AN IN-DEPTH LOOK AT REVERSE ROLL COATING

John A. Pasquale, III
Senior Vice President
P.O. Box 377
Hawthorne, NJ 07507
AGENDA

• Operating Features - 3 Roll Reverse Roll Coater
• Effect of Gap and Roll Speed on the Coating Process
• A Look Inside the Coating Gap
• The Role of Coating Properties
• Coating Defects – can and how are they overcome?
• Is it the Coater or the Coating?
Nip Fed Reverse Roll Coater

- Metering Roll
- Applicator Roll
- Carrier Roll
- Doctoring Blades
- Gap Adjusters
Reverse Roll Coater
Reverse Roll Coaters

- Applicator roll operates at 1.2 - 2.5 times web speed to vary coating weight
- Metering roll operates from zero to web speed, based on coating rheology
- Useful for a wide range of coating thicknesses, viscosities and speeds
- Typical Coating Properties
  - Viscosity: 200 – 50,000 cps
  - Wet thickness: .0008” - .018”
  - Web speed: 25 – 1750 fpm
  - Uniformity: 1% with precision rolls and bearings
Reverse Roll Coaters

- Coating applied and precisely metered onto applicator roll at the gap between the metering roll and applicator roll

- Gap determines initial coating application
  - It can be set manually or by the use of servomotors
  - Thickness gauge monitoring and control equipment can be added
Reverse Roll Coaters

• Relationship of metering roll speed to applicator roll speed is a major factor
  – Reverse metering flow is the key to thickness and quality
    • A major advantage of using a reverse roll coater
  – Increasing the speed ratio of metering roll (Vm) to applicator roll (Va) decreases coating thickness (to a point)
    • Linear reduction related to \( 1 - \frac{Vm}{Va} \)
  – Metering roll to applicator roll speed ratio also affects the occurrence of coating defects for a particular coating
    • When \( \frac{Vm}{Va} \) is too low, ribbing defects appear
    • When \( \frac{Vm}{Va} \) is too great, cascading (seashoring) appears
A Look Inside the Coating Gap

Forces developed in the gap of non-deformable rolls include the following:

- Viscous – based on coating rheology and the flow pattern geometry entering the roll gap
- Resistive – roll separating force developed when deforming the coating
- Operating – the external force required to maintain the roll gap during operation
- Capillary – the effect of surface tension in the curved roll gap
The Role of Coating Properties

Each coating material has a Capillary Number (Ca)

\[ Ca = \frac{\mu V_A}{\sigma} \]

where: \( \mu = \text{viscosity} \)

\( \sigma = \text{surface energy} \)

\( V_A = \text{Applicator Roll Speed} \)
The Coating Window

Using the Reverse Roll Coating method there is a window or range of usable settings.

- This window is the region of Vm/Va (metering to applicator ratio) that produces a uniform coating.
  
  • Below this ratio you will encounter ribbing.
    
    - Transition to ribbing is gradual.
  
  • Above this ratio cascading (herringbone or seashore) will occur cross web. The bead oscillates at a set frequency and can entrain air.
    
    - This is a sharp change over.
Operating Window Diagram
• Increased Metering ratio will linearly reduce coating thickness…to a point.
  – Excessive metering to applicator ratio will move the wetting line to the upstream side of the gap which can cause-
    • air entrainment
    • cascading
    • unpredictable coat weight
Cascade Defect
Ribbing Defect

- Ribbing develops when the flow in the coating zone becomes unstable.
- It is a function of the hydrodynamic pressure gradient and surface tension that develops in the coating zone.
- Gap and roll speed variation are the prime variants when applying a coating of specific viscosity at a given speed.
- When gap is the major (or only) variant (forward roll, slot die, knife, etc) the onset of ribbing occurs more readily.
- When gap and roll speed variation can be altered (as in differential offset gravure, reverse roll, etc) ribbing is more readily eliminated.
- If ribbing can not be eliminated, it usually requires a change in the coating material rheology.
Ribbing
Is it the Coater or the Coating?

- This is always the “Big Question”
- Since you can alter the gap and roll speeds in a reverse roll coater, you have better control than when you use coaters that can change only one parameter.
- To deposit thin, high viscosity coatings, it may require the use of a five roll coater to get more film splits (photo follows).
- If you can not find an operating condition at which your coating runs well, you may have to change the coating properties to develop a different operating window.
Five Roll Coater
REFERENCES

The following references were used, with permission of the authors:

1. “Principles of Roll Coating Equipment”, by John A. Pasquale III

2. “Reverse Roll Coating of PSA Adhesives”, by William Strong

Special thanks are extended to William Strong of National Adhesives who generously provided some of the data and visual materials he has compiled for his company as an Adhesive Coating and Drying specialist for 15 years.
Questions or Comments?