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CONTROLLING STEAM RE-MOISTURIZERS TO REDUCE EDGE CURL & IMPROVE WEB FLATNESS WITH CROSS DIRECTION MOISTURE PROFILE

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Edge curl and lay flat issues are often addressed with re-moisturizers in the label and converting manufacturing industry. Uneven moisture stratification can cause shrinkage or expansion of cellulose fibers as they equilibrate, resulting in curl, especially at the paper web edges. Moisture variance in layers during the lamination process can also cause lay flat problems, especially when high temperatures are used for silicone coated release liners. Curled stock is a problem for printing and packaging operations that need consistent flat product for efficient operation and low maintenance. Label stock manufacturers often re-moisturize product after drying or curing to raise the moisture to the original level and thereby reduce or eliminate curl. Common methods of re-moisturizing include liquid application systems (LAS), water decks and sprays and steam curtains or applicators.

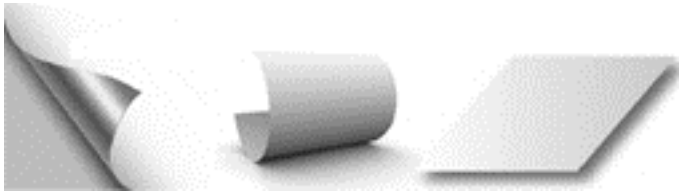

Figure I: Paper Curl Examples

Steam Re-Moisturizers

Steam re-moisturizers can be passive showers or enclosed systems. Passive showers are essentially tubes with evenly spaced holes across the web and they are subject to plugging and condensation that can lead to uneven moisture application and contamination. Enclosed systems include impingement, streaming and simple steam. Streaming (steam emitted parallel to the web) and simple steam typically need longer dwell times and slower web speeds for the moisture to be imparted to the paper. Impingement (steam directed into the web) pressure sprays force high speed saturated steam into the cellulose fibers, allowing for higher moisture levels to be imparted to the paper. Steam may be applied to one or both sides of the web, depending on application. Web speed, temperature, steam density and dwell time impact the steam re-moisturizer's ability to infuse moisture into the paper. Chill rolls are sometimes employed prior to the steam chamber to lower the paper temperature (125°F or less) to ensure the highest level of condensation on the web.

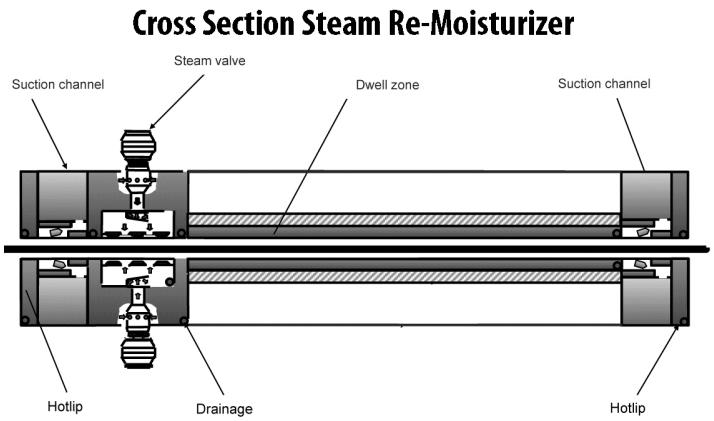

Figure II: Cross Direction Steam Re-Moisturizer

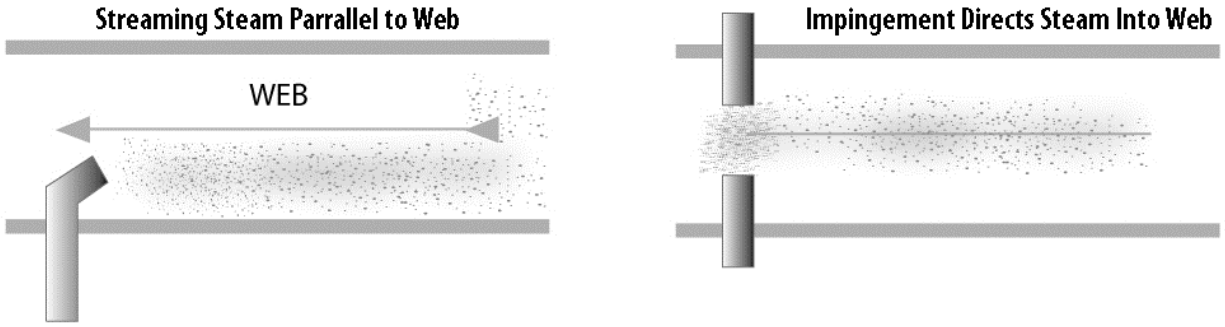

Figure III: Streaming versus Impingement Steam Re-Moisturizing

The steam chamber consists of a series of evenly spaced steam valves and diffuser plates in a sealed enclosure to prevent fugitive emissions from escaping, condensing and dripping onto the web. It should also include a vacuum or suction chamber to prevent liquid collection within the steam chamber. The steam valve is actuated with a pressure control signal, typically in the 0 to 30 psig range. Relative humidity, temperature and roll changes can all impact the required steam density to achieve moisture set point. Steam valves can also wear or plug over time, impacting performance. A cross-direction web moisture profile allows for automatic control of the steam valve pressure to ensure moisture set point.

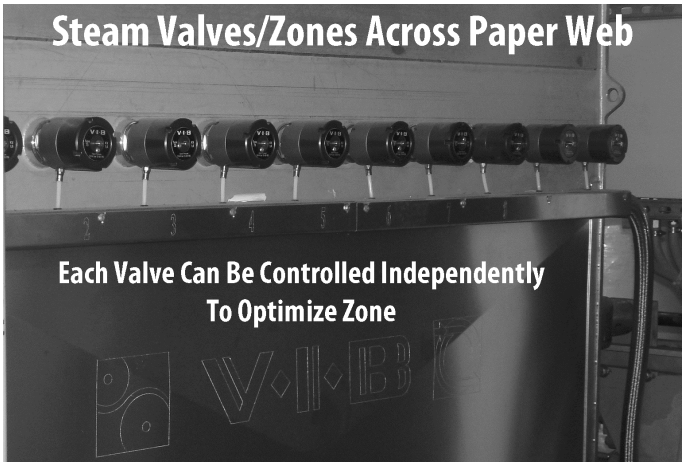

Figure IV: Steam Valves and Zones in Re-Moisturizer

Moisture Transmitters

Near infrared (NIR) transmitters are typically employed to measure paper moisture. Ideally, two NIR transmitters are employed to allow for feed forward control. One moisture transmitter is installed prior to the re-moisturizer, near the dryer or curing station exit, and one at the re-moisturizer exit. Often, a single moisture transmitter is mounted at the exit, only for feedback control. The exit moisture transmitter must be installed far enough downstream to allow for any paper water vapors present immediately after the steam applicator to dissipate. This is typically 10 to 20 feet from the chamber, depending on web speeds. A low-cost infrared thermometer is often enclosed within the NIR moisture transmitter, or mounted adjacent to it, for monitoring web temperature.

The moisture transmitter will have proportional analog and digital outputs, as well as a numerical display of percent moisture. The moisture transmitter is mounted between 6 and 16 inches from the paper web, and angled 15 to 20° off the normal if the surface is glossy to avoid specular reflection. NIR moisture transmitters measure water absorption at 1.94 microns and compare to one or two non-absorbing wavelengths, such as 1.82 or 2.05 (cellulose peak) microns to supply a measurement of moisture in whole percent. Accuracies of these transmitters typically exceed laboratory accuracy, due to sample handling issues involved in transporting paper samples to the laboratory, but are in the range of 0.1% or better. Calibration standards are used to confirm calibration performance every three months.

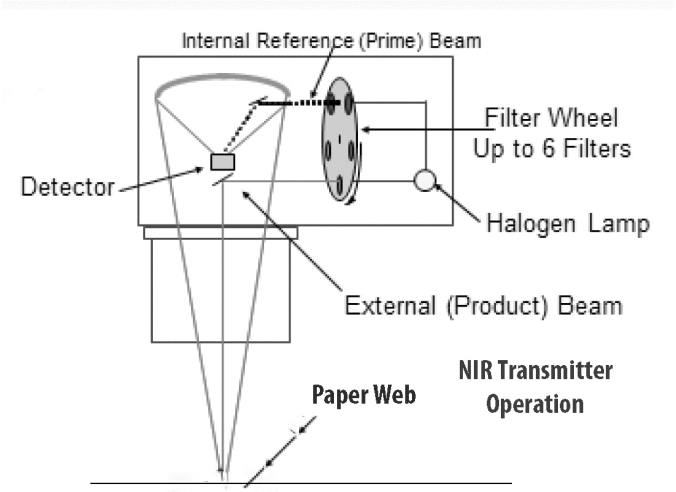

Figure V: Workings of an NIR Transmitter

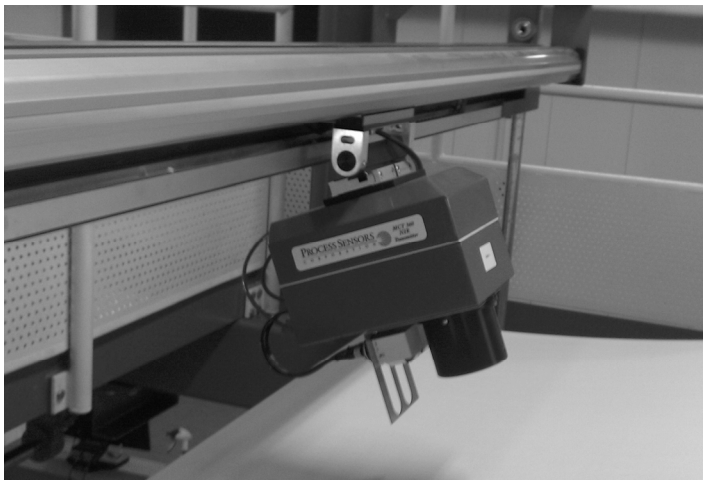

Figure VI: NIR Moisture Transmitter On Paper Web

Cross Direction Web Profile of Moisture

The NIR moisture transmitter is mounted on an automatic scanning frame with position encoder to allow mapping of the cross direction paper moisture web profile on an industrial PC. The local operator display will present zone averages across the web that will graphically illustrate the profile. These zones afford the operator a quick view of the profile and include color alarms, typically green-good (within specification), yellow-alert, red-alarm. The profile is a moving average of an operator-selected number of scans (usually 2 scans) with previous update outline in background so that the operator can see the results of any manual changes to operating conditions. The moisture transmitter and position encoder feed into the scanning frame controller board that relays the information to the industrial PC via Ethernet.

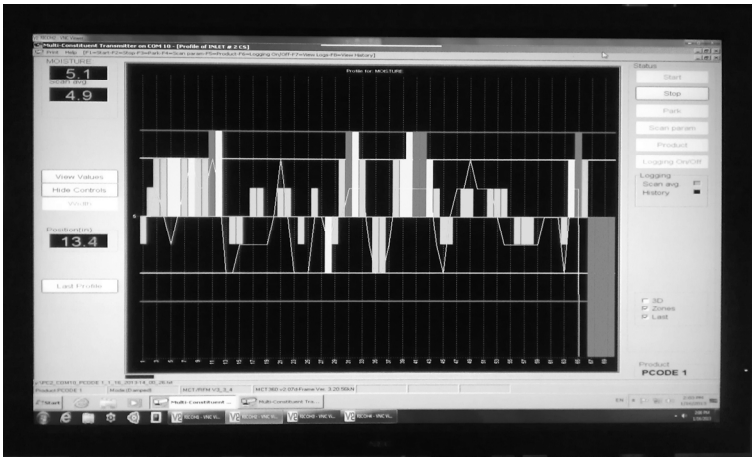

Figure VII: Cross Direction Web Profile

The computer outputs the raw data, including moisture and temperature measurements, web position, in motion/park and manual or automatic mode status, to a Programmable Logic Controller (PLC) or Human Machine Interface (HMI). An Open Process Control (OPC) server application acts as the interface between the hardware layer and the application layer to facilitate communication with the HMI. It is important to have status flags that indicate in-motion or parked position so that the process controller confirms that the transmitter is scanning and doesn't exercise control across the web based on single spot measurement if the transmitter has been placed in a fixed or parked position on the web in manual mode.

The data must be parsed according to web width and steam valve location. While the operator can select the number of zones and zone width for web profile display, these zones may not match up with the individual steam zones for varying web widths. For example, a converter may have a maximum width of 96 inches but also run product of 64 and 48 inches for different products or customers. The steam chambers would need to cover the full 96" and if the steam valves were spaced 6" apart, they would have a total of 16 valves. When a product change is made to a 64" web, the outer zones on both sides would be shut off and only 10 to 12 zones would be activated, depending on web positioning and weave. Changing web width to 48 inches would require at least 8 zones to be activated.

If the operator selected 2" zone segments for the web profile display, he would have 48 zones displayed for the 96" web width but only 24 zones for the 48" web width. By collecting the raw data independent of the displayed web profile, the data can be parsed to match the activated steam zones for each web width while allowing the operator to see a visual representation in smaller segments. This allows the PLC to control each individual steam valve actuator with a pneumatic signal, to increase or decrease the steam density and thus the paper moisture, in each zone. Automatic edge detection is a preferred option to account for web weave that occurs sometimes with roll changes or as a result of improper tension control.

Interfacing the moisture transmitter web profile system and PLC with the HMI has the advantage of simplifying operations. Instead of the operator having to enter a product change into the HMI, steam re-moisturizer PLC and the cross direction (CD) web profile systems separately, the operator can enter the product change into the HMI that will communicate the new product to the CD web profiler and PLC directly via the OPC server application. Different products may have different moisture targets, coatings and web widths and the use of the HMI simplifies the procedure for operators lowering the chance of operator error.

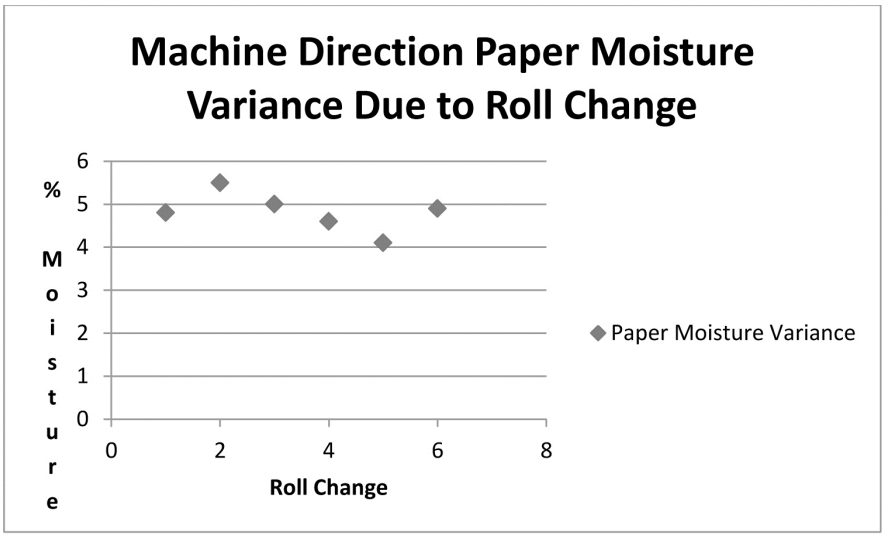

Figure VIII: Moisture Variance With Roll Change

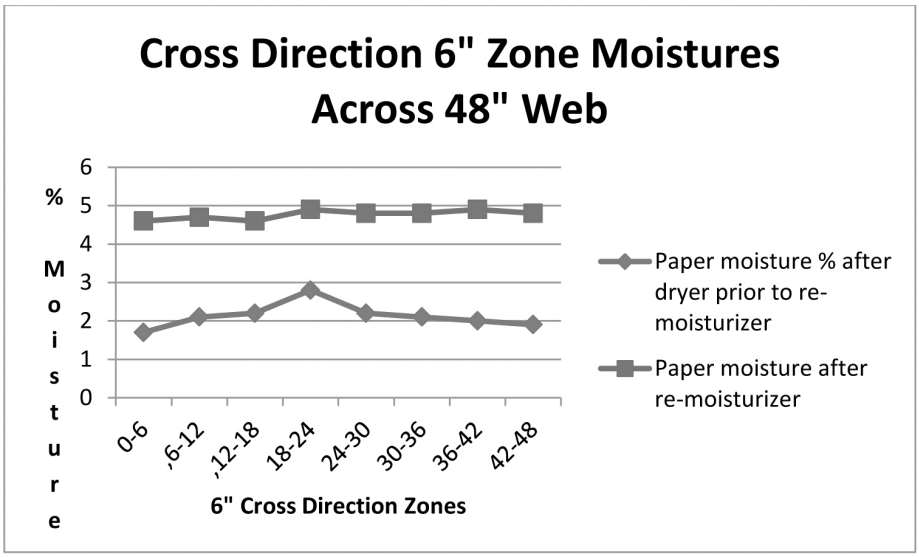

Figure IX: Web Profile Moisture Before and After Re-Moisturizer

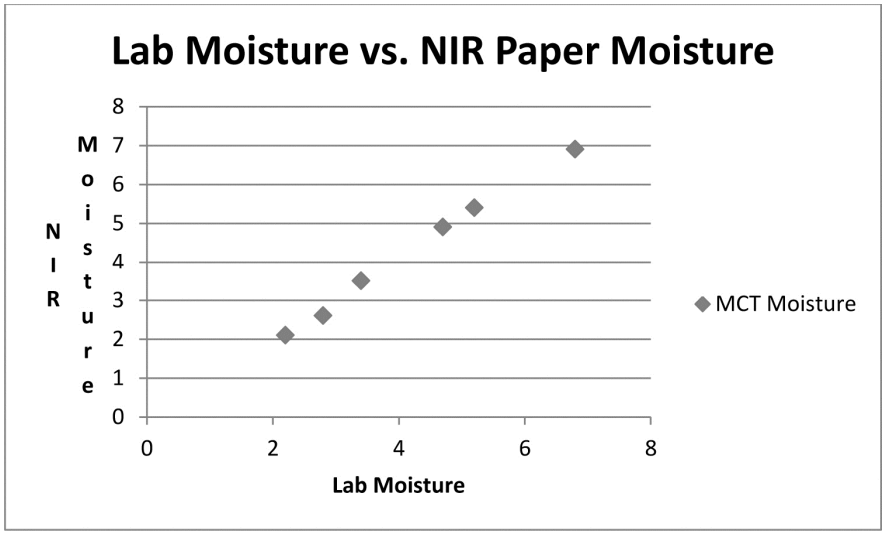

Figure X: Paper Moisture Measurement Comparison

Steam re-moisturizers are increasingly used to reduce edge curl, and consist of a series of steam chambers across the web. These chambers typically range from four to eight inches in width and can be single- or double-sided, depending on the application. Upgrading your steam foil/box to automatic control speeds startup, reduces scrap, and improves Quality Control. When considering an upgrade, a few points need to be considered to maximize value.

The best data to be used from the web profile is the raw data, instead of the moisture profiles zone averages, as they may not match up to the steam re-moisturizer zone chambers when web widths change. The raw data needs to be parsed to match up to the chamber zones and this means that the profiler must recognize varying web widths via a recipe. The parsed data is then sent to a Programmable Logic Controller (PLC) to control each steam zone's individual actuator valve.

Instead of having operators manually enter this recipe data individually into the profiler when product widths change, it's preferred to have the HMI (Human Machine Interface) Operator Station communicate to the profiler via a graphical interface such as Wonderware, Genesis, Interlution, SCADA or other, using Ethernet, Modbus, Profinet or other suitable protocol. This reduces the number of operator tasks and speeds product changeover. The moisture profile data should also be stored separately for data archiving, typically through an Ethernet link.

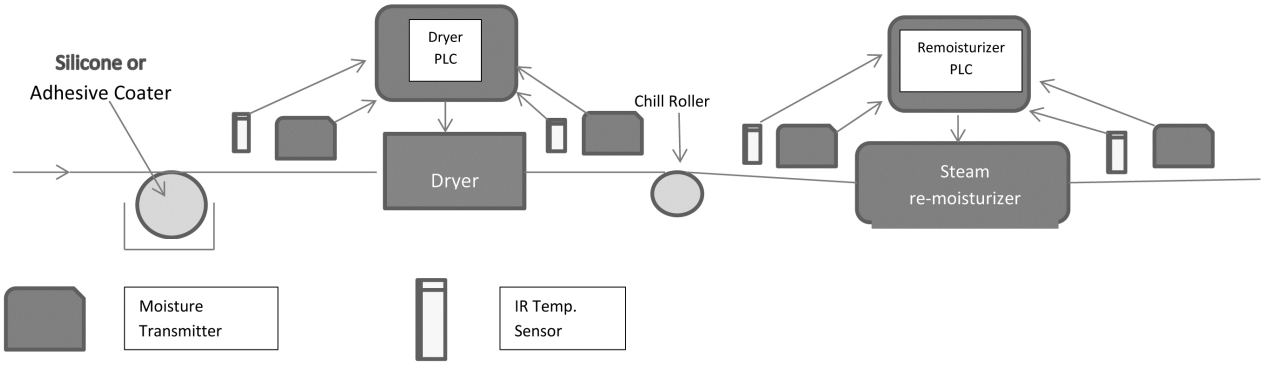

Figure XI: Flow Chart Re-Moisturizer

Summary

Steam re-moisturizers that reduce edge curl and improve flatness benefit from the incorporation of NIR moisture transmitters into the control scheme.

Acknowledgments

Phil Gehrish, AP Films
Joe Martin, Qualitek Solutions
Pat Hardin, PSC