Flocculation of cellulose fibres in a pipe flow - preliminary measurements of floc size by ultrasonic technique (UVP)

S. Skali-lami (University of Lorraine)
M. Campolo (University of Udine)
M. Simeoni (University of Udine)

Summary

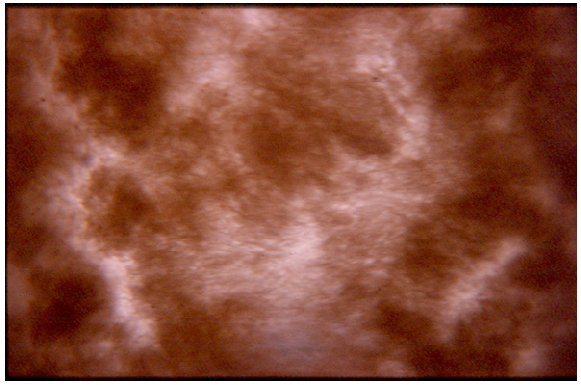
- Flocs in pulp flow-> behaviour in pipe
- Why it is relevant to measure the floc size in the pulp flow?
- Principle of UVP technique -> to measure flocculation rate.
- Preliminary results of floc size
- Conclusion

Flocculation in pulp flow

Flocculation is intrinsic and natural phenomenon of fibres
->(stiffness of the paper)

Pulp

Flocculation



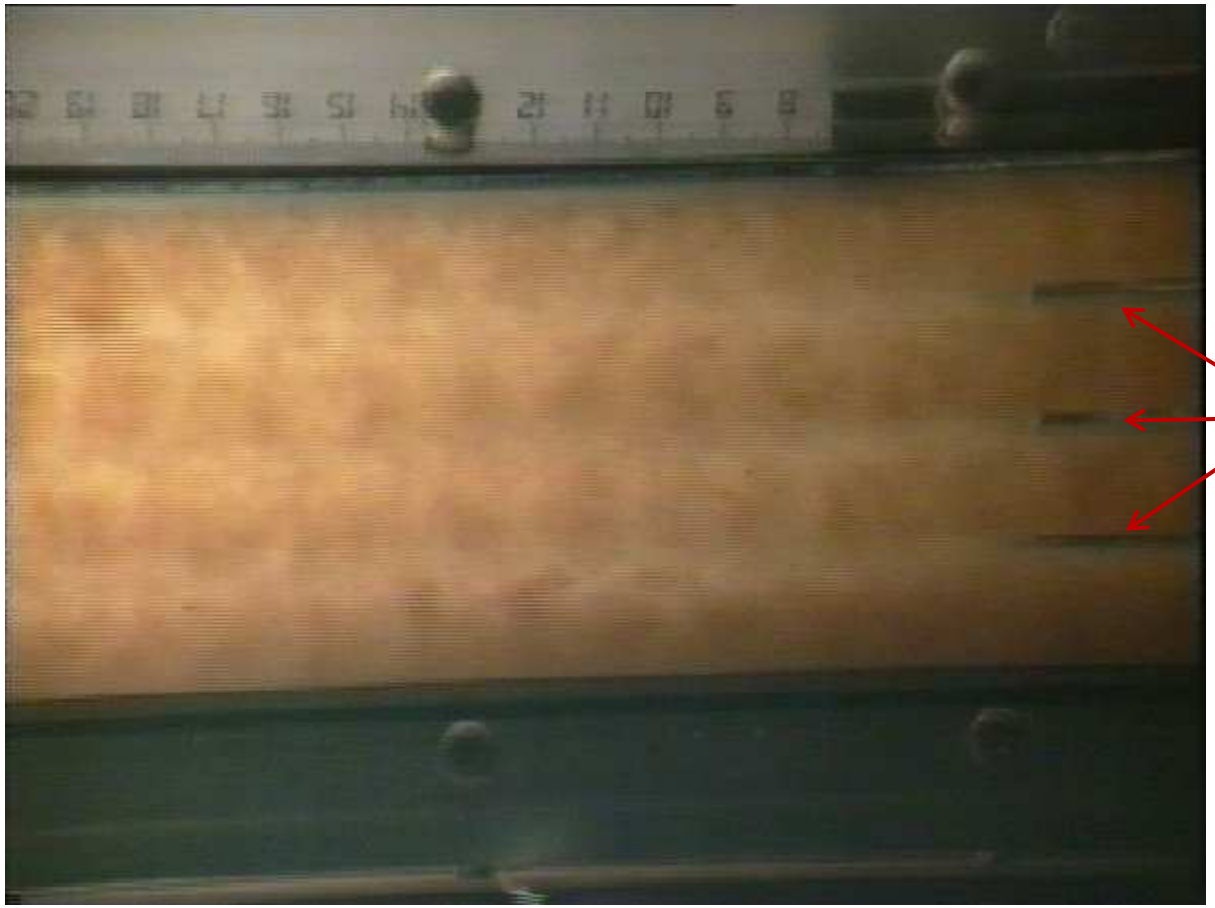
Flocculation - shear flow - turbulence: Complex Interactions
-> limitations in papermaking

Flocculation in pulp flow

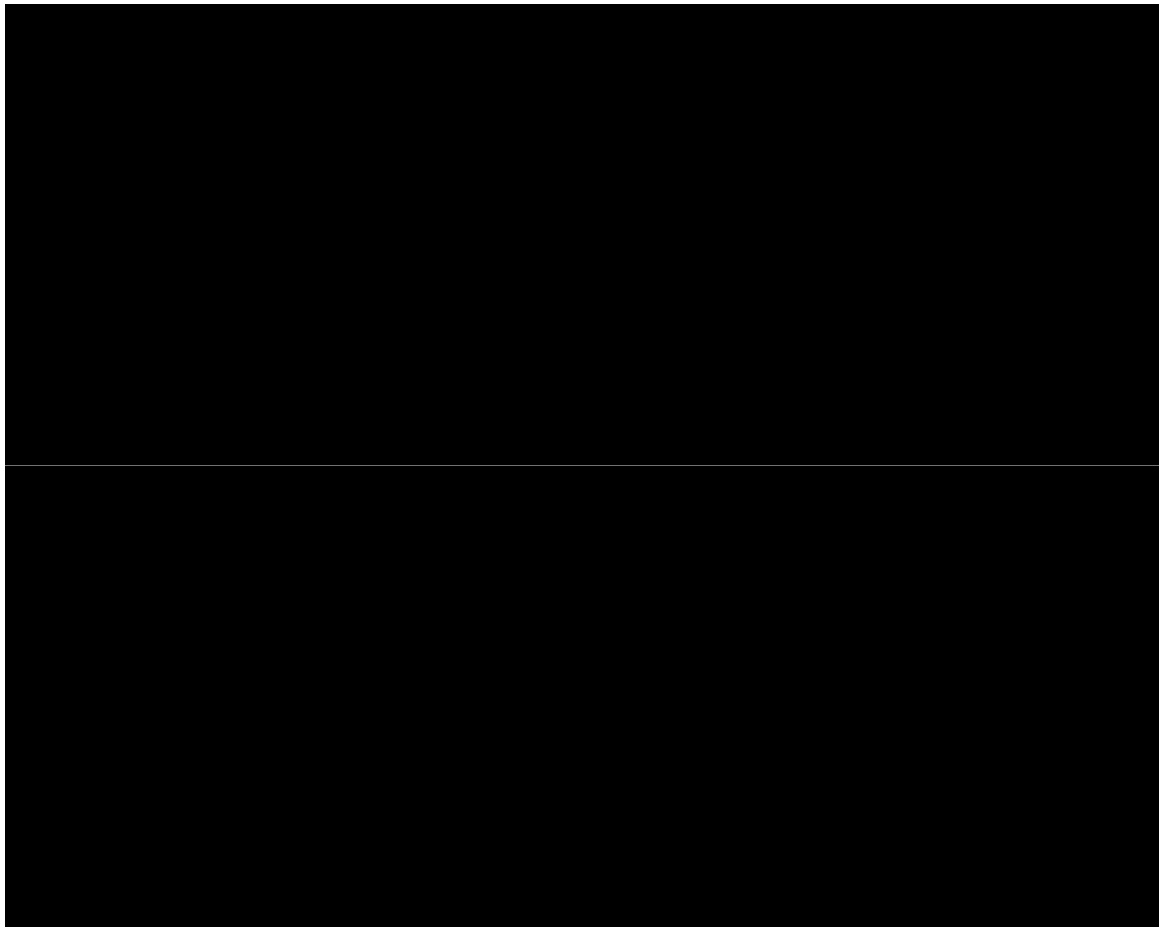
Flocculation in pure shear flow : pulp flow in Couette device

Flocculation in pulp flow

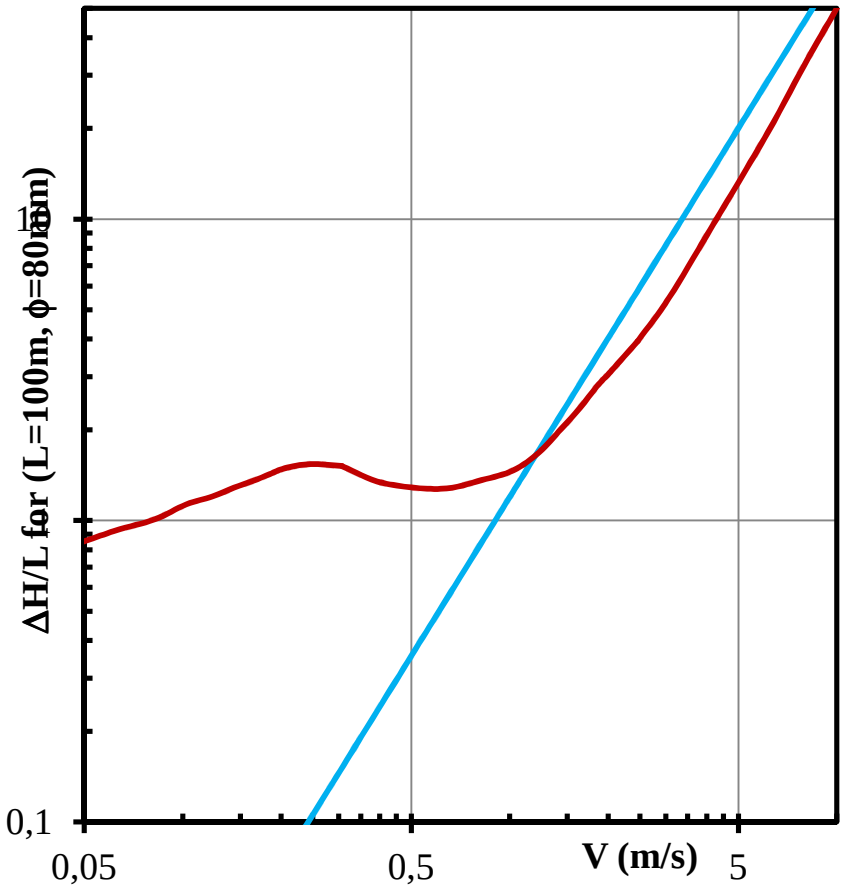
Flow of pulp of paper in rectangular channel



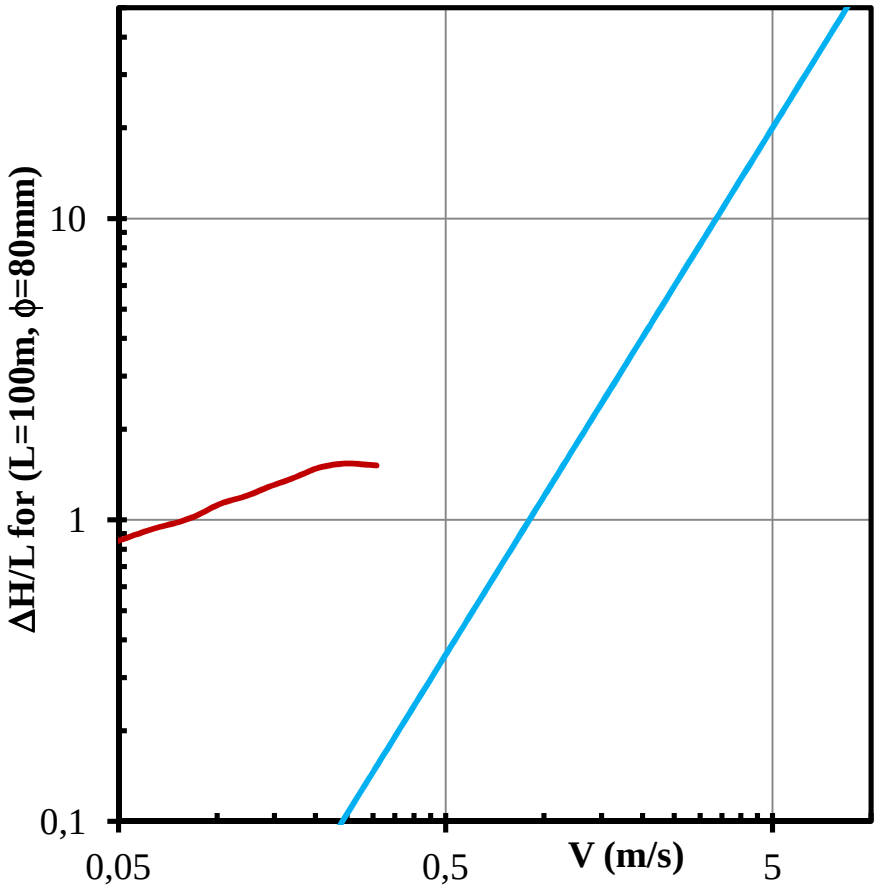
Flocculation in pulp flow



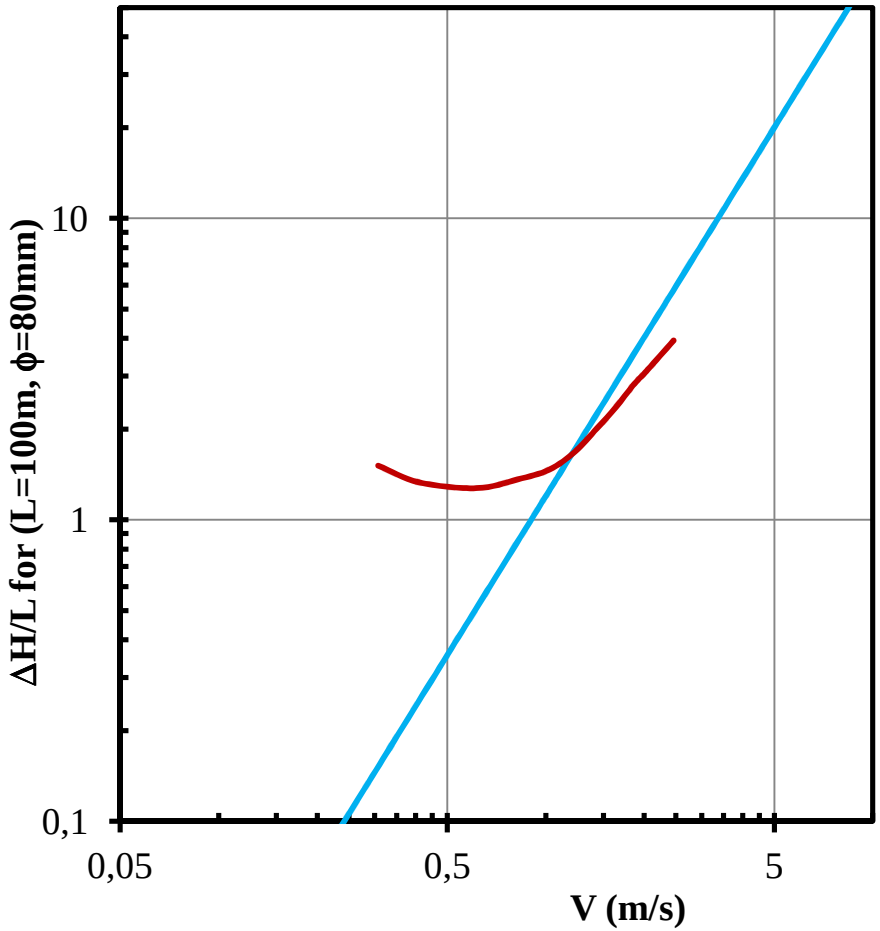
Pulp flow in pipes



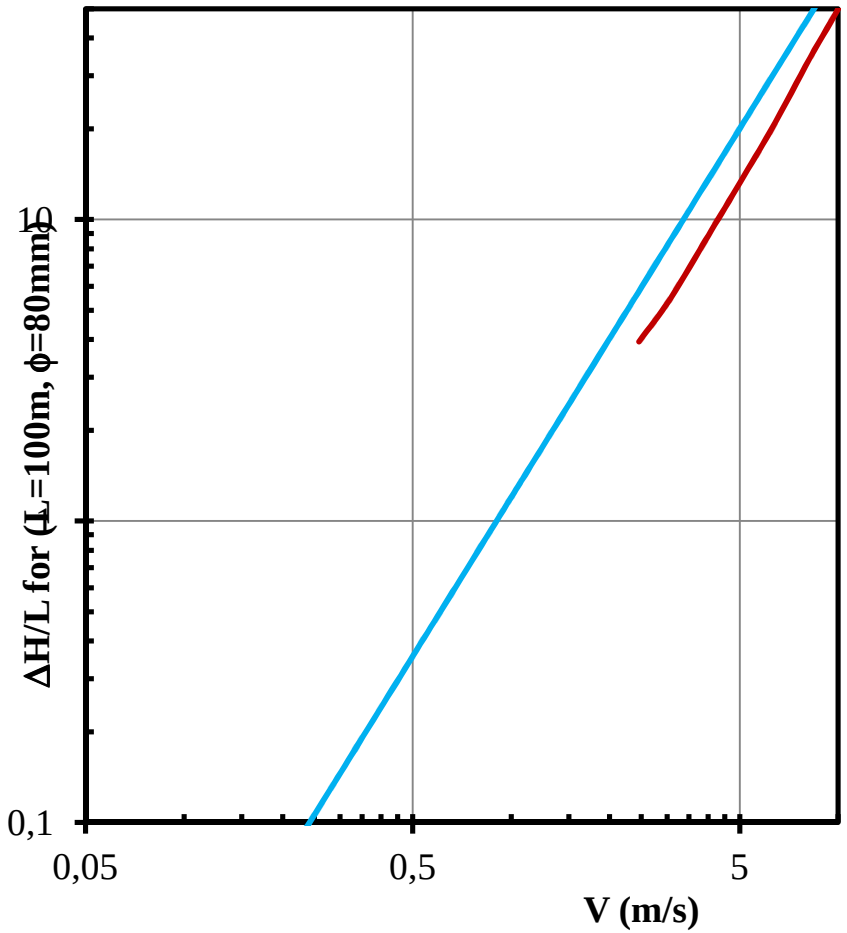
Pulp flow in pipes



Pulp flow in pipes

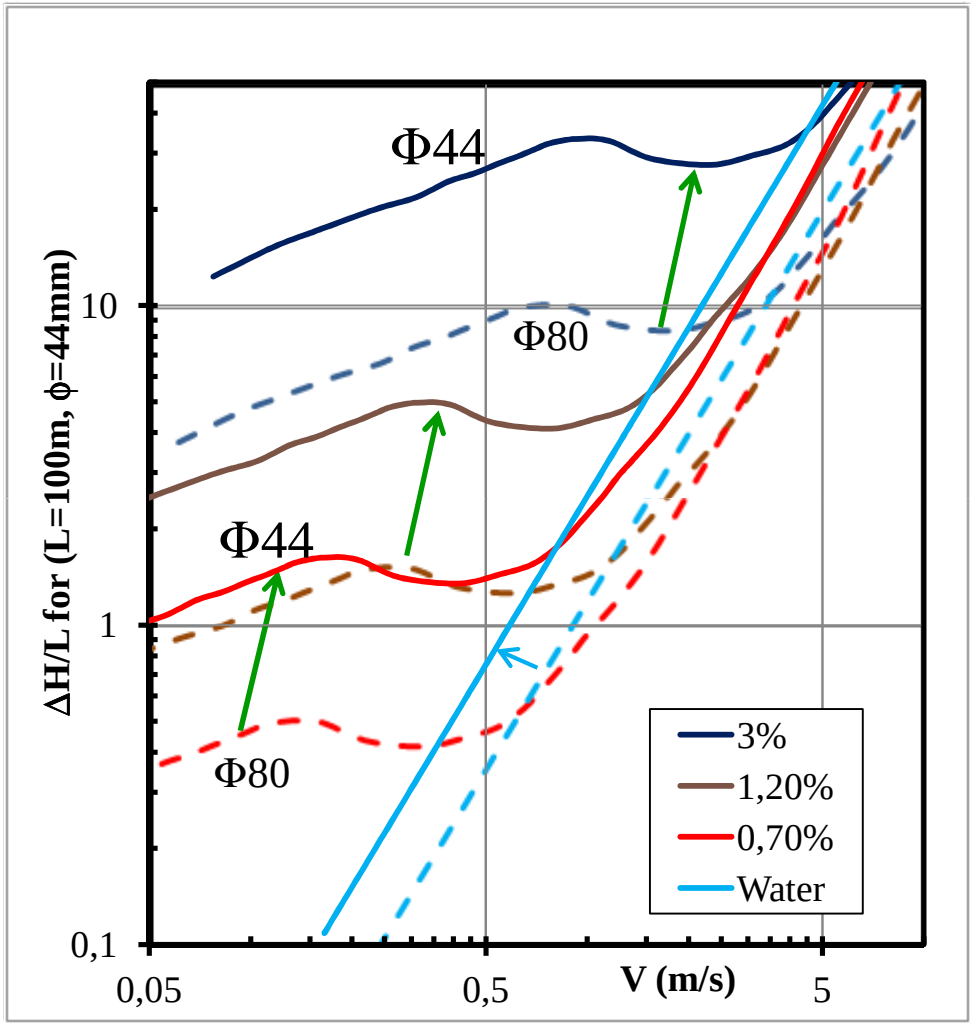


Pulp flow in pipes

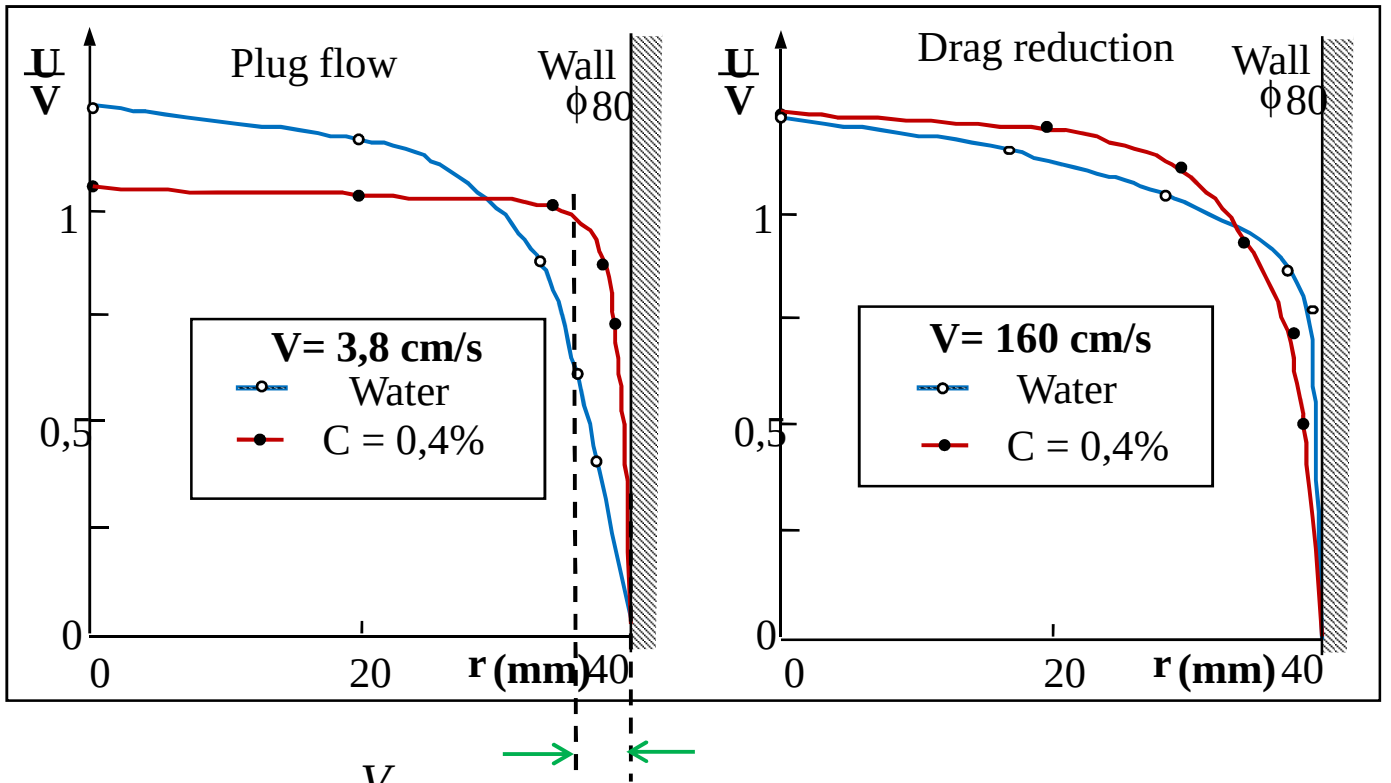


Pulp flow in pipes

Φ80mm → Φ44mm



Pulp flow in pipes



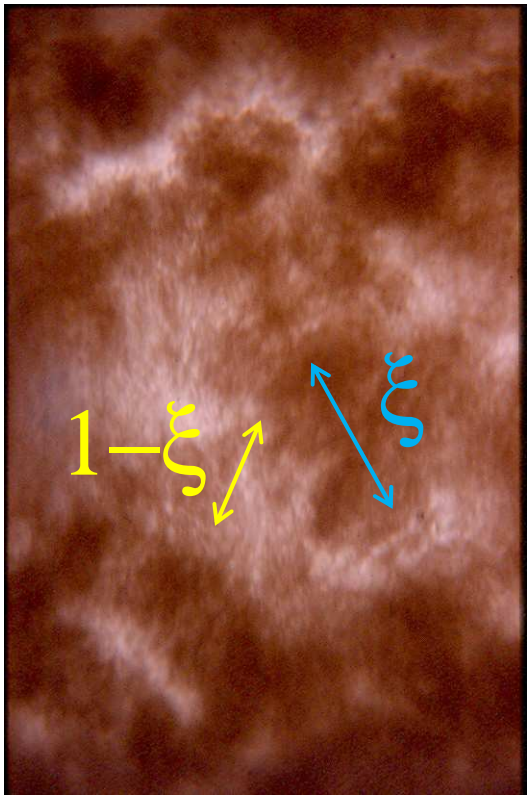
$$\tau_w = \mu_{water}\,\gamma_w \succ\succ \mu_{water}\,\frac{V}{\delta}$$

δ : liquid film

Why the Floc size is an relevant parameter in pulp flow ?

Theoretical approach

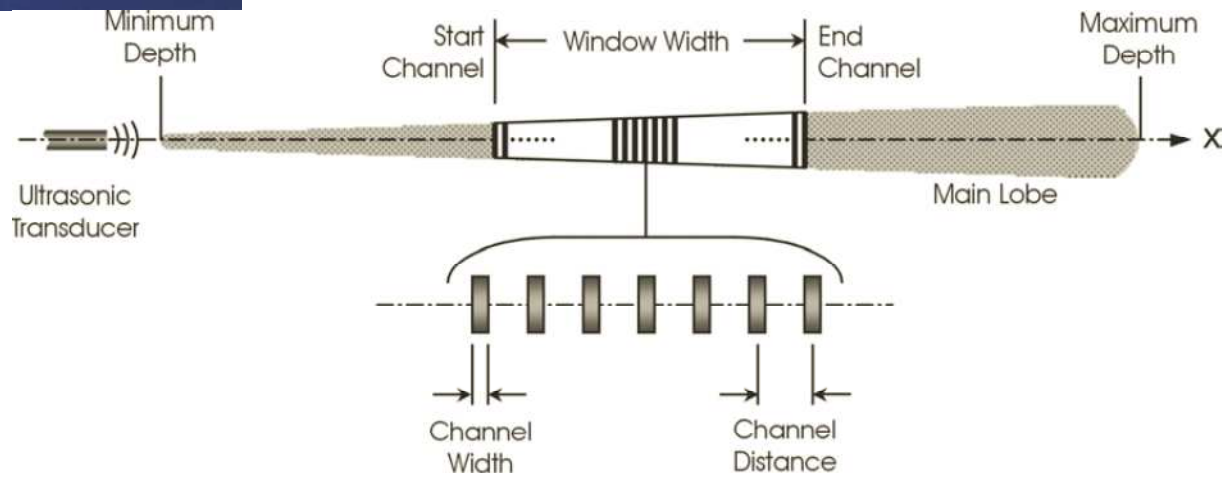
$$\sigma_{ij} = -\left(\frac{\delta_{ij}}{V}\int_{V-\Sigma v_0} P\, dV\right) + \mu(U_{i,j} + U_{j,i}) - \left(\frac{1}{V}\int_{V-\Sigma v_0} \rho\, \overline{u_i' u_j'}\, dV\right) + \sigma_{ij}^{f}$$



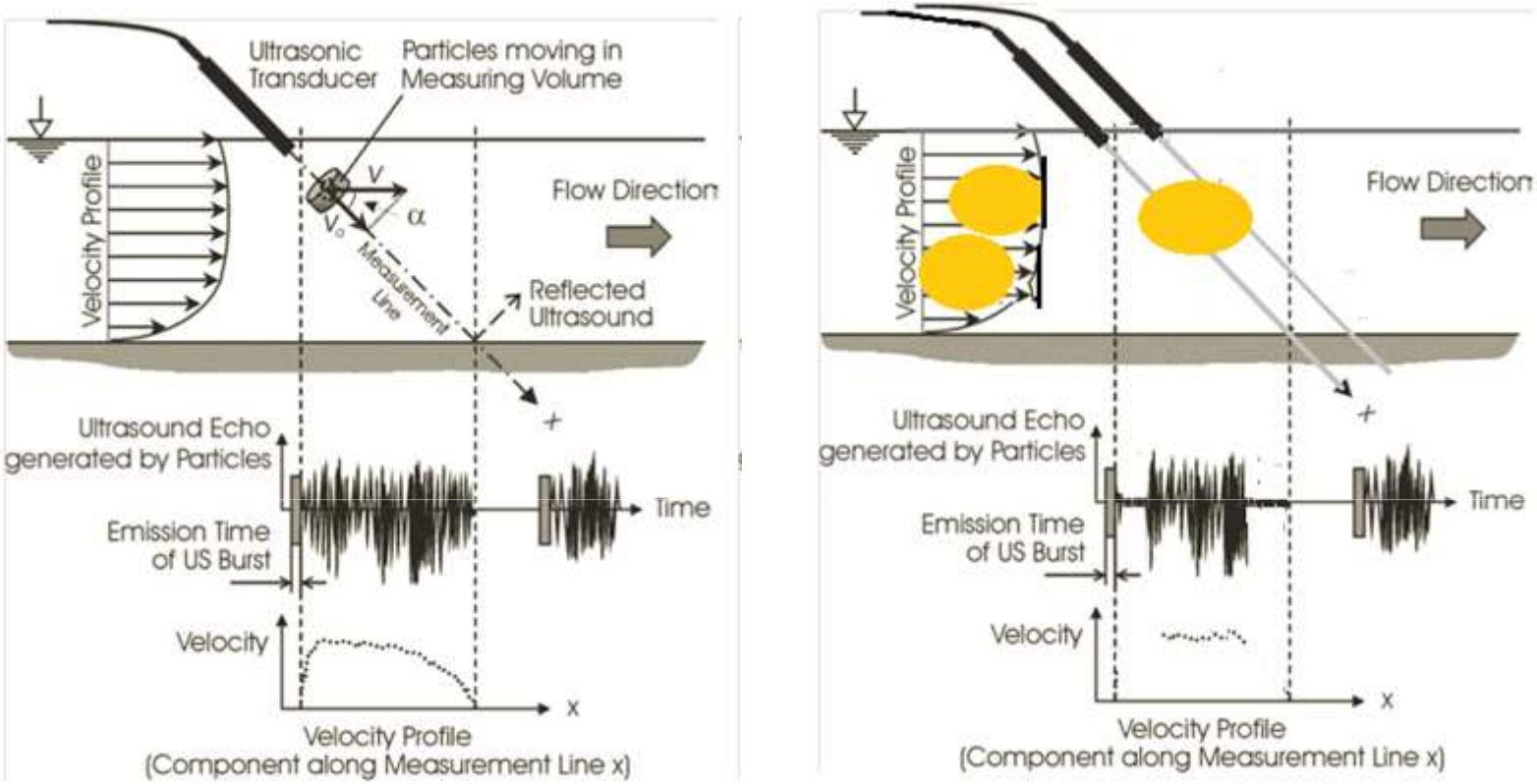
$$\sigma_{ij}^{f} = \cdot$$

$$\sigma_{ij}^{f} = [\sigma$$

UVP Technique -> flocculation rate



UVP technique with 2 probes



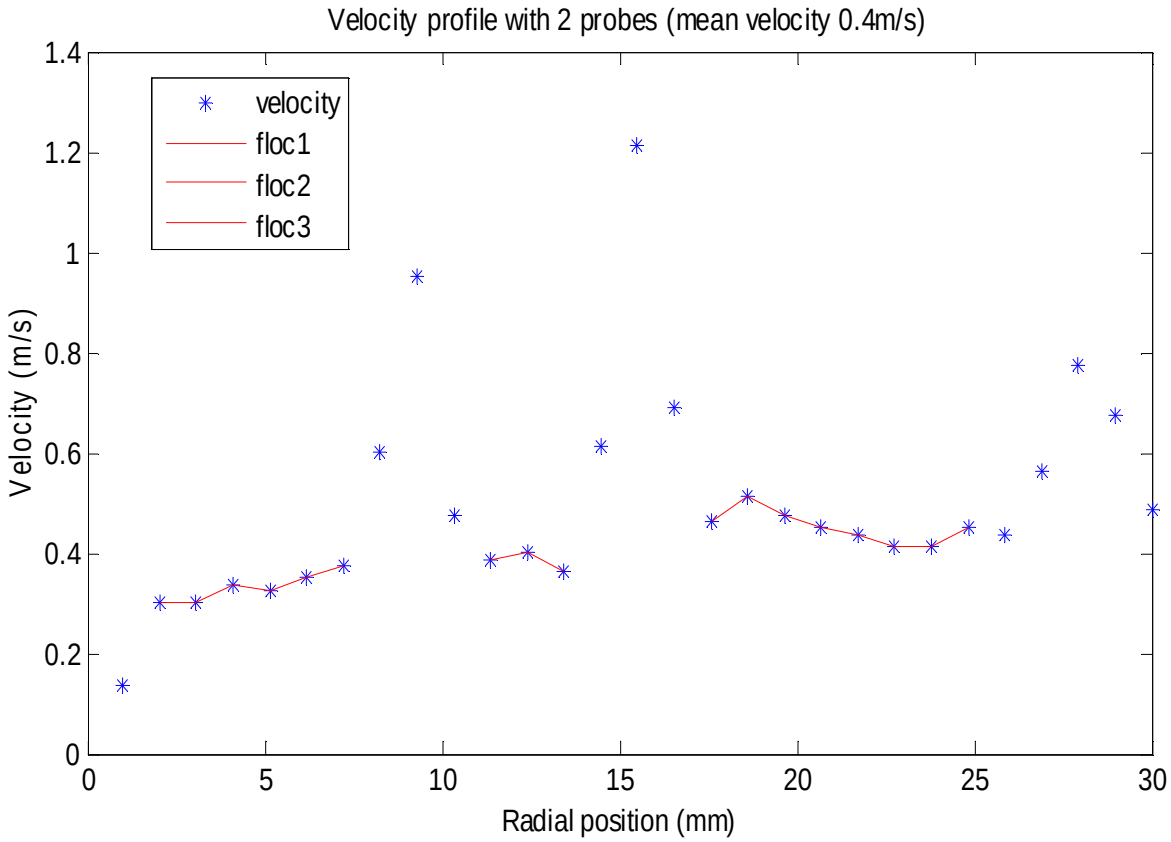
The instantaneous coupling signals of two ultrasonic probes can discriminate the Doppler shift emanate from a rigid structure (identical for both probes transmission) or a fluid structure (different velocity for the two probes)

UVP Technique -> flocculation rate

As a test of the validity of measurement of flocculation by two coupled ultrasound probes:

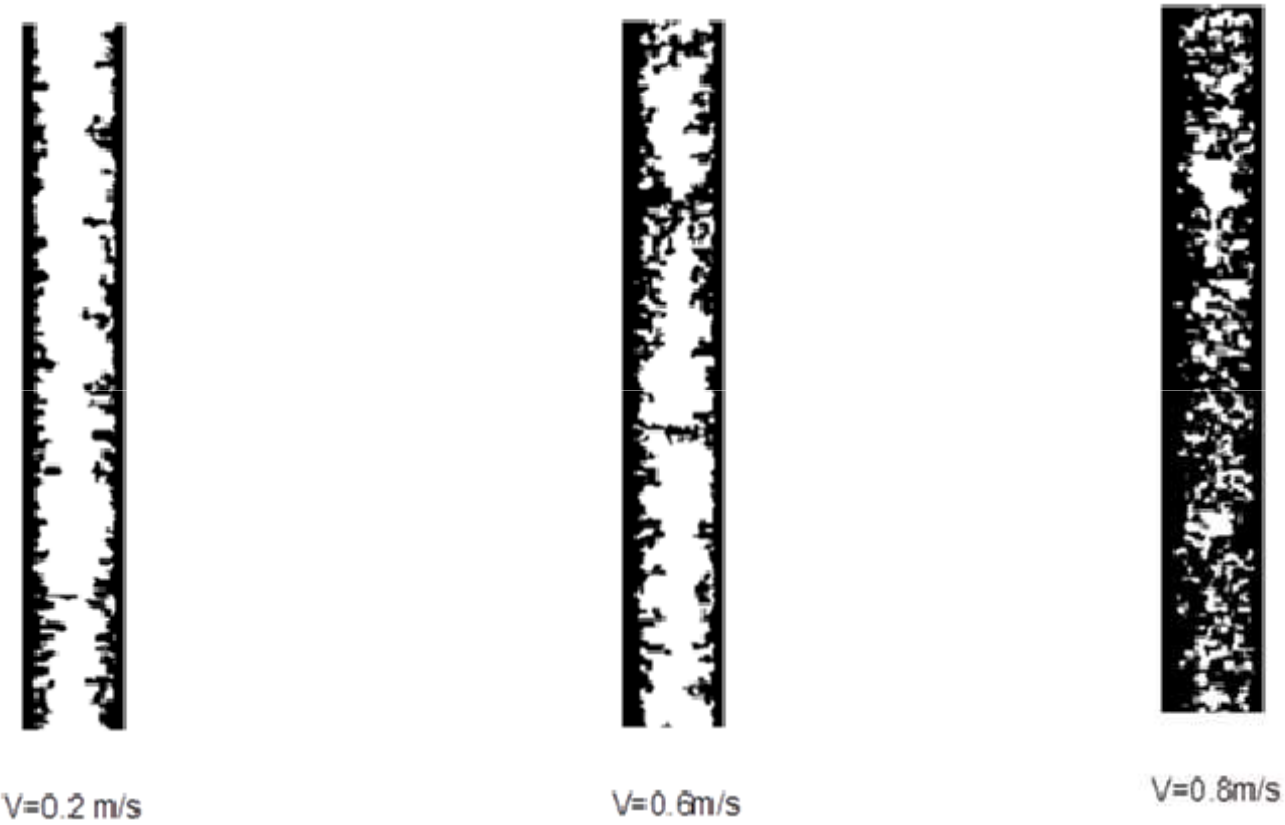
- Pipe of 30mm diameter
- Concentration of fibre suspension : about 0.6% weight
- Flow rates and pressure drops were not measured in these tests.

Sample of 1 velocity profile



Discontinuity in the velocity profile (outliers) at the junction of the flocs red line (two coupled signal provided by probes).

Preliminary results of floc size by UVP



Principal conclusions

- UVP using a coupled two probes appears to be a promising technique for measuring the floc size in a flow of pulp
- Future : * optimisation of the distance between probes
  * measurements in different conditions (C,V,D and ΔP)
- Theoretical approach need distribution of flocs size vs parameters of flow (C, V, D).

Thank you for your attention

Emile Gallé Nancy Artist