LAMINATION SYSTEM
APPLICATION AND DESIGN
CONSIDERATIONS

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OVERVIEW

In this presentation we will discuss several methods that exist for the lamination of multiple webs and how the process requirements determine which method is most suitable.

We will also cover several areas of consideration in the proper design of the laminating system.
What is lamination:
The combining of multiple webs to form a single, multilayer web.

Basic laminator design:
Two webs are combined by passing them between a pair of rolls that are pressed together at a controlled force and/or gap. Typically one of the rolls features a hard surface such as chrome plated steel, with the other roll featuring a resilient surface such as rubber.
WHY LAMINATE?

The primary reason for laminating webs together is to develop a product with properties that exceed those available from individual webs. These properties can be divided into several categories including:

• Layers that are combined to improve the web’s mechanical properties such as:
  – increasing tensile strength
  – adding a wear resistant layer
  – adding a protective layer
WHY LAMINATE?

The primary reason for laminating webs together is to develop a product with properties that exceed those available from individual webs. These properties can be divided into several categories including:

• Layers that are combined to improve the web’s **chemical properties** such as:
  – reducing the web’s vapor, gas or moisture transmission rates
WHY LAMINATE?

The primary reason for laminating webs together is to develop a product with properties that exceed those available from individual webs. These properties can be divided into several categories including:

• Layers that are combined to improve the web’s appearance such as:
  – adding a film to change the surface appearance of the web
  – adding a printed film to the web
TYPES OF LAMINATING SYSTEMS
TYPES OF LAMINATING SYSTEMS

The method by which webs are laminated together can be divided into three major categories:

- Wet Bond Lamination
- Dry Bond Lamination
- Fusion Lamination

The physical properties and characteristics of the materials that are being combined determine which of the above methods is used.

Another major type of laminating system is Extrusion Lamination. Due to the differences it has with the methods discussed here, we are not including it in this presentation.
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

In Wet Bond lamination a coating is applied to one or more of the webs which are then combined while the coating is still in a liquid form.

This type of lamination can take one of several different forms.
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

Using a water or solvent carrier based adhesive:

• adhesive is applied to one or both of the webs
• the webs are combined
• after lamination the water or solvent is removed by passing the laminate through a drying process
• at least one of the webs needs to be permeable/porous so the water or solvent can escape
• the adhesive is typically applied to the non-porous web so that it stays on the surface
• in certain cases, particularly where light water based adhesives are used in conjunction with an absorbent web, drying may not be required to remove the water
TYPES OF LAMINATING SYSTEMS
Wet Bond Lamination

Using a water or solvent carrier based adhesive:
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

Using a curable or cross linking adhesive:

- adhesive is applied to one or both of the webs
- The webs are combined
- once the webs are combined, the curing/cross linking is performed through the web(s) with a system such as a U.V. unit.
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

Using waxes, paraffins, or similar thermoplastic adhesive:

- the coatings are heated to their liquid form and applied to one or both of the webs
- the webs are combined
- once the webs are combined, the coating is cooled to its solid state by passing the laminated product about cooling roll(s), through a water bath or through a cooling chamber
- in this case neither web needs to be permeable since the 100% solid coating has no water or solvent that needs to be removed
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

Using waxes, paraffins, or similar thermoplastic adhesive:
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

Design features of a Wet Bond Laminator:

• The lamination nip:
  – operate at a low pressure and/or with a gap between the rolls since the adhesive between the layers of web is still in a liquid form
  • too much pressure can result in the adhesive being squeezed into the porous web or out from between the webs, resulting in poor bonding of the layers
TYPES OF LAMINATING SYSTEMS

Wet Bond Lamination

Design features of a Wet Bond Laminator:

• desirable to have the lamination point as near to the coating application point as possible
  – prevents premature flashing of the solvent or water
  – prevents absorption of the coating into the web (if it is porous)
TYPES OF LAMINATING SYSTEMS
Wet Bond Lamination

Design features of a Wet Bond Laminator:

• Once the webs are combined it is important that they are dried, cured/cross linked or cooled as soon as possible since the adhesive doesn’t develop its full strength to hold the webs together until this happens.
TYPES OF LAMINATING SYSTEMS

Dry Bond Lamination

In **Dry Bond** lamination, an adhesive coating is applied to the web and dried (solidified) prior to lamination. As with wet bond lamination, this system can take one of several forms.
TYPES OF LAMINATING SYSTEMS

Dry Bond Lamination

Using a water or solvent carrier based adhesive:

- a water or solvent based adhesive coating is applied to one of the webs

- once the coating is applied, the web passes through a dryer in which the water or solvent is removed, leaving a layer of (solidified) adhesive

- upon exiting the dryer, the coated side of the web is combined with a second web at the laminating nip with the adhesive bonding the two webs together

- because the water or solvent is removed prior to lamination, neither of the webs needs to be porous
TYPES OF LAMINATING SYSTEMS
Dry Bond Lamination

Using a water or solvent carrier based adhesive:
TYPES OF LAMINATING SYSTEMS

Dry Bond Lamination

Using a water or solvent carrier based adhesive:
TYPES OF LAMINATING SYSTEMS

Dry Bond Lamination

Using a curable adhesive:

• a curable adhesive coating is applied to one of the webs
• once the coating is applied, the web passes through a curing section such as an electron beam or ultra violet unit to cure (solidify) the adhesive
• upon exiting the curing unit, the coated side of the web is combined with a second web at the laminating nip with the adhesive bonding the two webs together
TYPES OF LAMINATING SYSTEMS
Dry Bond Lamination

Using web(s) that are pre-coated with adhesive:

- often referred to as off-line laminating since coating and drying/curing occur prior to the laminating machine
- can take one of several forms depending on the adhesive
  - a web with an adhesive that sticks to surfaces at room temperature can be used
    - the two webs are unwound and combined at a simple laminating nip
  - a web with an adhesive that is heat activated can be used
    - the adhesive coated web is heated prior to lamination
TYPES OF LAMINATING SYSTEMS
Dry Bond Lamination

Using web(s) that are pre-coated with adhesive:
TYPES OF LAMINATING SYSTEMS
Dry Bond Lamination

Design features of a Dry Bond Laminator:

• The lamination nip:
  – since the adhesive is solidified prior to lamination, the lamination nip typically operates at moderate to high pressures
  – depending on the application, the nip roll(s) are often heated
Design features of a Dry Bond Laminator:

- it is desirable to have the lamination point as near to the exit of the dryer or curing unit as possible
  - to minimize exposure of the coated web
  - to maintain the heat in the web/coating for those processes that require heat at lamination
- pre-heating should occur as close to the lamination point as possible so the heat that is put into the web(s)/adhesive(s) is not lost prior to lamination
- it is important to cool the web after lamination as quickly as possible
TYPES OF LAMINATING SYSTEMS
Thermal Lamination

In Thermal Bond lamination, which is often referred to as fusion lamination, two or more webs are combined using heat and pressure without any adhesives.

Since the webs are being combined using just heat and pressure, it is important that the webs being combined have similar thermal properties.
TYPES OF LAMINATING SYSTEMS
Thermal Lamination

In this form of lamination:

• heat is applied to one or more of the webs prior to lamination

• the lamination assembly may feature a large diameter main heat roll, about which the primary web is heated prior to reaching the nip point

• the secondary web may also be preheated prior to lamination, typically by passing about preheat rolls

• the secondary web is introduced to the primary web at the nip point
TYPES OF LAMINATING SYSTEMS
Thermal Lamination

Secondary Web Pre-heat Rolls

Rubber Laminator Roll

Secondary Nip Roll

Steel Laminator Roll (heated)
TYPES OF LAMINATING SYSTEMS
Thermal Lamination

Design features of a Thermal Laminator:

• The lamination nip:
  – typically operates at moderate to high pressures to assist in the bonding of the materials
  – the control of the heating of the webs is critical
    • not enough heat will result in poor bonding
    • too much heat will distort or melt the web
    • the amount of heating and temperatures that are required is determined by factors such as
      – the type of material
      – the material thickness
      – the operating speed
DESIGN CONSIDERATIONS IN A LAMINATOR
The design of the laminating section is critical to the success of the process. There are several factors that need to be addressed in the design, some of which are common for all laminating processes and some that are unique to each.
DESIGN CONSIDERATIONS IN A LAMINATOR

Roll Design

Factors to consider in the design of the laminator rolls:

Roll Diameter:

• the greater the pressure between the rolls, the greater
  – the roll deflection/bow in the middle
  – the compression of the rubber rolls surface and therefore “footprint” (the area of the rubber roll that compresses and contacts the steel roll)

• as the deflection/bow increases the footprint becomes uneven, with a narrower contact area in the middle than on the edges
Factors to consider in the design of the laminator rolls:

Roll Diameter:

- the uneven footprint can cause several issues including:
  - the force between the rolls varying across the width, resulting in an uneven lamination bond
  - a difference in the rubber roll diameter due to the uneven footprint, causing a variation in the surface speed, leading to web wrinkles and/or stresses
Factors to consider in the design of the laminator rolls:

Roll Diameter:

• as the roll diameter increases so does its stiffness, reducing the deflection and bow and therefore the variation in footprint
DESIGN CONSIDERATIONS IN A LAMINATOR

Roll Design

Factors to consider in the design of the laminator rolls:

Roll Heating:

It is typical, particularly in dry bond and thermal lamination, to heat the steel laminating roll so that it heats the web that contacts it. This heating can be done in several ways including:

- internal electric heating
- passing a heating fluid through the rolls, such as
  - Steam
  - Water
  - Oil
Factors to consider in the design of the laminator rolls:

Roll Heating:

The temperature profile across the roll must be uniform so that heating across the width of the web is uniform to assure uniform lamination

• fairly easy to address in internally electrically heated rolls
• the internal design of the fluid heated roll is critical and should be engineered to address this through
  – double shell construction
  – spiral passages between the shells
  – reduced pitch passages
  – proper flow rate
DESIGN CONSIDERATIONS IN A LAMINATOR

Roll Design

Factors to consider in the design of the laminator rolls:

Roll Accuracy:

The accuracy of the rolls’ diameter and run-out needs to be considered

• variations in the diameter and run-out can result in local speed and pressure changes causing poor lamination

Surface Finish:

Another consideration in the design of the rolls is the consistency in their surface finish

• variations in surface finish can result in marks or blemish in the product
DESIGN CONSIDERATIONS IN A LAMINATOR

Roll Design

Factors to consider in the design of the laminator rolls:

Rubber Roll Material and Hardness:

It is important to match the selection of rubber material and hardness with the application, taking into consideration:

• pressure requirements
• chemicals/materials that the rubber will be exposed to
• temperature requirements
  – includes the internal design of the core for passage of heat transfer fluids for either heating or cooling depending on the temperature requirements
DESIGN CONSIDERATIONS IN A LAMINATOR

Nip Pressure Control

The design of the nip pressure system is critical.

• the pressure must match the application’s requirements
  – the cylinders’ bore and working fluid’s pressure should be selected based on these requirements

• it is important to be able to control and set the pressure
  – this can be done manually using a local regulator and gauge or automatically from the main operating system
DESIGN CONSIDERATIONS IN A LAMINATOR

Gap Control

For certain applications the two nip rolls need to be held in close proximity to each other without touching. Examples of this are:

- during wet bond laminating, where nipping the rolls together may result in the coating being forced into the porous web or out from between the web layers
- when laminating thick webs or coatings that may be damaged by over compression

It is typical to locate an adjustable gap control device between the nip rolls’ bearing housings.
DESIGN CONSIDERATIONS IN A LAMINATOR

Gap Control

Factors to consider in the design of the gap control system:

• what accuracy and range is required on the device
• will the control be local/manual or automatic/remote
• can the device be retracted to allow the rolls to contact (run in pressure mode)
DESIGN CONSIDERATIONS IN A LAMINATOR

Roll Drive

It is typical to drive the rolls at the laminating nip. One must consider several factors regarding the driving of the nip rolls:

• should one or both nip rolls be driven
  – certain processes allow for a motor/drive on one roll, with the other roll being driven through the web by the nip force
  – some processes require both rolls to be independently driven to provide a product free of wrinkles and/or curl
    • lamination of thick or extensible webs
    • gap mode lamination

• how should the roll drive(s) be controlled
  – can this be the lead section, tension regulated, torque controlled
Web Handling

The handling of the webs into and out of the laminating section is critical for proper lamination. One needs to consider the following regarding web handling into and out of the laminating section:

• proper tension control into the lamination nip – poor tension control can result in flaws in the laminated product such as:
  – wrinkle lines
  – stretch lines
  – fold-overs
  – web curl

• proper tension control out of the lamination nip:
  – particularly in wet bond lamination where the bond strength between the layers has not yet formed
DESIGN CONSIDERATIONS IN A LAMINATOR

Web Handling

The handling of the webs into and out of the laminating section is critical for proper lamination. One needs to consider the following regarding web handling into and out of the laminating section:

- the inclusion of spreader rolls to address wrinkles
- the angle at which the webs are introduced to each other
  - to assure no contact between the webs prior to the lamination point
  - at a large enough angle between them to reduce the chance of air entrapped between the layers of the laminate
DESIGN CONSIDERATIONS IN A LAMINATOR

Guarding

Of extreme importance is the guarding of the laminating section for operator safety. The guards must be designed to:

• restrict access to the hazardous areas such as
  – in-running nip rolls
  – crush points (such as between bearing housings)
  – heated surfaces
  – drive transmission assemblies

• allow for the threading without compromising the operators’ safety

• allow for maintaining of the equipment without compromising the operators’ safety
CONCLUSION

There are several different ways to laminate webs together, with the choice of the proper system typically dependent on the products that are being combined.

Once the appropriate system has been selected, there are several critical design features of the laminator that need to be addressed to assure successful lamination of the product.
Acknowledgment

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