Consistency and Freeness

Pulp Consistency

- Definition
- Ranges
- On-line measurement
- Control principles
- Reference: “Accurate Consistency: a handbook on accurate consistency”

- Consistency is the percent of oven dry mass in the pulp

$$\text{Consistency} = \frac{\text{Dry weight of sample}}{\text{Total weight of sample}} \; 100\%$$

- Accurate consistency control vital to uniform quality and production
- Consistency affects the efficiency and productivity all most all unit operations
  - Many have narrow operation range, eg screens plug at too high consistency
  - Many have narrow range of efficient operation, eg, cleaners are not effective above 1.5% consistency.

Consistency ranges

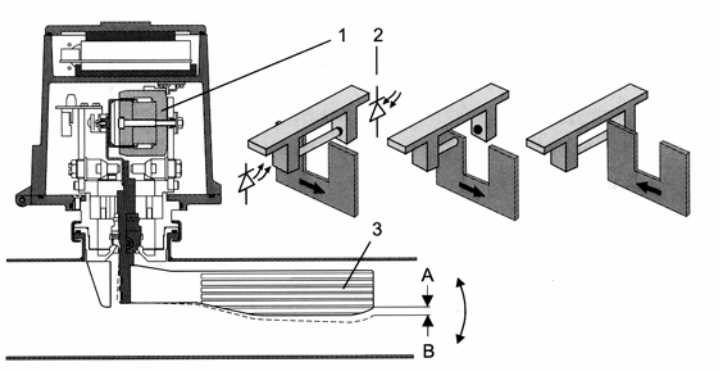
12-40%	High Consistency	Mechanical pulping, reject refining, bleaching, storage
5-12%	Medium Consistency	Cooking, bleaching, storage, repulping
1-5%	Low Consistency	Stock prep, cleaning, screening, beating blending
0.1-1.0%	Very Low Consistency	Headbox, whitewater flotation deinking
0.01-0.1%	Ultra Low Cnsistency	Clarifier, clear white water

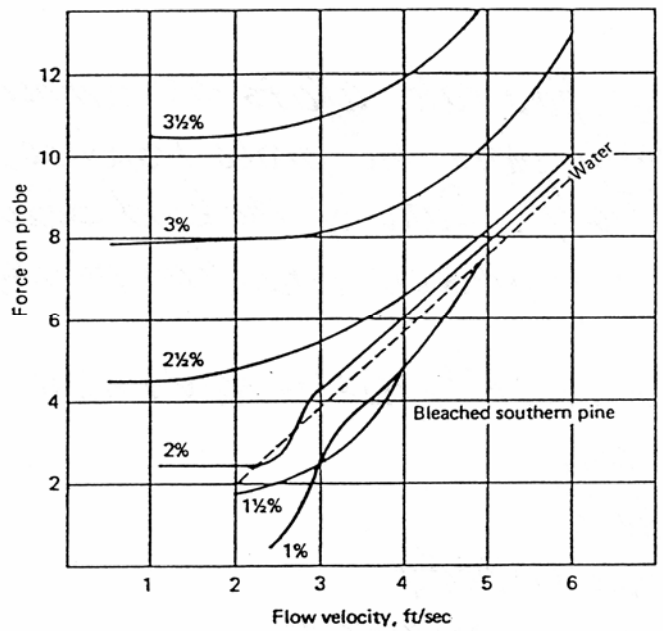
Consistency Measurement

- Shear Force
  - Most widely used in the industry
  - Blade (passive)
    - A blade is placed in the pulp flow.
    - Force on the blade is dependent on network strength and fluid velocity
  - Rotating (active)
    - More accurate and expensive
    - Effective fluid velocity is more controlled

Blade consistency transmitters

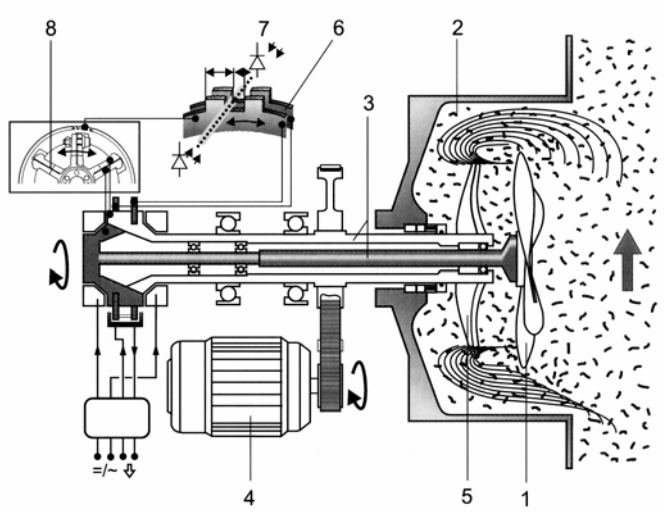
- Practical consistency range 0.8 to 16%, velocity range 0.3 to 1.4 m/s
- Different consistencies give different drag relations
- Network strength dependent on
  - Pulp type
  - Fibre length, filler and fines content.
  - Pulp processing, refinign …
  - Chemical addition, ph





Rotating consistency transmitters

- Very common, more reliable and expensive
- Consistency range > 0.8%, velocity range 0.1 to 1.4 m/s
- Rotor speed is large with respect to flow velocity therefore approximately independent of flow
- Dependent on factors affecting network strength



Other methods

- Optical
  - Light scattering / absorption (1980's)
  - Transmission or reflection types
  - Hope to get accurate low consistency measurements. Not very accurate or reliable.
  - Dependent on total surface of fibres
    - Varies with refining, fines content, filler etc.

Other methods

- Nuclear, gamma gauge
  - Detect density of fluid
    - In theory it is possible to calculate consistency from the density difference between water and cellulose fibres.
    - Cellulose is approx 1.5 g/ml
  - Very sensitive to high Z (Nuclear mass) material. Fillers i.e. clay, CaCO3, TiO
  - Black liquor content

Other methods

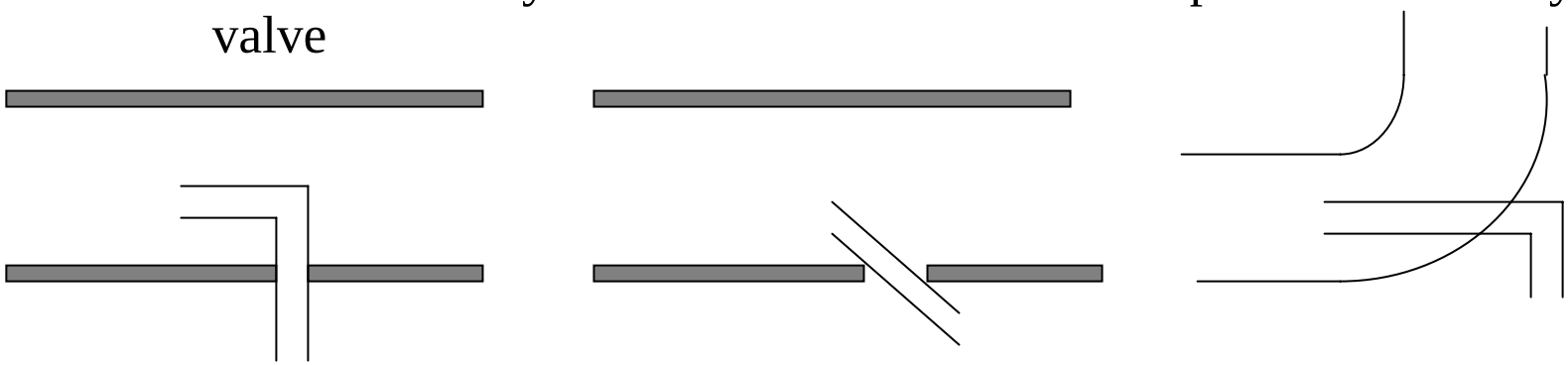
- Microwave
  - Measures wave speed through fluid
  - Calculate the dielectric constant .. Get water content.
  - Range 1% to 25%
  - Depends on
    - Air content in water
    - Conductivity, liquor and bleaching carryover
    - Poorly mixed pulp
    - Deposits on sensor

Other methods

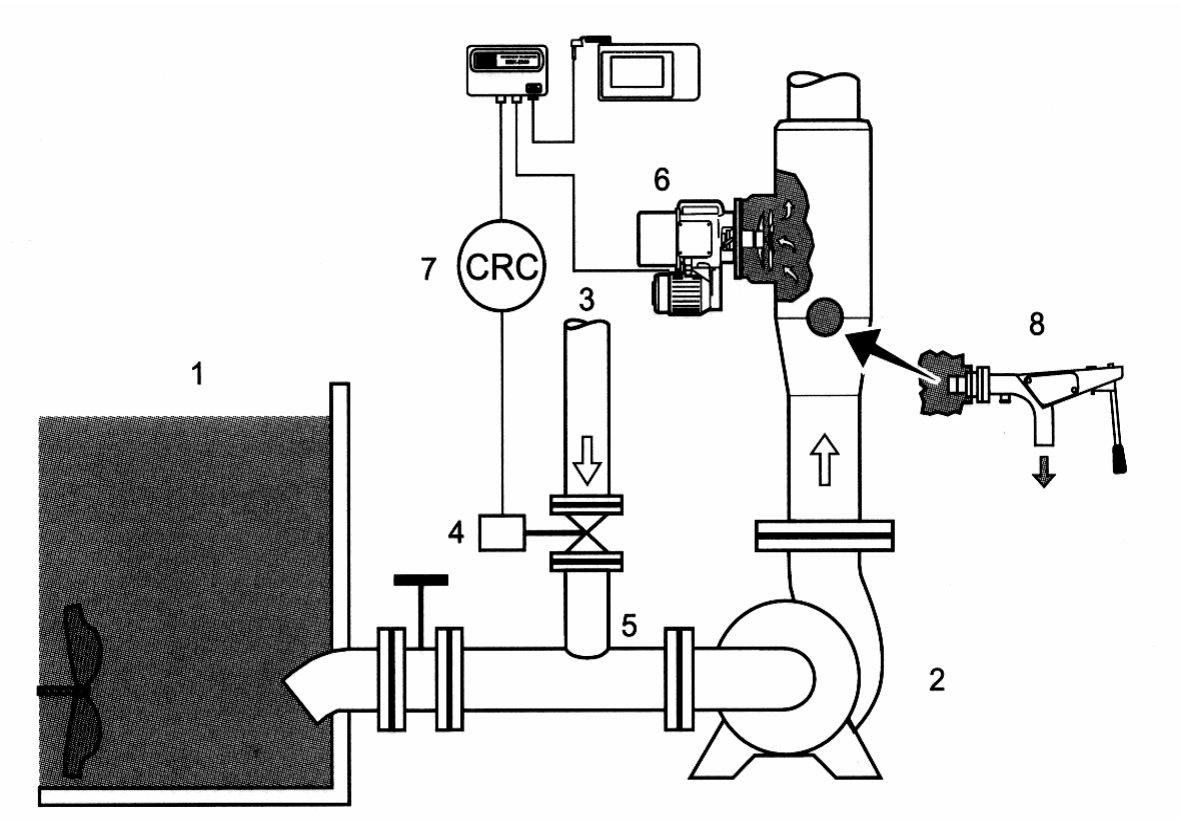
- Pressure drop across a length of pipe
- Ultrasound
- Video imaging …
- For greater 30% consistency
  - NIR
  - Dielectric measurement of water
  - No really good method to measure these high consistencies

Laboratory Measurements

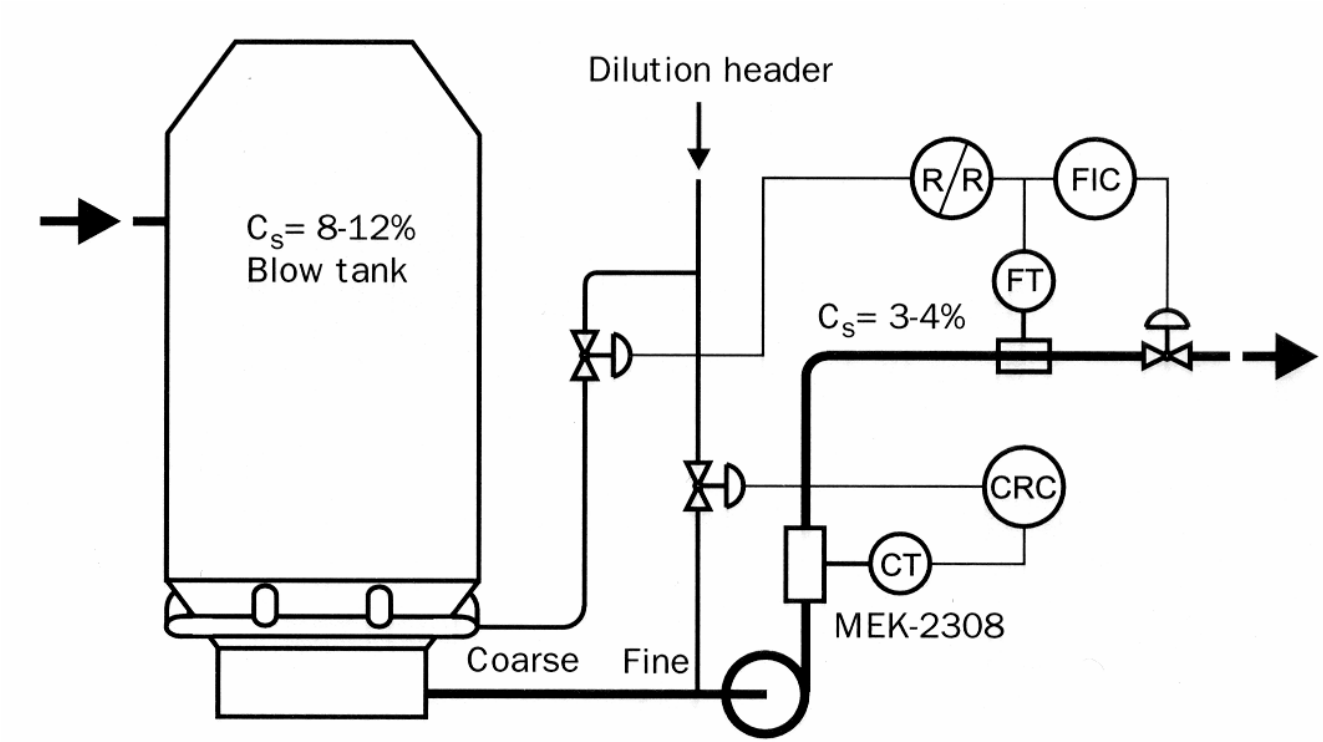
- Oven dry for
- Sampling: Difficult to get representative sample
  - Varies with time so you need a sampling time long enough to get average
  - Varies spatially in flow
    - Plug in the centre of the pipe, water annulus at wall, therefore an artificially low sample consistency if tapped off the wall
    - Need to ensure a proper sampling tap placement.
  - Dewaters easily at valve. Need ball valve or special consistency valve



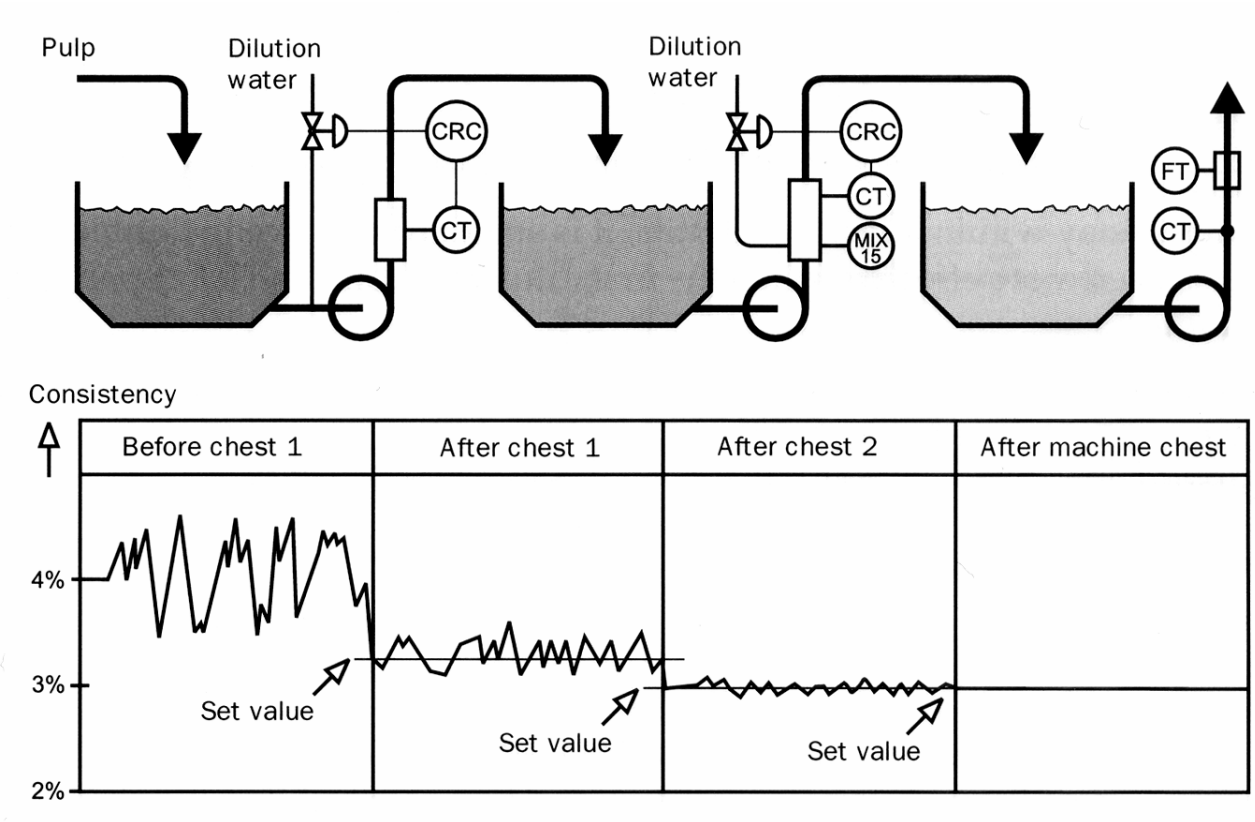
Consistency control



Blow tank consistency control



Staged consistency control



Canadian Standard Freeness

- Ability of water to drain through the pulp
- Measured as volume of water draining through side-orifice (units of mL)
- Function of surface area, coarseness, fibrillation, flexiblity, fines content, others …

CHAMBER

FUNNEL