STEAM REMOISTURIZING TECHNOLOGY FOR PAPER BASED LABEL MANUFACTURERS

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ABSTRACT

To remain competitive in today's marketplace, paper based label manufacturers must be able to produce a stable, flat product. This requires controlling the moisture content in all layers of the final product to equilibrium.

Coated or laminated paper processes typically require high temperature curing which creates moisture imbalances between the paper substrate and the coating or laminated layer(s). These imbalances, if significant, cause static electricity buildup, web brittleness and curl. All of these conditions can negatively affect product quality and production throughput.

In the current economy, label producers need to coat efficiently, effectively, and with improved economies for margins and the marketplace. One often overlooked, yet important piece of equipment in this equation is the remoisturizer. Identifying what conditions are critical in this unit operation for maintaining process stability is essential. Conditions to consider include: the proper amount of moisture for the web; machine speed and protection of the coated surface from contamination.

Most label manufacturers employ some means of remoisturizing the web after curing to bring the moisture in the substrate, the coating, and the laminated layers into equilibrium. Existing solutions include exposing the coated and cured web to steam showers, water sprays or reverse roll coaters to impart the required amount of moisture. In this presentation, we will be comparing the various remoisturization techniques and providing data to assess these technologies.

LOW MOISTURE AND CURL

A reduction in the moisture content of coated paper which occurs during the curing process can cause downstream production problems such as web brittleness, static electricity buildup and curl. Although brittleness and static electricity can cause immediate problems with web breaks and promoting fires or explosions, curl is not as easy to detect and it can significantly impact the efficiency of downstream processes. Therefore, we will focus this paper on how to address this problem.

Curl occurs when layers of fiber within a sheet of paper or layers of laminated paper expand or contract unevenly. Uneven shrinkage or expansion causes a bending moment because of the differences in shear forces. There are a number of variables in coating or laminating processes that can cause curl. For example: differences in tension between two laminated layers can cause curl. Relative humidity differences in operating environments can also cause curl. Or, differences in the % moisture between each layer of laminated paper can cause curl. (This is particularly evident in pressure sensitive label manufacturing since high cure temperatures are often used for silicone coated release liners and solvent based adhesive coated face stock.)

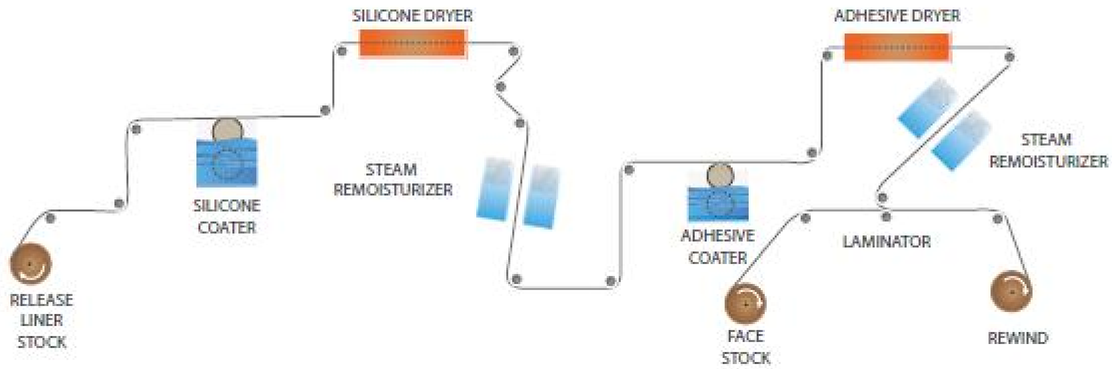

Figure 1: Typical Label Manufacturing Process

THE PROBLEMS THEY CAUSE

In today's competitive marketplace customers want label stock they purchase to "lay flat". This is not just an aesthetic issue but more importantly it is so that customers can efficiently and cost effectively process label stock into a finished product. For example: pressure sensitive label stock will undergo printing before it is eventually attached to its intended surface. Curled stock can jam equipment, slow printing and cause other inefficiencies in downstream processing. When faced with choices of which supplier to purchase from, customers will choose manufacturers who can produce stable products to "lay flat" specifications.

SOLUTIONS

Figure 2: curl vs. lay flat

Manufacturers of labels and other coated paper products use various solutions to eliminate curl. Some examples include adjusting the web tensions of each laminate layer before bonding so that stretches are equal; the use of decurling bars (mechanical deforming) accompanied by high intensity drying or moisturizing; and remoisturization which is essentially putting the moisture back into the paper that was lost during the curing process so that the overall moisture % is once again stable.

Water sprays, steam sprays and liquid application systems (LAS) remoisturizers are some of the most commonly used techniques for remoisturizing. Table 1 shows the capabilities of each method of controlling curl. Steam applicators provide the most consistent results since they enable moisture to be controlled more accurately and with fewer maintenance issues, so this paper will address the various methods of applying moisture using steam.

	CURL CONTROL	MOISTURE ADDED	CONSISTENT RESULTS
MECHANICAL	Yes	No	No
LAS	Yes	Yes	No
WATER SPRAYS	Yes	Yes	No
STEAM	Yes	Yes	Yes

Table 1 : Capabilities

TECHNIQUES FOR STEAM REMOISTURIZING

There are different techniques for applying steam to the cross direction of a moving paper web. The simplest and least expensive means of applying steam is through the use of passive steam showers. These essentially employ a tube the length of the web's cross direction that is equipped with drilled holes that allow steam to escape. The tube is mounted over the web downstream of the ovens and is connected to a steam source supplying continuous saturated steam at a nominal pressure.

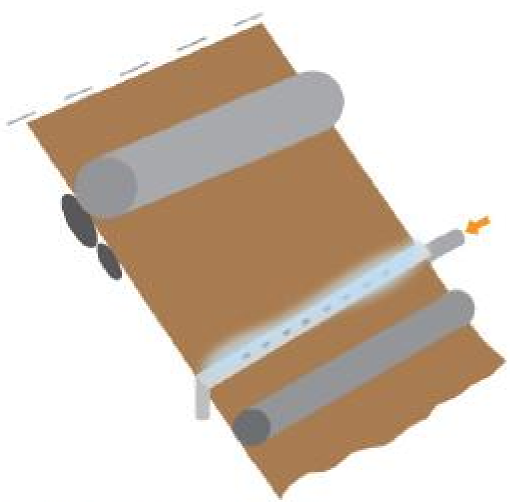

Figure 3: Passive Steam Shower

This technique, although relatively inexpensive, has several disadvantages. One, there is no way to control the moisture profile across the web (a key variable process engineers want in SPC for label manufacturing) since all the holes in the tube are drilled to the same diameter and, if not plugged, will produce the same amount of steam. Two, controlling where the steam condenses is impossible since it is open to the atmosphere. Condensate may form on the tube's exterior or on adjacent web handling equipment and eventually drip onto the coated web causing product quality problems. And finally, the effectiveness of imparting the desired moisture is less than other closed system methods since the steam showers are susceptible to air currents and the penetration of the steam into the fibers of the paper is minimal.

Another technique for applying steam is through the use of a closed system applicator. Such applicators enclose the web long enough for multiple steam sprays from either or both sides to impart the required amount of moisture to the paper. The steam is applied at near saturation temperature across the web from individual steam valves spaced at intervals down to 6” apart. The amount of moisture absorbed by the paper is determined by the temperature of the web entering the enclosure, the density of steam touching the web and the dwell time or time that the steam is in contact with the web.

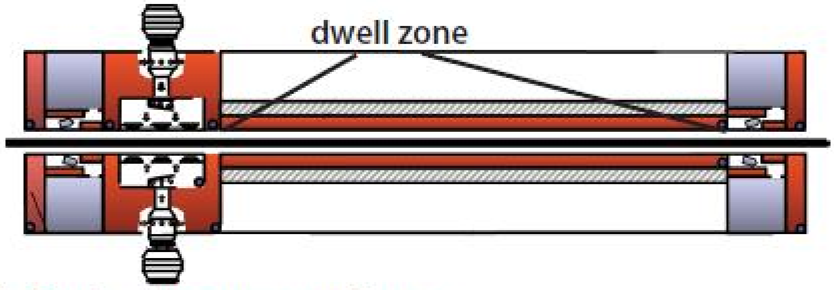

Figure 4 : Enclosed steam applicator

There are basically two types of enclosed steam applicators; lazy steam or streaming steam applicators and impingement applicators. Streaming steam applicators spray steam parallel to the web and rely on the Coanda effect to absorb the steam onto the web.

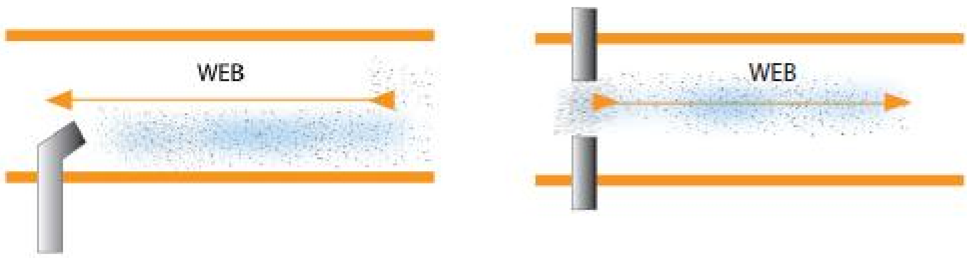

Figure 4a: Streaming steam applicator
Figure 4b: Impingement applicator

The Coanda effect states that a fluid or gas stream will hug a convex contour when directed at a tangent to that surface. However, since the web is moving, it creates a counter phenomenon called “ground effect” which causes a cushion of air to exist between the web and the steam until they make contact. Hence, the dwell zone must be longer or the speed of the web slower to achieve the optimum dwell time to maximize moisture absorption.

Impingement applicators use high velocity or pressure sprays to inject saturated steam, directly into the fibers of the web thus enabling the addition of up to 3 % additional moisture. These sprays contain minimal entrained air so the density of steam is maximized. The steam contacts the web immediately when it enters the enclosure and the steam continues to contact the web until it leaves the enclosure. Hence, for a given web speed, the dwell zone can be shorter to produce the same web/steam exposure time (dwell time). Or, if the dwell zone is longer, the web can absorb the same amount of moisture at a higher machine speed.

CRITERIA FOR CHOOSING A REMOISTURIZER SOLUTION

Before selecting a remoisturizer solution, several process criteria should be considered.

It is a good idea to request production application data from suppliers which shows that their units can provide the required amount of moisture for the machine speeds, coating application and basis weight of the paper that will be running. Or, if possible, visit an existing installation or speak with the process engineer or plant manager.

Table 2 is an example showing the % moisture before and after remoisturizing for a silicone coated release liner using different paper stocks.

Temperature measurements of the web should be taken at the location where the remoisturizer will be installed. The ideal temperature for the web entering a closed system steam applicator is between ambient and 125 degrees F. This will ensure that maximum condensation occurs on the web. If the web temperature is above the ideal range it may be necessary to install chill rolls in front of the remoisturizer to bring the temperature to within the ideal range.

BASIS WEIGHT wt.	MACHINE SPEED feet/minute	TEMPERATURE degrees F	MOISTURE IN %	MOISTURE OUT %
40	600	100	1.5	4.8
40	1200	90	2.3	5.2
60	800	110	0.9	4.1
60	1000	85	2.8	5.5
80	500	96	1.2	4.6
80	700	92	2.1	4.9

Table 2 : Production Application Data

The unit should be totally sealed to prevent fugitive steam from escaping and condensing on web handling equipment. Also, the outer surface of the applicator should be heated during start-up so no condensation occurs but not hot enough to cause safety issues if touched by plant personnel. Any condensation that forms on the exterior of the applicator or other web handling equipment can drip on the web and cause product quality problems.

Materials and welds used to manufacture the steam applicator should be of the highest quality alloys to minimize maintenance and downtime over the life of the unit. Stainless steel and titanium are proven to enable welds to accommodate thermal expansion. A 12 foot long steam applicator can expand up to ½ inch when heated, so it is important that welds won't crack in order to minimize leaks. The valves should also be robust enough to withstand years of cycling without replacement.

Controlling moisture to a target % is possible to achieve with automatic controls. One automatic control strategy for minimizing curl is to ensure the moisture content in the finished product is approximately the same as the moisture content of the paper used at the unwinder or before the curing oven. This can be accomplished by using two IR moisture sensors with two PID control loops. The first IR sensor cascades the set point for the control loop receiving the signal from the second IR sensor which sends an output signal to the steam valves to adjust flow accordingly. Since most steam applicators provide multiple valves for controlling moisture in the cross direction, the IR sensors can be mounted on a scanner or can be moved manually if mounted on a sliding mechanism to check for consistency across the web. A PLC can provide the necessary digital interlocks for start-up, shut-down and rethreading.

Color displays representing key process variables also make it easier for operating personnel to respond to alarms and make adjustments.

Finally, it is more cost effective if the steam applicator can be fabricated to fit an existing process line vs. forcing plant personnel to accommodate a standard size applicator. This flexibility saves downtime for installation and costly modifications to web handling equipment. Hence, the total cost of ownership is minimized.

CONCLUSION AND ECONOMIC JUSTIFICATION

Steam remoisturizing label stock is an effective method of reducing curl and producing "lay flat" product. The typical economic payback for steam remoisturizing systems is between 12 and 18 months. The IRR which can be achieved will vary according to the parameters for each unique application. However, the parameters which will contribute most to IRR include incremental sales from the availability of "lay flat" product; reduced material scrap; and improved production efficiencies. Table 3 illustrates the results a label manufacturer with annual revenues between $40 and $50 million could expect to achieve with a single remoisturizer control system on the adhesive coating line.

	NET CASH FLOW AFTER EXPENSES (assumes 10% after expenses)					
INVESTMENT $	INCREASED SALES $ / YR	WASTE REDUCTION $ / YR	IMPROVED EFFICIENCY $ /YR	TOTAL NET CASH FLOW $ /YR	PAYBACK (MONTHS)	5 YR. IRR %
$150,000	$80,000	$40,000	$35,000	$155,000	12.4	100%

Table 3: Representative Economic Benefits