Sheet Forming and Formers

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Water Removal

Forming Section
5,947 gpm

Press Section
124 gpm

Dryer Section
72 gpm

Most water removal occurs in the forming section. Since fibers are hydrophilic, water removal gets increasingly difficult.
Types of Formers

- Fourdrinier
- Hybrid or Top Wire
- Twin Wire or Gap
Board & Packaging – MultiPly Formers

Two ply using secondary headbox

Two ply using mini top fourdrinier

Three ply using multiple fourdriniers
Fourdrinier Terminology

- Typical forming table layout
  - Breast roll
  - Forming board
  - Foil boxes
  - Low vacuum boxes
  - Flatboxes or high vacuum boxes
  - Couch roll
  - Wire turning roll
  - Wire return rolls (including guide and stretch rolls)
Fourdrinier Basic Functions

- Forms and consolidates the fibers into a web
- Increase consistency of the sheet from <1% at the slice to 20-25% at the couch.
- Retain the fiber and filler – typically around 85% first pass retention.
- Provide the best Z-direction uniformity possible – one of the limitations for fourdrinier machines.
- Transfer the sheet into the presses.
The Problem of Flocculation

- Most papers formed at less than 0.7%.
- Fibers like to form networks called flocs.
- Flocs result in lumpy paper, poor formation.
Forming Process

Forming is a combination of three hydro-dynamic processes:

- Drainage
- Oriented Shear
- Turbulence

- Each occurs simultaneously and can be controlled within limits by the papermaker.
- It is the control of these processes that will ultimately determine the characteristics of the paper produced.
Forming Process

Drainage

INITIAL FORMING (OVER FORMING BOARD)

THICKENING FIBER MAT

THICKENING

FIBER MAT DEVELOPED (AFTER FORMING BOARD)

PREFILTERED SUSPENSION

FILTERED FIBER MAT

FILTRATION
Forming Process

Drainage

FIBER MAT DEVELOPMENT ON A TRIPLE LAYER FABRIC

2.0 gsm

4.0 gsm

7.0 gsm

10.0 gsm
Controlling Slice Flow

- The way the jet hits on the forming wire controls initial fiber mat formation.
- Retention of fines and filler depend on good mat formation.
Controlling Slice Flow

- L = bottom lip extension
- b = slice opening
- L/b ratio.
- L/b determines jet angle.
- Velocity forming vs. pressure forming.
3 DEGREE IMPINGEMENT

Pressure forming vs. Velocity Forming

5 DEGREE IMPINGEMENT
Shear at slice impingement

- The speed of the jet leaving the headbox can be faster or slower than the forming fabric.
- This creates shear on the bottom side of the jet.
- This speed difference is called rush/drag or jet-to-wire.
- It can be stated as a speed ratio or as the exact speed difference in fpm.

Point of shear
Forming Process
Turbulence

- Turbulence is added to the forming zone to minimize floc formation.
- Turbulence doesn’t last.
- Smaller the scale, faster it dissipates.
- Must constantly be added.
Forming Board

- First drainage element on the former
- First blade is wider and has a rugged mount system
- Blades are flat (usually)
- Gap should open up as the front wall follows down the breast roll
Forming Board

- Supports the forming fabric
- Catches the headbox jet
- Must be very rigid to avoid deflection and vibration under load
- Usually fix mounted but some models can be moved on the run

Weavexx Adjustable FB
Forming

Two examples of jet delivery over the forming board

Case 1

Case 2
Foil Unit

Blade angles are fixed. Must be removed to change the angle and stock activity.
Gravity Foils - Concept

- Slurry
- Suspended Layer
- Dewatering
- Forming Wire
- Machine Direction
- Activity
- Mat
- Angle of Divergence
- Foil Blade
- Foil Pressure Profile

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Blade Spacing

Pulse Profile
Relationship Between Foil Spacing And Pulse Frequency

Frequency \( (H_z) \) = \( \frac{\text{Fabric Speed (mpm)}}{0.06 \times \text{Blade Spacing (mm)}} \)

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Description</th>
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<tbody>
<tr>
<td>&lt;30 Hz</td>
<td>Difficult to agitate stock</td>
</tr>
<tr>
<td>30-40</td>
<td>Historical design standard</td>
</tr>
<tr>
<td>80-100 Hz</td>
<td>Present design standard</td>
</tr>
<tr>
<td>100 Hz</td>
<td>Maximum possible for fourdrinier</td>
</tr>
<tr>
<td>150+ Hz</td>
<td>Gap or top-wire formers</td>
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</tbody>
</table>

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Operation of Foils

- Foil blade angles and widths are variables used to develop controlled activity.
- Maximum foil angle of 3 degrees for slow machines and typically 0.5-1.0 degrees on fast machines.
  - Experience and trial and error is used to find the right set up
  - Goal is fine scale turbulence and controlled drainage
- Long fiber furnish is more difficult to agitate
Examples of Activity Level

MD

Low

Transition

High
Foil box activity

Initiate Activity

Maintain Activity

Note the two different types of blade construction
Moveable Angle Foil Units

IBS Hydroline foil units with adjustable angles and height.
Low Vacuum Boxes

Bottom discharge Lovac
- high flow capacity
- low \( \Delta P \) potential
- require pan depth or modification to w/w tray for leg height

End discharge Lovac
- low flow capacity
- high \( \Delta P \) potential
- can fit in shallow pan area
- require space on back side of machine for drop leg
Low Vacuum Boxes

- Lovacs take over at 2-3% consistency.
- Lower drag and energy than high vacs.
- Capable of up to 10% consistency (6% more common).
- Use blower for vacuum needs-- 5-50” water.

Bottom discharge
Low Vacuum Boxes

- Low vacs should be connected to a separate vacuum blower.
- Each box needs a separator.
- Special control valves designed for low vacuum operation are normally used.
- Alternately a hand valve can be used on the box to bleed air into the box reducing the vacuum.
Low Vac Operating Limits

Forming fabric

Wire to vacuum inlet

Maximum Allowable Vacuum

Wire to overflow

Vac In

Lovac Body

Drop Leg

Seal Pot

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Low Vac Operating Limits

Low Vac Box Vacuum

Vacuum exceeds maximum allowable

Vacuum Level, in. water

Time
Pulsative Drainage Units

- Controlled activity without sealing the sheet.
- Early attempts with lovacs after the forming board unsuccessful.
- Two types of pulsative drainage units
  - broken plane
  - step foils
Broken Plane Unit

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Step Foil Unit

EXPANSION

COMPRESSION

2 - 10" H₂O VACUUM
Moveable Element Lovac Units

IBS Varioline flovac units with height adjustable t-bars and control blades.
Flatbox (Hivac) Operation

- Take over from lovacs
- Vacuum levels of 5-50 kPa (1.5-15”Hg)
- Consistency of 14-19% before couch
- High drag load so want to minimize the number of boxes
- High quality ceramic covers a must on high speed machines
Flatbox (Hivac) Operation

<table>
<thead>
<tr>
<th>( \Delta P ) Inches Hg</th>
<th>% Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOX 1</td>
<td>BOX 2</td>
</tr>
<tr>
<td>3.8</td>
<td>4.6</td>
</tr>
<tr>
<td>1.4</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>1.5</strong></td>
<td><strong>5.2</strong></td>
</tr>
<tr>
<td>3.0</td>
<td>4.8</td>
</tr>
<tr>
<td>1.4</td>
<td>4.8</td>
</tr>
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</table>

* BC: Before Couch  ** AC: After Couch (15” Hg)

Air Flow Density 2 cfm/in²  1.8 cfm/in²

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Couch

- Vacuum of 15-25” Hg
- Takes the sheet from 16% consistency up to 22-24%.
- Consolidates the sheet.
- Shower water 1.6 gpm/100”
- Rewetting
  - outgoing side past deflector
  - incoming side past the wipe
- Double doctors result in drier sheet to presses
Couch Rewet
Double Doctor On Couch
Forming Drainage Elements

Couch Roll Setup

Sheet Rewetting

Full Width Packing Strips

Correct Setting, Throw-Off goes in Saveall

Hi

Vacuum Box

Lo

Saveall

Couch Roll Adjustment

Deckle Adjusters

Worn Gear Adjuster

Couch Roll Vacuum Box Adjustment
Forming

Example of Good Couch Throw-off
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