Design and Operation of Headboxes

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Headbox Video
Basic Headbox Functions

- Convert CD flow in a pipe to uniform MD flow out a nozzle.
- Deflocculate the stock.
- Control basis weight in the MD, CD, and minimize random variation.
- Control fiber orientation.
- Provide control over forming variables such as jet impingement and jet speed.
Development of the Headbox Inlet (Manifold)
Tapered Manifold
Development of the Headbox Manifold

4 to 6 pipe diameters

Tapered Inlet Header
Recirculation Line

Recirculation Valve

No more than 5 psi pressure drop across the valve
Main Fiber Orientation with Recirculation too small and too large

- recirculation
- main fiber orientation

recirculation too small

recirculation too large

MD
Alternate Technology

Radial Distributor
Headbox Types

- Three basic types of headboxes
  - Open
  - Rectifier roll (Air Pad)
  - Hydraulic
- Within the types are a number of styles
Open Headbox

First type of headbox (slow machine speeds)
Jet speed regulated by height of the liquid level in the vat or pond
As speeds increased, so did the height of the vat until it became impractical
Only seen today on some pulp machines and old, slow specialty machines
This lead to the development of a closed headbox pressurized with air

St. Regis Paper Co.'s “Whatsit Box” Tacoma, WA.
Rectifier Roll Headboxes

- High pressure drop tube bundle (varies with supplier).
- Stilling chamber to allow turbulence to settle down-1.0-1.5 fps pond velocity.
- Rectifier rolls to deflocculate stock.
- Air pad with level control used to provide desired head (pressure)
Rectifier Roll Headboxes
Two styles of hole pattern shown

Square
Spiral
Rectifier Headbox Wake Effect

Roll distance to slice lip is important to prevent streaking.
Rectifier Roll Headboxes

- **Advantages**
  - Air pad “cushions” pulsations.
  - Good flexibility for wide speed range.

- **Disadvantages**
  - Large flocs left in jet discharge.
  - Max speed around 3500 fpm.
  - Cause streaks if overloaded.
  - Maintenance of moving parts.
Hydraulic Headboxes

- First developed to work with twin wire formers
  - Work at any angle
  - No air pad
  - Much smaller
- Higher stock velocity 7-15 fps
- Deflocculation by hydraulic shear
Hydraulic Headboxes
Early Fourdrinier Style

Stock Inlet
Tube Bank
Plate
Stock to Fabric
Converflo Element
Stilling Chamber
Tapered Header
Recirculation Outlet
Hydraulic Headbox

- Advantages
  - Smaller size
  - Higher shear to deflocculate the stock
  - No moving parts
  - Have not yet reached a speed limit

- Disadvantages
  - Less flexibility for speed range
  - Higher pressure drop – more energy
  - Narrower range for MD/CD fiber ratio
  - Susceptible to MD weight variation from pressure pulsation or vibration
Controlling CD Profile

Traditional Slice Lip Bending
Slice Bending

Slice Lip

Basis Weight
Controlling CD Profile

Dilution Control

- Dilution profiling is selective consistency control in the cross direction
  - Much narrower (better) control of weight
  - Does not cause fiber orientation issues
  - Greater range of control up or down on weight
- Requires additional equipment on headbox and on the control systems
Dilution Control

Slice Opening Uniform

Velocity Uniform

Consistency Varied

Tube Flow Rate Unchanged

White Water Injection

Main Header Flow
Voith Consistency Profile System

ModuleJet I Unit MasterJet II

Motor – by HMX

White water control valve

Parabolic headers

Throttle

Mixing chamber

TAPPI Paper Machine Operations Course
Consistency Profile Water

- Water usually from the silo
- Dedicated pump with barrier screen to keep debris from plugging the CP valves
CD Weight Responses for Dilution and Slice Controlled Headboxes

-400 -300 -200 -100 0 100 200 300 400

Dilution Control
60 mm Actuator Spacing

Slice Control
100 mm Actuator Spacing

60 mm dilution zone
Headbox Nozzle

Door is called the pond side

Lamellas in the Headbox Nozzle

Lamella length can be optimized for:
- Jet Quality
- Eliminate Tiger Stripes
- MD/CD Ratio
- Formation

Outlet of Turbulence Generator - with grooves for Lamella mounting
Nozzle Lamella

- Used to provide micro turbulence in the jet to aid formation
- Variables include length, thickness, type of tip (tapered or blunt)
- Can be damaged in handling. Avoid excessive bending and surface damage (scratches)
- Follow guidelines for chemical and temperature exposure
- Inspect on regular basis
Nozzle Lamella

- Sheets supplied in polycarbonate (Lexan), graphite, or polyphenylene sulphone (PPSU)
  - Lexan is clear
  - PPSU is blue
- Each has its advantages and disadvantages
The apron is a highly polished and precision machined piece. It must be protected from scratches and mechanical damage or profile will suffer.
Basic Headbox Controls

- Total Head
  - Head is another name for pressure inside the headbox
  - Pressure determines the jet velocity
  - The jet can be faster or slower than the forming fabric
    - This is called jet-to-wire (J/W) ratio
    - The computer may show this as an actual speed difference in fpm (+/-) or as a ratio (ratio of 1.0 is equal speed)
  - Head is normally controlled by fan pump speed but some older machines use a large valve in the approach pipe
Basic Headbox Controls

- J/W ratio
  - Jet to wire ratio influences:
    - MD/CD fiber ratio (sheet squareness)
    - This effects ratio of sheet properties like tensile and tear
    - Changes sheet shrinkage and draw
    - Changes formation
  - Tough to measure accurately and very small changes make a difference
How do you determine your actual j/w ratio?

The ratio of MD and CD tensile strengths is a good indicator: it will have a minimum at jet speed = wire speed.
Another way is to measure the sheet width at the reel. The maximum sheet width is at the square point.

![Graph showing indicated and real sheet widths](image)
Basic Headbox Controls

- Slice Flow
  - Slice flow determines the consistency inside the headbox (amount of dilution of the fibers).
  - This effect sheet formation and sheet properties.
  - Lowering consistency means more water on the table and may be a problem.
Basic Headbox Controls

- **Slice Flow**
  - To increase the slice flow you normally open the vertical slice
    - This lowers the pressure inside the headbox and the fan pump rpm will increase to provide constant head
    - If the fan pump is in manual control, head will drop and no change in flow occurs
Headbox Problems

- Over-sized for application
- No longer capable of handling the flow.
  - Streaky sheet
  - Edge problems
  - Bulging, leaking headbox
- Physical problems
  - Warped, lining coming loose, rust
  - Physical damage to inside, slice lip, or apron
Increase in Internal Pressure

- Jet velocity is determined by the pressure in the headbox.
- In air padded boxes, this is the sum of the hydrostatic pressure and the pressure of the air pad.
- For low speeds, $V = (2gh)^{1/2}$. 

![Graph showing total head in a headbox with speed in feet per minute]
Valmet Original Headbox
Valmet Original Headbox
New GL&V Headbox
New GL&V Headbox
Design and Operation of Headboxes

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