform absorption of subsequent coating applications.

DRYERS

Most coating lines use forced air dryers. The most common type is the single sided dryer. On this design the web is carried through the dryer supported on idler rolls with heated air blown down on the coated side. This dryer tends to have the lowest evaporation rate, because the energy transfer is from only one side, and the most tendency to curl the paper.

Another, more sophisticated, forced air dryer is the flotation dryer. This type of dryer conveys the web on a cushion of air without the mechanical contact of idler rolls. Energy transfer is to both sides of the web. This, combined with its characteristic sinusoidal web path, tends to reduce or eliminate curl.

Steam, gas, fuel oil, and electricity are the typical means of heating the air in a forced air dryer.

Infrared dryers work by radiating energy from a hot source (either electric or gas fired) to the paper in order to dry the coating. While infrared dryers are sometimes used as the only means of drying coatings, their high energy output (usually 3 to 5 times that of forced air systems) can damage sensitive coatings. They are most commonly used in combination with air dryers as a means of raising the paper and coating to the drying temperature quickly. The air dryer is then used to finish the drying process more slowly.

ANCILLARY EQUIPMENT

The major components of a typical coating line have been discussed above, but a number of key smaller items also contribute to a well running coating line. Ancillary equipment components include:

- **Idler Rolls:** These must be designed with low inertia for easy turning with low tension materials, but must also have sufficient stiffness to handle high tension materials.
- **Suction Rolls:** These are driven devices used to provide tension isolation, with single side contact between sections of the coating line that need to run at different tensions.
- **Web Cooling:** Used to reduce the temperature of the web prior to winding, to eliminate one side of the web sticking to the other when the roll is unwound. Sometimes used between coating stations on light-weight webs.
- **Turnbars:** These are devices used to flip the web over between coating stations to allow selection of which side of the web is to be coated.
- **Line Control System:** This is the equipment necessary to control and power the coating line. It would include motors, motor controllers, tension feedback devices, moisture and coat weight measurement gages, programmable logic controllers, and the main system computer.

CAPABILITY, COMPLEXITY AND COST

Figures 6 through 11 show six different line configurations ranging from the very simple to the very complex. A comparison of System 2 and System 6 illustrates the capabilities and limitations of coating lines from opposite ends of the cost and complexity spectrum.

	SYSTEM 2	SYSTEM 6
Tonnes Per Year:	17,500	60,000
Basis Weight:	100-350 GSM	50-450 GSM
Base Stocks:	Virgin Kraft/SBS/Coated	Test Liner/Bag Stock, SBS Recycled and Virgin
Incoming Smoothness:	250-350 Sheffield	300-600 Sheffield
Functional Coating:	Yes	Yes
Color Coating:	Yes	Yes
Functional Coating and Color Coating Simultaneously:	No	Yes
Coat Weight/Moisture Basis Weight Gauging:	No	Yes

Speed:	175 MPM	500 MPM
Calenders:	None	Two - 1 Combination Hard/Soft Nip 1 Hot Soft Nip
Drying:	Forced Air Only	Combination I.R./Forced Air
Coating Heads:	Two - Rod/Rod	Four - Rod/Rod/Air Knife/Rod
Turnbars:	None	Three
Unwind Stand:	Accumulator-Type	Turret-Type
Web Cooling:	No	Yes

The System 2 line is designed with limited capabilities. This line is more narrowly focused on smaller tonnages. It provides flexibility for future expansion, should tonnage requirements increase. It can barrier coat or color coat but cannot do both simultaneously. Double side coating would be done in two passes through the machine. The coaters selected are rod coaters, primarily using a smooth rod in the first application and a grooved rod in the second. It cannot process basis weights below 80 GSM because it has the less expensive accumulator-type unwind stand. Since no calendering is provided, it will use more expensive base stocks in order to have the required web properties for coating. No web cooling is provided. Care must be taken to limit the web temperature as it exits the forced air dryer. All coat weight measurement is off line.

At the other end of the spectrum, the System 6 line is a highly automated, large capacity line designed to handle a wide range of base stocks. It includes a preconditioning calender designed specifically for barrier coating lines. The first nip of the calender is steel on steel, which evens the caliper of the paper and dramatically improves its surface smoothness. The web wraps the middle roll of the calender, which is arranged to allow for web heating or cooling, depending on desired web properties. It then passes through the second nip, which is a soft nip. The soft nip calenders to constant density to eliminate hard and soft spots in the web, which affects the ability to absorb subsequent coating evenly. The calender has individual crown control, so that it can run with either nip open or closed. Some webs will require soft nipping only. Other heavier base stocks that might be subject to ply bond failure in the soft nip can be run hard nip only. Air loaded rod coaters are utilized for most barrier coatings, because of their ability to apply a level, streak-free coating, without pin holes.

For applications where performance requirements dictate a contour coating, a rod premetered air knife is required. This coater applies a more even amount with less leveling, but still pin hole free. This system utilizes a coarse threaded rod to volumetrically premeter the excess applied to the web prior to the air knife, and eliminate air voids and skips. The air knife randomizes the final coat weight application and meters to a uniform coating thickness.

The coaters are arranged with turnbars to allow up to four coatings on one side although a more usual approach would be two coatings on each side. The line would typically apply a functional barrier dispersion coatings to the back of the web, and color coatings to the front.

The drying strategy utilized on this line is a combination approach. After each coating station, an infrared preheat section is used to raise the temperature of paper and coating to the drying temperature as quickly as possible. This minimizes penetration and reduces consumption of expensive coatings. The web then enters a two-sided air flotation dryer, which dries as well as cures the coating at a much lower evaporation rate than the infrared dryer would. Use of a flotation dryer provides the maximum safe drying rate, and reduces the tendency to curl.

After the last drying station, the web passes through a heated soft nip calender that can further condition either surface.

Finally, the web passes through a cooling section, which can be either a number of water cooled rolls or an air flotation non-contact cooler, using ambient temperature air.

The entire line is operated under computerized coat weight control. A scanning gauge measures incoming moisture and basis weight. Gauges after each coating head control coat weight and moisture.

CONCLUSION

Coating lines for barrier coat materials can range from the very simple to the very sophisticated. Working with your machine supplier to clearly define the goals of the line prior to purchase will result in the most cost-effective installation.