VARIOUS COATING TECHNIQUES
AN OVERVIEW

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AGENDA

• Features of the following Coaters
  – Direct, Reverse and Offset Gravure
  – Kiss
  – Direct and Reverse Roll
  – Slot Die
  – Curtain
  – Knife Over Roll
  – Air Knife
  – Saturation/Dip and Squeeze

• Similarities and Differences

• Preferred Applications for Use
Selection

- There is no universally superior coating method, only the best type for a given application
- Know the coating properties, coat weight or thickness requirements, and desired accuracy
- Analyze the substrate properties – tension limitations, finish and caliper uniformity
- Look at the operating range and speed limitations of different coating methods
- Consider the cost to manufacture your products using any of the various methods
- Select a coater that enables you to manufacture the majority of your products successfully
Direct, Reverse and Offset Gravure Coaters

- **Direct** – Both rolls run opposed to each other at same speed
- **Reverse** – Anilox roll runs opposite direction of web
- **Offset** – Anilox roll runs in either direction to effect film split
Gravure Coaters

Factors That Affect Coating Weight and Quality

- Applicator roll pattern, cell volume and shape
- Impression roll covering thickness and durometer
- Applicator/impression roll nip pressure
- Doctor blade type and position
- Coating viscosity and flow properties
- Material and finish of web being coated
- Web speed and operating environment
Direct Gravure Coater

- Rolls rotate at same speed opposed to each other
- Coating transferred by nip force between rolls
- Coating metered by engraved cell pattern

- Useful for applying low to medium solids at moderate to high speed
- Typical Coating Properties
  - Viscosity: 10 – 2000 cps
  - Wet thickness: .0001” - .003”
  - Web speed: 25 – 2300 fpm
  - Uniformity: 2%
Reverse Gravure Coater

- Applicator roll rotates opposite the direction of the web
- Coating is metered and transferred by reverse action of applicator roll, removes cell pattern
- Film split between applicator roll and web affects coat weight

- Useful for applying low to medium solids at moderate to high speeds
- Typical Coating Properties
  - Viscosity: 10 – 2000 cps
  - Wet thickness: .0001”- .003”
  - Web speed: 25 – 2300 fpm
  - Uniformity: 2%
Offset Gravure Coater

• Transfer and Anilox rolls rotate at different speeds, affecting coating weight
• Two film splits further reduces coat weight
• Anilox roll operates in forward or reverse direction

• Useful for applying low to medium solids at moderate to high speeds
• Typical Coating Properties
  – Viscosity: 50 – 12000 cps
  – Wet thickness: .0001” - .005”
  – Web speed: 25 – 2500 fpm
  – Uniformity: 2%
Kiss Coater

- Applicator roll can be smooth or lightly engraved
- Coat weight based on web tension, wrap angle and roll speed
- This method has limited viscosity and speed range
- Coat weight can be further controlled by Mayer Rod unit

- Useful for applying low solids at low to moderate speeds
- Typical Coating Properties
  - Viscosity: 50 – 1000 cps
  - Wet thickness: .0002”- .003”
  - Web speed: 100 – 1000 fpm
  - Uniformity: 10%
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 by gap between metering roll and applicator roll

• Gap determines initial coating application
  – Gap set controlled manually or by the use of servomotors
  – Closed loop system using thickness gauge monitoring equipment can be added

• Speed of metering roll with respect to applicator roll
  – Controls coating quality
  – Allows small changes in coating thickness
Reverse Roll Coater
Direct (Forward) Roll Coaters

- Much more limited in its use compared to reverse roll coater
- Operates over a narrow low viscosity range
- Ribbing may easily occur due to roll speed and gap limitations
- Useful for applying low to medium solids at moderate speeds

- Typical Coating Properties
  - Viscosity: 20 – 2000 cps
  - Wet thickness: .0005” - .008”
  - Web speed: 100 – 1500 fpm
  - Uniformity: 7% - 10%
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.

- Shows an example of a “ribbing” pattern that occurs in a roll coater - caused by small gap/low roll speed.
Slot Die Coating

- Delivers a pre-metered amount of coating to the die
- Wide viscosity range – vacuum box used for low viscosity coatings
- Die to backing roll gap and die operating angle affect coat weight
  - Wide range of products
  - No recirculation
  - Operating Conditions:
    - Viscosity: 5 – 20000 cps
    - Wet thickness: .002”-.015”
    - Line speed: 20-1750 fpm
    - Accuracy: 2%
Curtain Coater

• Pre-metered amount of coating applied - dependent on flow rate, width, surface tension and coating rheology

• Curtain height, impingement and edge guides affect coating quality

• Used in paper coatings, photographic films, ink jet paper, and adhesives.

• Operating Conditions:
  – Viscosity:
    5 – 5000 cps
  – Wet thickness:
    .0003”-.012”
  – Line speed:
    250-1250 fpm
  – Accuracy: 2% - 5%
Knife Over Roll

• Applies heaviest coatings over a wide viscosity range
• Coating speed limited by shear forces at the blade
• Entry contour of the blade controls penetration into the web

Typical Coating Properties

- Viscosity: 100 – 50000 cps
- Wet thickness: .001” - .030”
- Web speed: 10 – 350fpm
- Uniformity: 3% - 10%
Air Knife Coating

• Useful for low viscosity water based coatings; knife pressure controls coverage.
• Coverage increases with speed & viscosity; decreases with air knife pressure.
• Susceptible to streaks & chatter
• Operates in metering and squeegee modes
• Operating Conditions:
  – Viscosity: 1 – 500 cps
  – Wet thickness: .0001” - .005”
  – Line speed:
    50 - 400 fpm - metering
    125 – 2000 fpm - squeegee
  – Accuracy: 5%
Saturation/Dip and Squeeze

- Self-metering system - uses free meniscus to apply coating
- Web exposure, viscosity and surface tension dependent
- Nip pressure can saturate or impregnate the web

Typical Coating Properties
- Viscosity: 10 – 3000 cps
- Wet thickness: .002” - .016”
- Web speed: 50 – 1000 fpm
- Uniformity: 7% - 10%
## Summary of Coaters

<table>
<thead>
<tr>
<th>Coater Type</th>
<th>Viscosity Range (cps)</th>
<th>Wet Thickness (in.)</th>
<th>Line Speed Range (fpm)</th>
<th>Uniformity (%)</th>
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</thead>
<tbody>
<tr>
<td>Direct Gravure</td>
<td>10-2000</td>
<td>.0001-.003</td>
<td>25-2300</td>
<td>2</td>
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<tr>
<td>Reverse Gravure</td>
<td>10-2000</td>
<td>.0001-.003</td>
<td>25-2300</td>
<td>2</td>
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<tr>
<td>Offset Gravure</td>
<td>50-12000</td>
<td>.0001-.005</td>
<td>25-2500</td>
<td>2</td>
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<td>Kiss</td>
<td>50-1000</td>
<td>.0002-.003</td>
<td>100-1000</td>
<td>10</td>
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<td>Reverse Roll</td>
<td>200-50000</td>
<td>.0008-.018</td>
<td>25-1750</td>
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<td>Direct (Forward) Roll</td>
<td>20-2000</td>
<td>.0005-.008</td>
<td>100-1500</td>
<td>7-10</td>
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<td>Slot Die</td>
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<td>.002-.015</td>
<td>20-1750</td>
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<td>Curtain</td>
<td>5-5000</td>
<td>.0003-.012</td>
<td>250-1250</td>
<td>2-5</td>
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<td>Knife Over Roll</td>
<td>100-50000</td>
<td>.001-.030</td>
<td>10-350</td>
<td>3-10</td>
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<td>Air Knife</td>
<td>1-500</td>
<td>.0001-.005</td>
<td>50-400 – metering 125-2000 – squeegee</td>
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<tr>
<td>Saturation/Dip &amp; Squeeze</td>
<td>10-3000</td>
<td>.002-.016</td>
<td>50-1000</td>
<td>7-10</td>
</tr>
</tbody>
</table>
REFERENCES

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

1. “Principles of Roll Coating Equipment”, by John A. Pasquale III
2. “Coating Methods: Selecting the Right Coating Methods”, by Dr. Edward D. Cohen

Special thanks are extended to Dr. Edward D. Cohen who generously provided some of the data and visual materials he has compiled over many years of service to the industry.