oe4625 Dredge Pumps and Slurry Transport

Vaclav Matousek
October 13, 2004

Delft University of Technology

6. SPECIAL SLURRY FLOW CONDITIONS

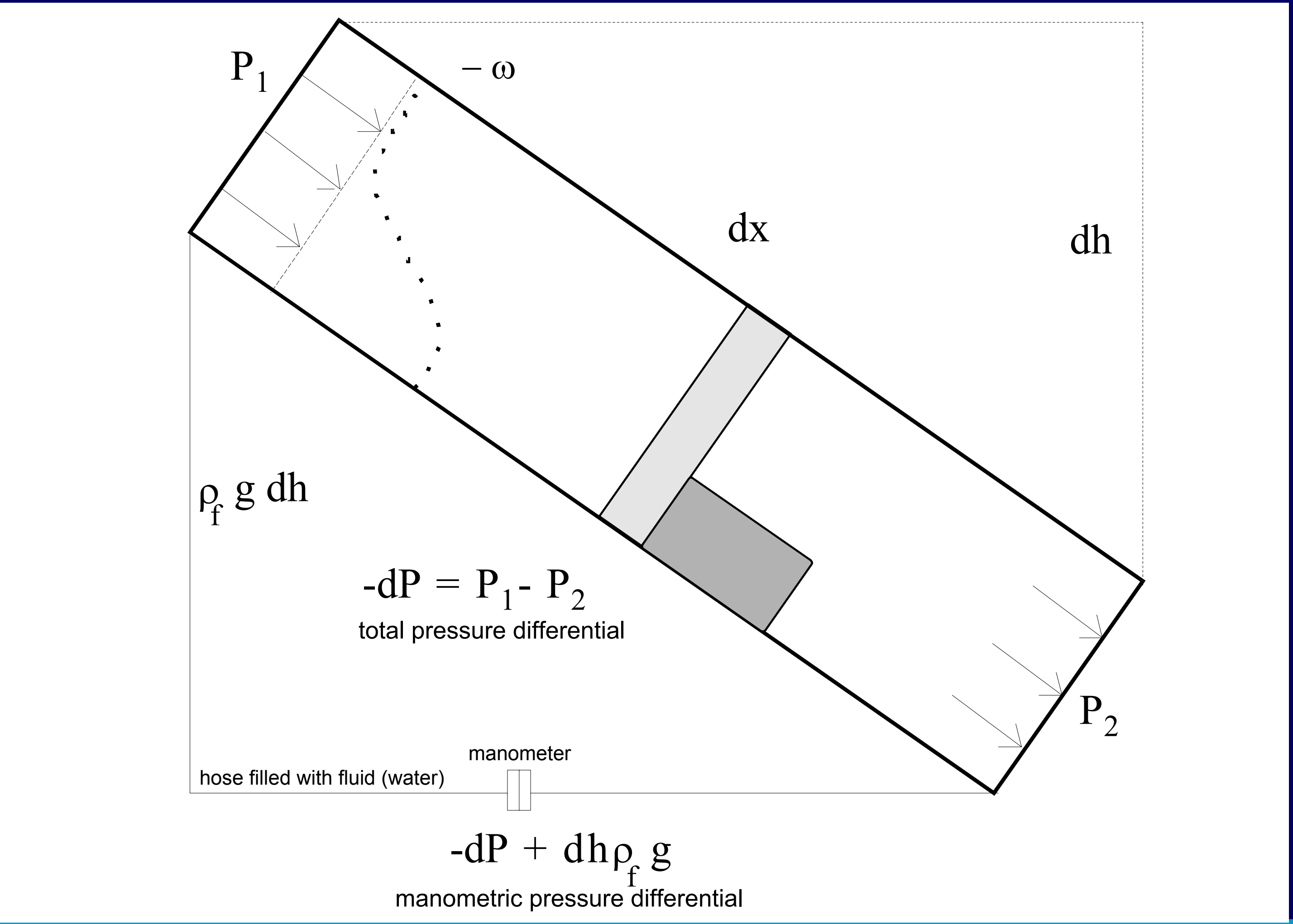
INCLINED FLOWS

UNSTEADY SOLIDS FLOWS

INCLINED FLOWS

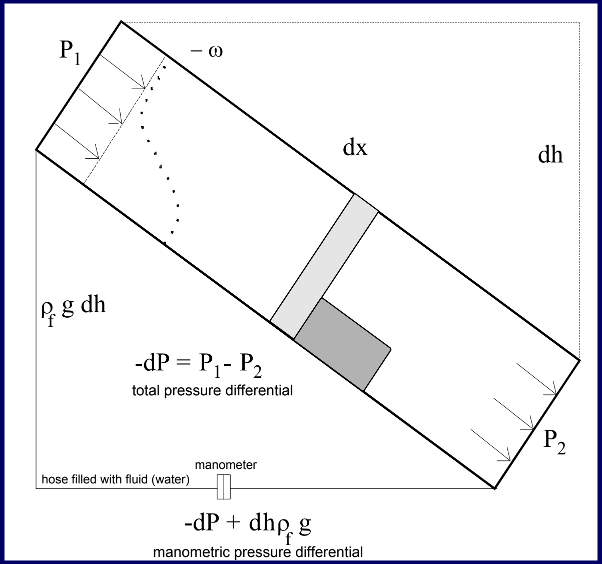
PRINCIPLES AND MODELING

Inclined Flows



TUDelft

Inclined Flows



A. Physical background:

The **total pressure gradient:**

(P1-P2)/dx = -dP/dx over a pipe section of the length *dx* is composed of

the **static pressure gradient:** *d(gh)/dx*, giving the potentially reversible effect of elevation change on the total pressure gradient in a slurry flow of the density gaining the height *h* and

the **pressure gradient due to friction:** *-dP/dx - d(gh)/dx* that is the irrecoverable energy loss due to friction in inclined slurry flow over the pipe length *dx*.

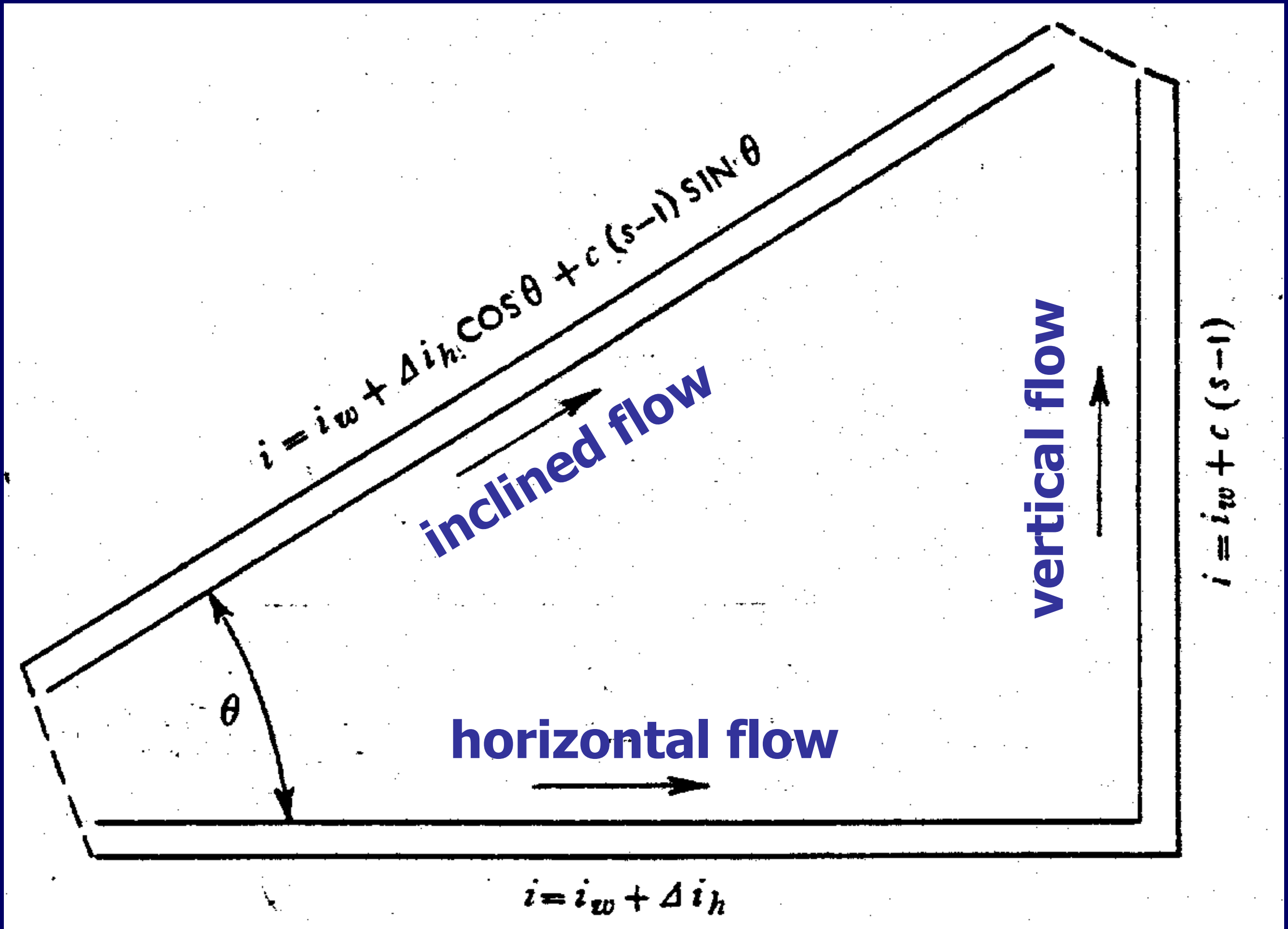
Inclined Flows: Worster-Denny Model

B. Construction of the model for I_m:

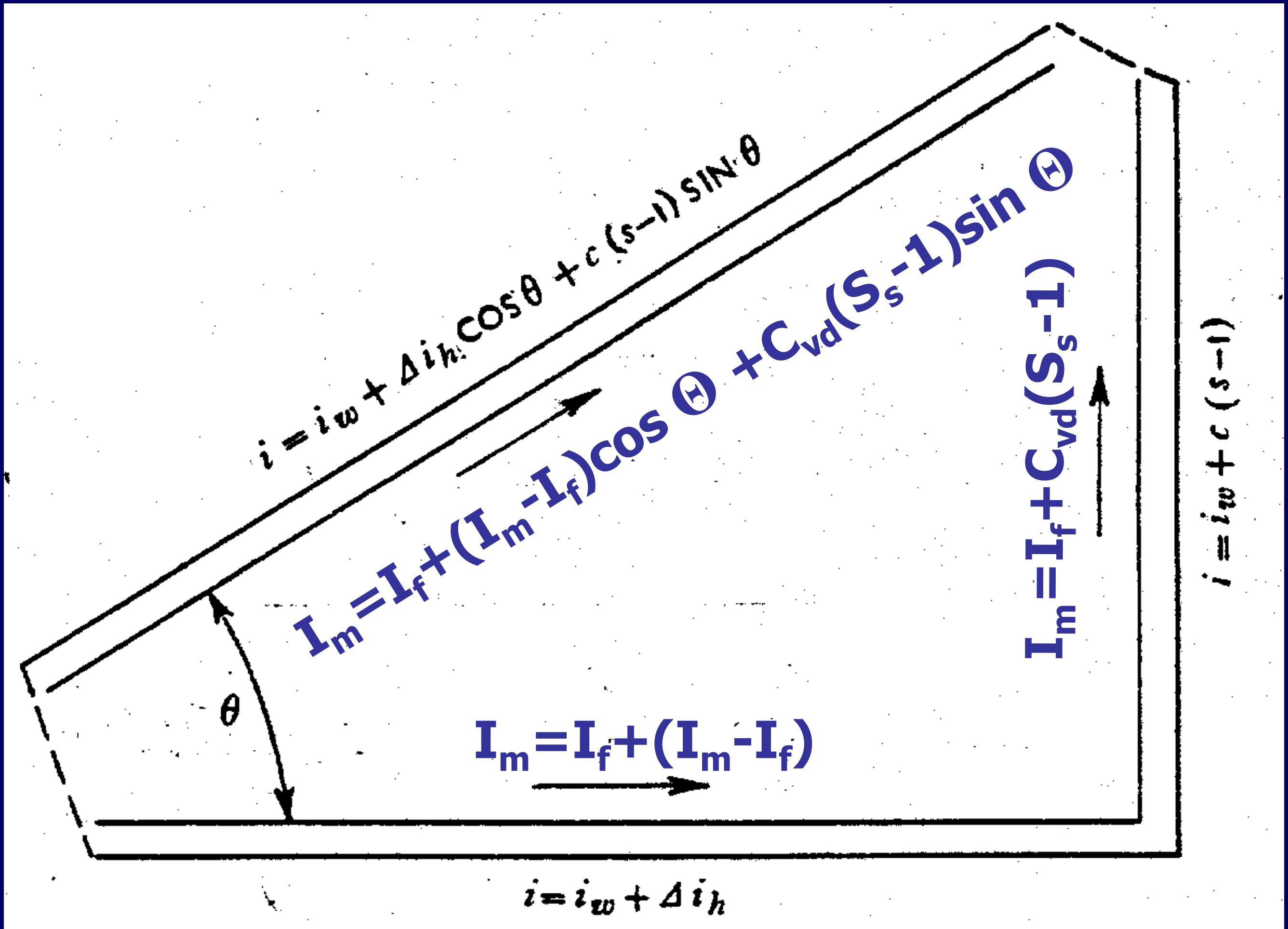
- An inclined flow is a transitional flow between a horizontal flow and a vertical flow.
- **The hydrostatic effect**: all particles in a pipe contribute to the static slurry column; the manometric static head considered in the model = slurry column (in the pipe) – water column (in hoses of different. pressure transmitter).
- **The frictional effect**: the pressure drop due to friction is lower in inclined pipe than in horizontal pipe. The solids effect for inclined flow

$$\frac{solids\ effect\ in\ inclined\ pipe}{solids\ effect\ in\ horizon\ pipe} = \frac{I_{m,\theta} - I_f}{I_m - I_f} = \cos\theta < 1$$

Inclined Flows: Woster-Denny Model



Inclined Flows: Woster-Denny Model



Inclined Flows: Worster-Denny Model

C. Discussion on the Worster-Denny model:

- The model predicts the same frictional pressure losses in the ascending and descending pipes of the same inclination angle [cos(0)=cos(-0)]. This means that the model expects the same solids distribution in both pipes. The assumption is correct only for non-stratified flows.

$$\frac{solids\ effect\ in\ inclined\ \ pipe}{solids\ effect\ in\ horizon\ pipe} = \frac{I_{m,\theta} - I_f}{I_m - I_f} = \cos\theta < 1$$

TU Delft

Inclined Flows: Lab Tests

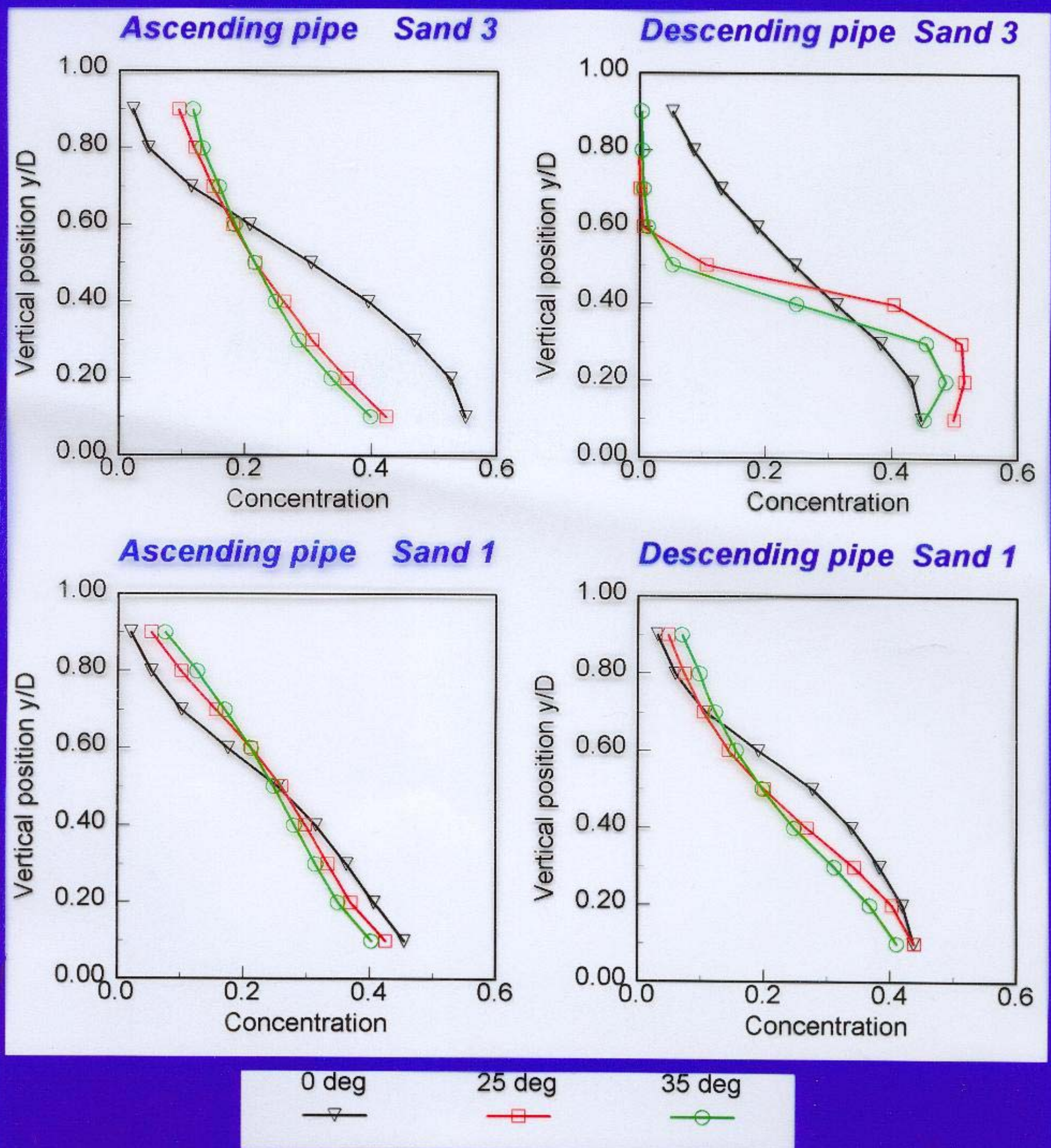


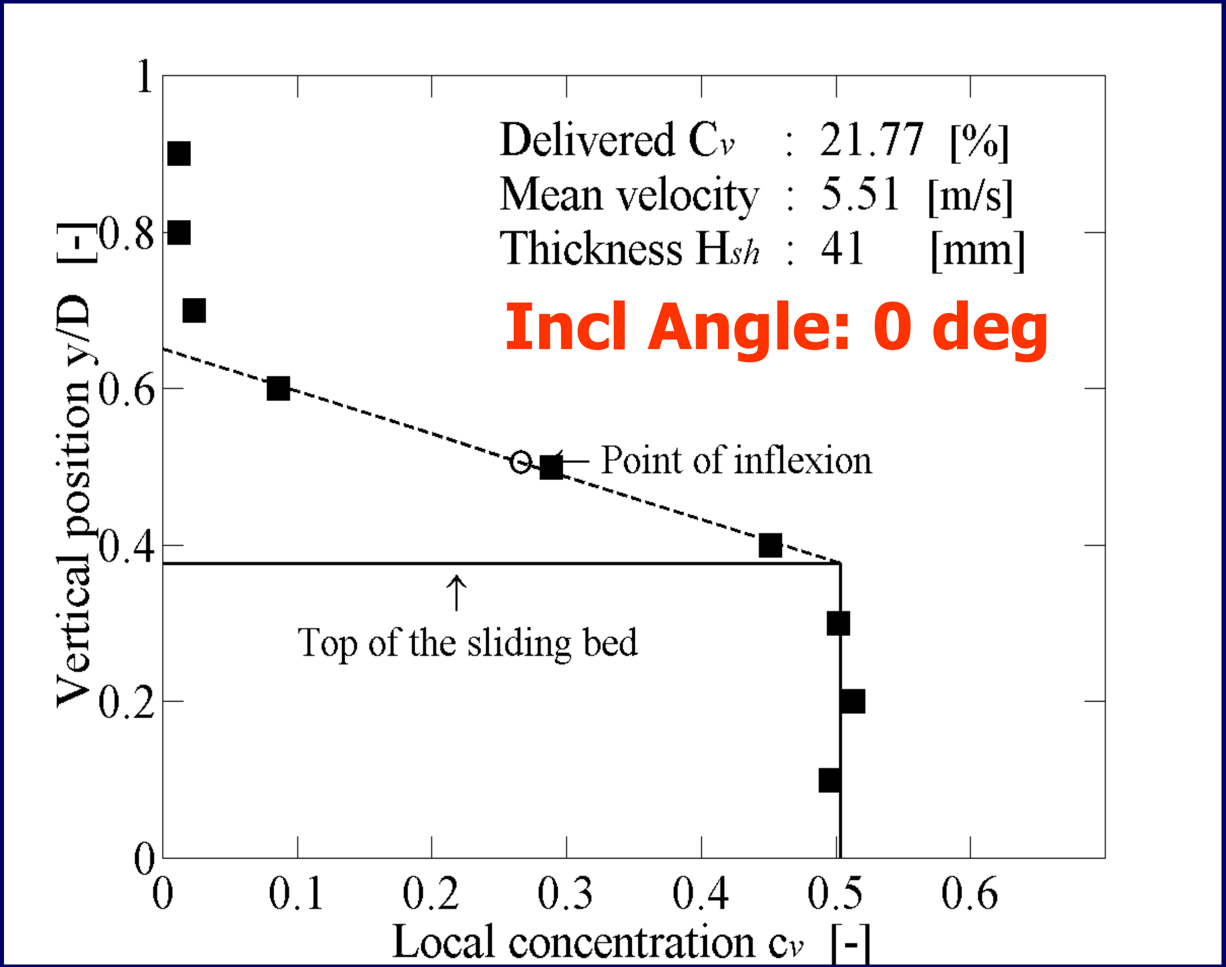
Figure: Concentration distribution in inclined DN150 pipe (Vm=3.50m/s, Angle in legend).

Inclined Flows: Two-Layer Model

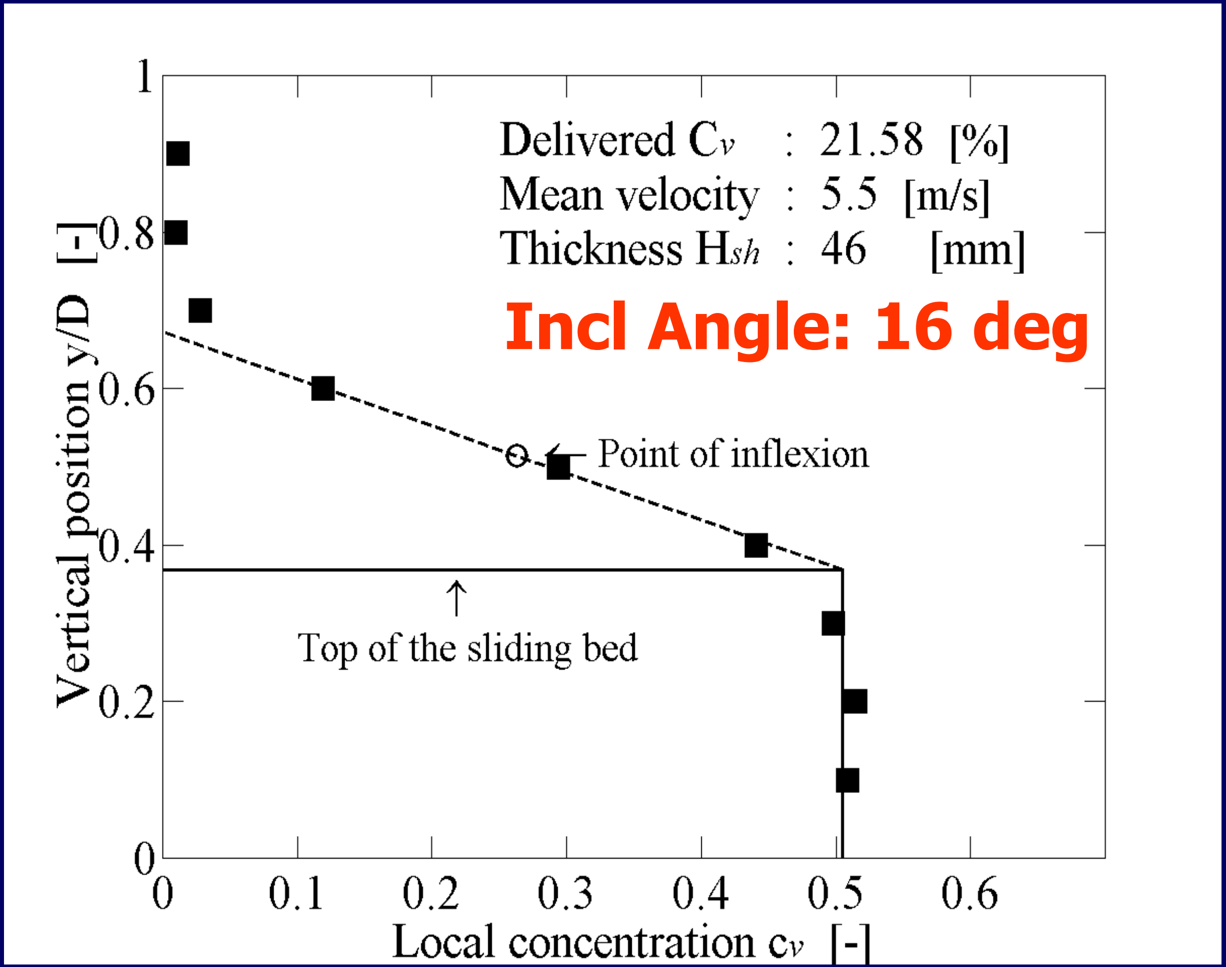
A. Physical background:

- For layered inclined flows the two-layer model is much better predictive tool than the empirical Worster-Denny model.

Inclined Flows: Coarse slurry d=1.8 mm

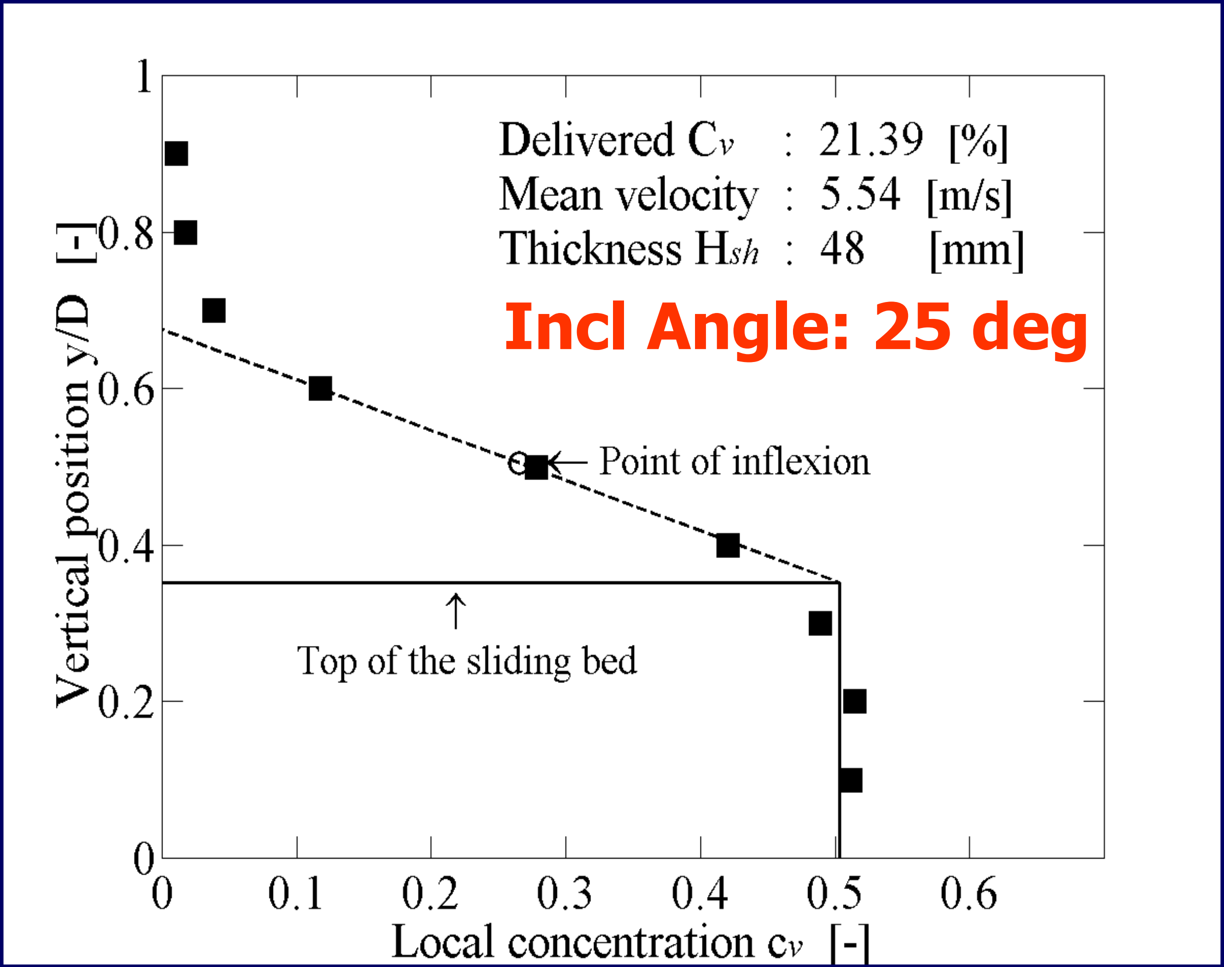


Inclined Flows: Coarse slurry d=1.8 mm

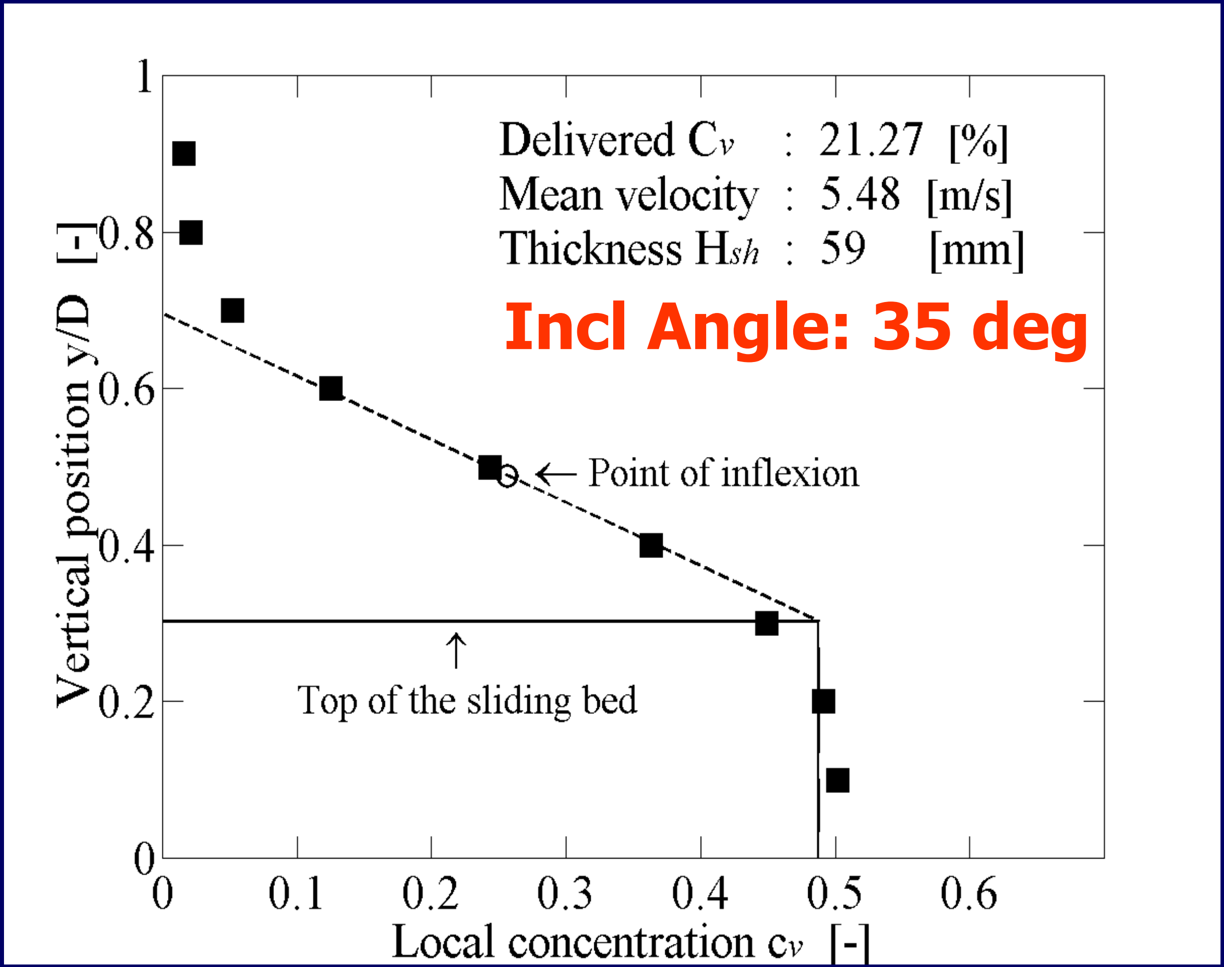


TU Delft

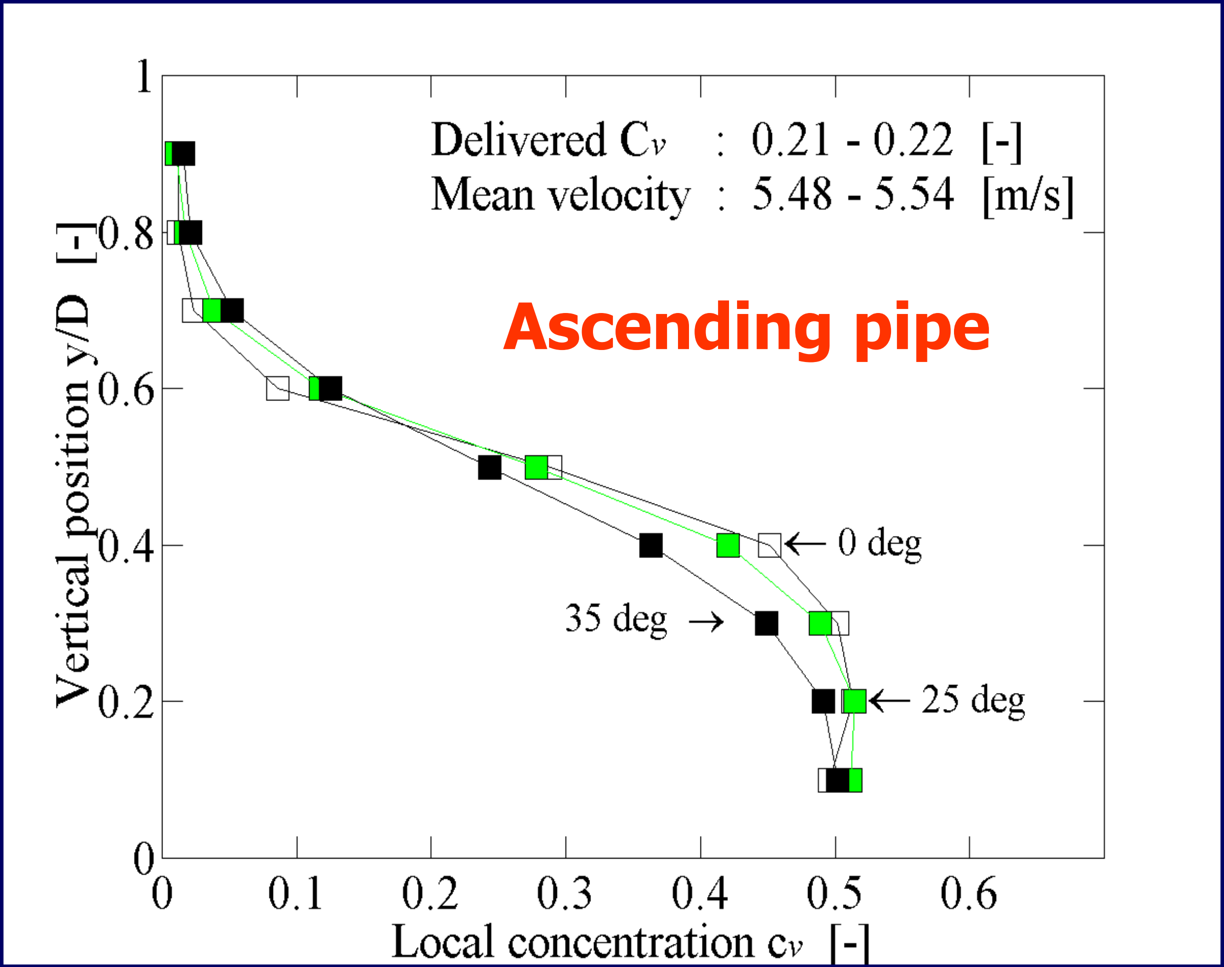
Inclined Flows: Coarse slurry d=1.8 mm



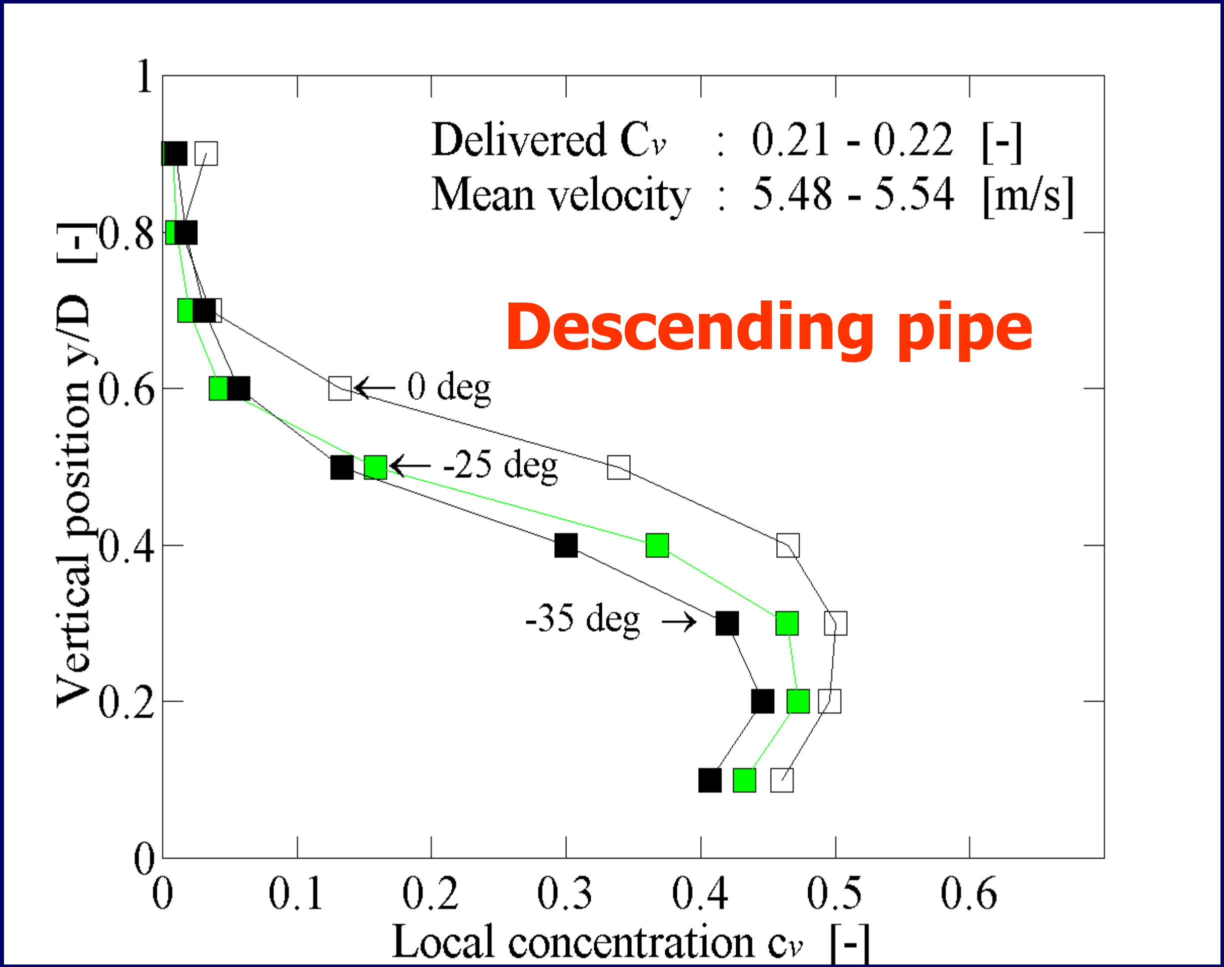
Inclined Flows: Coarse slurry d=1.8 mm



Inclined Flows: Coarse slurry d=1.8 mm

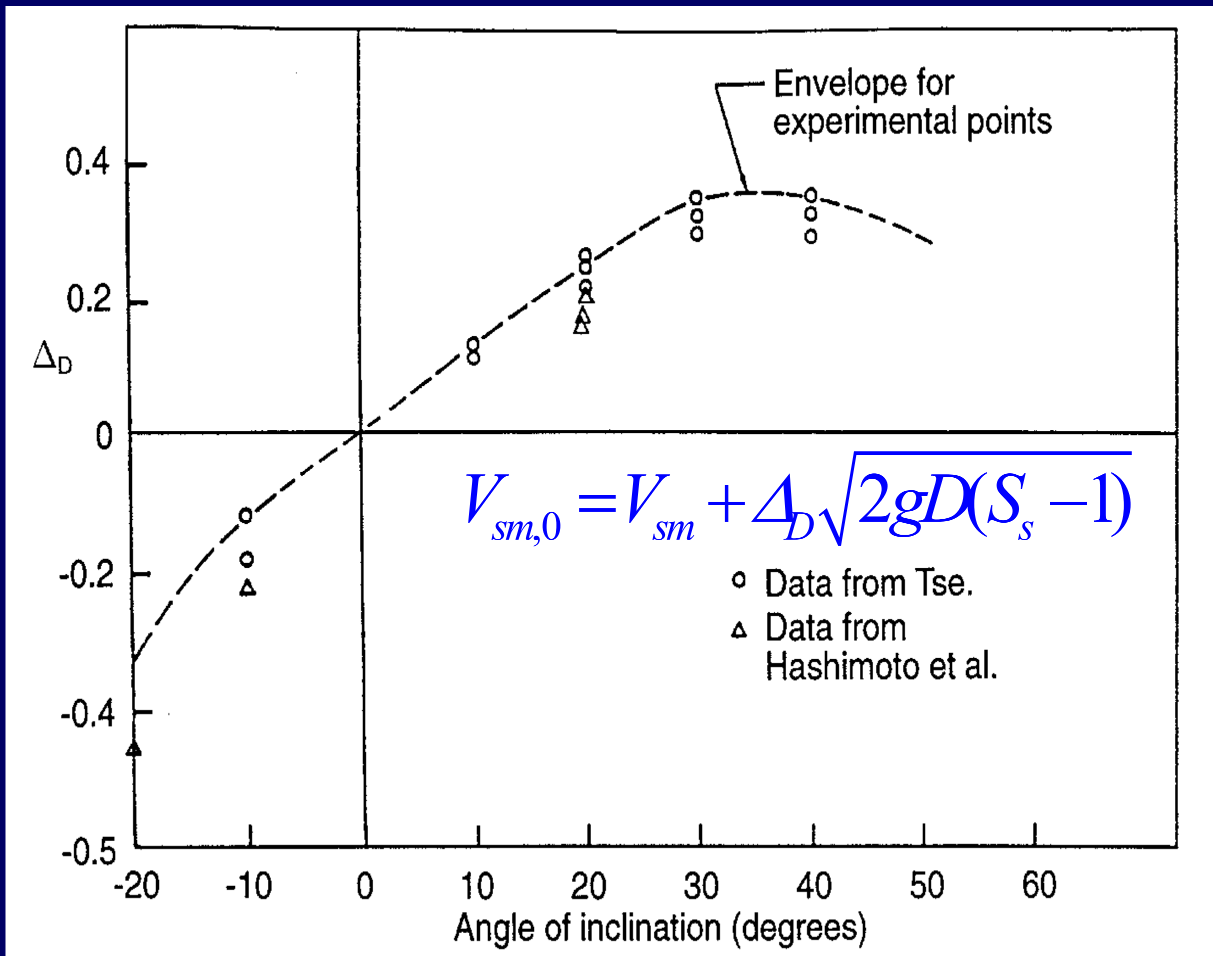


Inclined Flows: Coarse slurry d=1.8 mm



TU Delft

Inclined Flows: Wilson-Tse Model



$$V_{sm,0} = V_{sm} + \Delta_D \sqrt{2gD(S_s - 1)}$$

Effect of inclination on the deposition limit velocity.

The empirical model based on visual observations in a small pipe.

V_{sm} is the velocity from the demi-McDonald’s diagram for horizontal flow.