Laminator Static Control

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ABSTRACT

New and emerging products produced using roll-to-roll (RtR) operations require better static control because electronic devices, thin layers of engineered materials, and biologically active layers are sensitive to contamination and changes in surface chemistry driven by static discharges. Many new products are enabled by multilayer laminates that provide durable surfaces, excellent water and oxygen barriers, mechanical strength, and many other customer features. However, static charges sealed inside a laminate cannot be neutralized. Static charges must be neutralized on the interior web surfaces prior to lamination. Presented here is a static control system designed for a lamination line with two unwind turrets, a corona treater, a solvent based adhesive coating station, a dryer, a laminator, and a winder. Two key insights are that (1) static dissipaters are unable to neutralize polar charge, which remains on the web through the process, and (2) static must be neutralized before the uncharged web surface touches a roller. The static control system needed to have a static free web entering the winder is described along with the rationale for each dissipater.

1. INTRODUCTION

Improvements in printing, embossing and etching technologies enable roll-to-roll (RtR) manufacturing to be used to produce a wide variety of new products including flexible electronic circuits, electronic displays, solar cells, and biologically active sensors. These products each have carefully designed surfaces that provide high value to the end product. Static charges that accumulate during production processes on insulating polymer web risk attracting dust and causing sparks that damage the carefully engineered surfaces, resetting machine control systems, igniting flammable solvent vapors, and injury operators.

Controlling static in RtR operations has been a challenge at least since the 1906 when a static bar using pins that are electrically connected was claimed for use in a printing press [1]. New and emerging products produced using RtR operations will require better static control because electronic devices, thin layers of engineered materials, and biologically active layers are sensitive to contamination and changes in surface chemistry driven by static discharges.

Multilayer laminates provide durable printed surfaces, excellent water and oxygen barriers, mechanical strength, and many other customer features. Static control in a laminating process is challenging because the webs are typically highly insulating polymers such as polyethylene (PE), biaxially oriented polypropylene (BOPP) and polyethylene terephthalate (PET). These polymers are on the negative side of the triboelectric series [2] and they are prone to becoming highly charged in RtR operations. And, once two webs are laminated, any static charge on the interior surfaces of the web becomes sealed within the laminate. This electrical charge trapped within the insulating web cannot be neutralized. The sealed charges will be present in the wound roll and delivered with the material to the next operation and eventually to the customer. Charged trapped within a laminate can be the root cause for a number of static problems including attracting dust and fibers, causing sparks and electrical discharges, shocking operators, and causing jams and waste in subsequent operations. Good static control in a lamination process is achieve by
neutralizing static on the webs throughout the process from the unwind for each web to the winder.

2. OVERVIEW

2.1 Charge Control Strategy

![Diagram of charge control strategy](image)

**Fig. 1:** The electric field from the static on the web surface draws ions from the static dissipater. For effective static control, the strategy is to prevent charge from accumulating on both sides of the web. Static bars effectively neutralize static only when static is on the surface of the web facing the dissipater. The web in Fig. 1 has negative static charge only on the top surface. The static bar mounted on the machine frame generates ions of both positive and negative polarity. The electric field from the negative static on the web attracts ions of opposite polarity generated by the static bar. Ions with the same polarity as the static on the web flow to the grounded machine frame.

Static dissipaters are unable to neutralize static when the web has static on one side and an equal amount of static having the opposite polarity on the other side. This pattern of charge is termed “polar charge” [3]. The web in Fig. 2 has negative static on the top surface and an equal amount of positive static on the bottom surface. The electric field of the polar charge is only within the web because it extends from the positive charges on the bottom surface only to the negative charges on the top surface. The static bar generates ions of both positive and negative polarity. However, no ions are attracted to the web. The polar charge on the web is unchanged by the static dissipater.

An effective static control system neutralizes static at the source of charging before static can accumulate on both sides of a web.
Fig. 2: With static one on surface and an equal amount of opposite polarity static on the other surface, no ions are drawn to the web.

2.1 Layout of a Lamination Line

Fig. 3: A static control system for this lamination line includes static dissipaters in each operation.

An effective static control system is needed on a lamination line to prevent static charge from being sealed within the laminate. Unwind #1 and the winder are located together in the lamination line in Fig. 3 to centralize roll handling operations. Web #1 is commonly the thicker, high value web that is corona treated prior to being coated with a solvent based adhesive. The
dryer arch is located on a mezzanine level above unwind #1 and the winder. Web #1 and web #2 enter the laminator just prior to winding.

3. STATIC CONTROL SYSTEM

3.1 Unwinders

![Diagram of static control system](image)

Fig. 4: Static is neutralized on both sides of the web exiting the unwinding roll. Static bars SB1 & SB2 and idler rollers 1 – 5 are in fixed positions. SB3 neutralizes static from the nip.

The static control system in Fig. 4 effectively neutralizes static on both sides of the web exiting the roll, which may unwind in either direction [4]. For clarity, only the static charges for the “over unwind” or clockwise direction are shown. The outside surface of the roll has negative static and the inside surface of the web exiting the roll has equal amount of positive static. Static bar SB1 is positioned to neutralize the outside surface of the roll. The web is conveyed over idler roller 1 that touches the charged, inside surface of the web. Static bar SB2 is positioned to neutralize static on the inside surface of the web.

When the unwind direct is changed to the “under unwind” or to the counter-clockwise direction, the locations of static bars SB1 and SB2 are unchanged. Switching the unwind direction requires only a simple change in the web path.

Unwinders commonly have a tension control nip shown as roller 5 in Fig. 3. Static bar SB3 is positioned to neutralize the static from the polymer nip roller.

3.2 Corona Treater

The corona treater in Fig. 5 deposits a large amount of static charge on the treated surface. Static bar SB4 is positioned to neutralize static on the treated surface. The static on the treated surface must be neutralized before the untreated side of the web touches a roller. To see why, look at the situation when the charged web passes over roller 3 in Fig. 5.

In Fig. 6, the web has a large amount of positive static on treated surface. The untreated surface is neutral. The static on the web induces an electric field between the web and the roller.
The high level of static on the treated surface must be neutralized prior to the first roller that touches the back side. When the charged web is very close to the roller, the field is so strong that air is ionized generating ions of both positive and negative polarity. This ionization in the region where the charged web approaches the roller is called “pre-nip ionization.” The negative ions are drawn towards the web and partially neutralize the static on the web. The positive ions move to the roller surface. The result is that pre-nip ionization partially neutralizes the static on the web.

Note that the electric field does not cross the web.

The web in Fig. 7 has a large amount of positive static on the corona treated surface. In this case, the roller touches the uncharged surface of the web. The static on the web induces an electric field between the web and the roller. Note that the electric field must cross the web. When the charged web is very close to the roller, the field is so strong that pre-nip ionization generates ions of both positive and negative polarity. The negative ions are drawn towards the web and deposit...
on the previously neutral surface of the web. The result is that the exiting web has static on both sides of the web.

![Diagram showing static charges and electric field](image)

Fig. 7: This roller that touches the neutral side of a charged web deposits static on the neutral side by pre-nip ionization. Note that the electric field crosses the web.

The web now has a combination of polar charge and net charge. Polar charge is formed because the negative ions deposited by pre-nip ionization may be paired with some of the positive ions. And, the net charge is the abundance of positive ions.

Static must be neutralized before the charge web passes over a roller that touches the uncharged surface. When the neutral side of a web touches a roller, polar charge is formed that persists on the web through each operation to the winding roll.

3.3 Coater

The solvent based adhesive is applied to the web by the gravure coater in Fig. 8. Static sparks can ignite the solvent vapors. The entering web should be neutral if the static control system is functioning properly. In the event of a failure, static bar SB 5 on the in-feed side of the coater is a safety net that insures that the entering web is neutral.

Installation of static bar SB6 is a “best practice.” If the static control system is functioning properly, the web passing SB6 should be electrically neutral. However, should the coater run dry due to a solvent pump failure, the nip between the dry coating roller and the pressure roller can deposit enough static on the back of the web to cause a spark. SB6 is a “fail-safe” to insure that the web exiting the coating nip is neutral in the event of a failure.
3.4 Dryer

The dryer in Fig. 9 has many low wrap, low traction, backside rollers. Even in dryers with tendency drives, where the outer races of the bearings are driven to minimize drag, the uncoated side of the web can accumulate significant amounts of static when conveyed through a dryer. In normal operation, static bar SB7 effectively neutralizes static on the backside. However, the web can accumulate a sufficient amount of static to cause static discharges inside the dryer. Normally, the solvent concentration is well below the LEL in the dryer so these sparks are of no concern. However, in the event of a fan failure of other unusual event, the solvent concentration within the dry can increase posing an ignition concern. The ionizing cords or tinsels installed in the dryer in Fig. 9 reduce the static charge on the backside of the web to prevent static discharges.

3.5 Laminator

The coated web and web #2 entering the laminator in Fig. 10 are electrically neutral if the static control system is functioning properly. So, no static dissipaters are needed immediately before the laminator. The laminate becomes highly charged passing through the high pressure.
lamination nip by contact with the polymer roller. Static bar SB8 neutralizes the static on the top surface of the laminate exiting the lamination nip. The laminate must be neutralized before the uncharged surface of the web touches a roller as illustrated in Fig. 7.

![Diagram of lamination nip](image1)

Fig. 10: Static bar 8 neutralizes charge from the polymer lamination roller. Note that there are no static dissipaters on the webs prior to lamination.

3.6 Winder

![Diagram of winding process](image2)

Fig. 11: Static bar 9 neutralizes charge from the polymer nip roller. SB10 neutralizes static from the lay-on roller and also limits the potential of the winding roll.

The web entering the winder is electrically neutral if the static control system is functioning properly. A tension control nip near the winding roll controls the web tension during roll changes and start-ups. The web surface that touches the polymer nip roller becomes charged. Static bar SB9 neutralizes the charge from the tension control nip.
This winder uses a lay-on roll to improve roll quality. The lay-on roller deposits a significant amount of static on the outside surface of the winding roll. Static bar SB 10 neutralizes the static from the lay-on roller. SB10 also reduces the electric potential of the winding roll. Even when the static control system is functioning properly, the web may carry a low and normally insignificant amount of static charge. The winding roll stores a large amount of web. The low and normally insignificant amount of static on the large amount of web stored in the winding roll can raise the electric potential above ±20KV and cause sparking and shocks to operators. SB10 reduces potential from this residual charge to nearly zero.

**SUMMARY**

- Static should be neutralized at the source of charging for effective charge control.
- Static charge must be neutralized before the neutral surface of the web touches a roller. When the neutral surface of the web touches a roller, pre-nip ionization deposits charge on the previously neutral surface. Both surfaces of the web become charged.
- Polar charge is a pattern of static where one surface has positive charge and the other surface has an equal amount of negative charge.
- Static dissipaters are unable to neutralize polar charge. As a consequence, polar charge persists through the process to the winding roll.
- Charge control in a lamination line is important to prevent static from being seal within the laminate.
- The static control system for this lamination line requires 13 static bars and three static cords or tinsels.
- The static control system neutralizes static during normal operation and provides fail-safe neutralization for the solvent rich coater and potentially solvent rich dryer.
- A static bar is needed to neutralize static from a winder lay-on roller. This final static bar also reduces the electric potential of the winding roll caused by residual levels of static on the web. Within the winder static bar, the electric potential of the winding roll can exceed ±20KV, which is sufficient to cause sparks and shock operators.

**REFERENCES**