OPTIMIZATION OF JET MIXER GEOMETRY AND MIXING STUDIES

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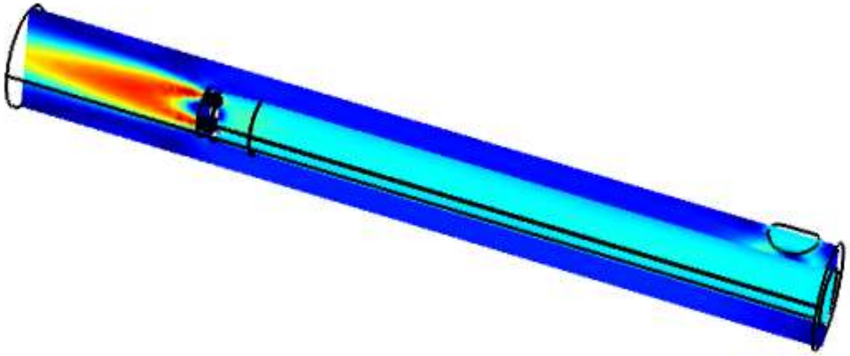
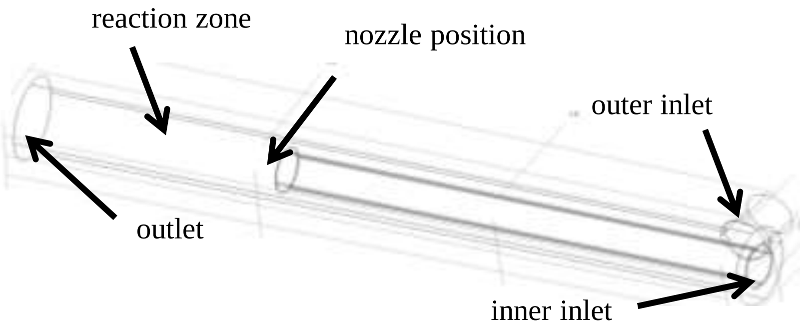


Introduction

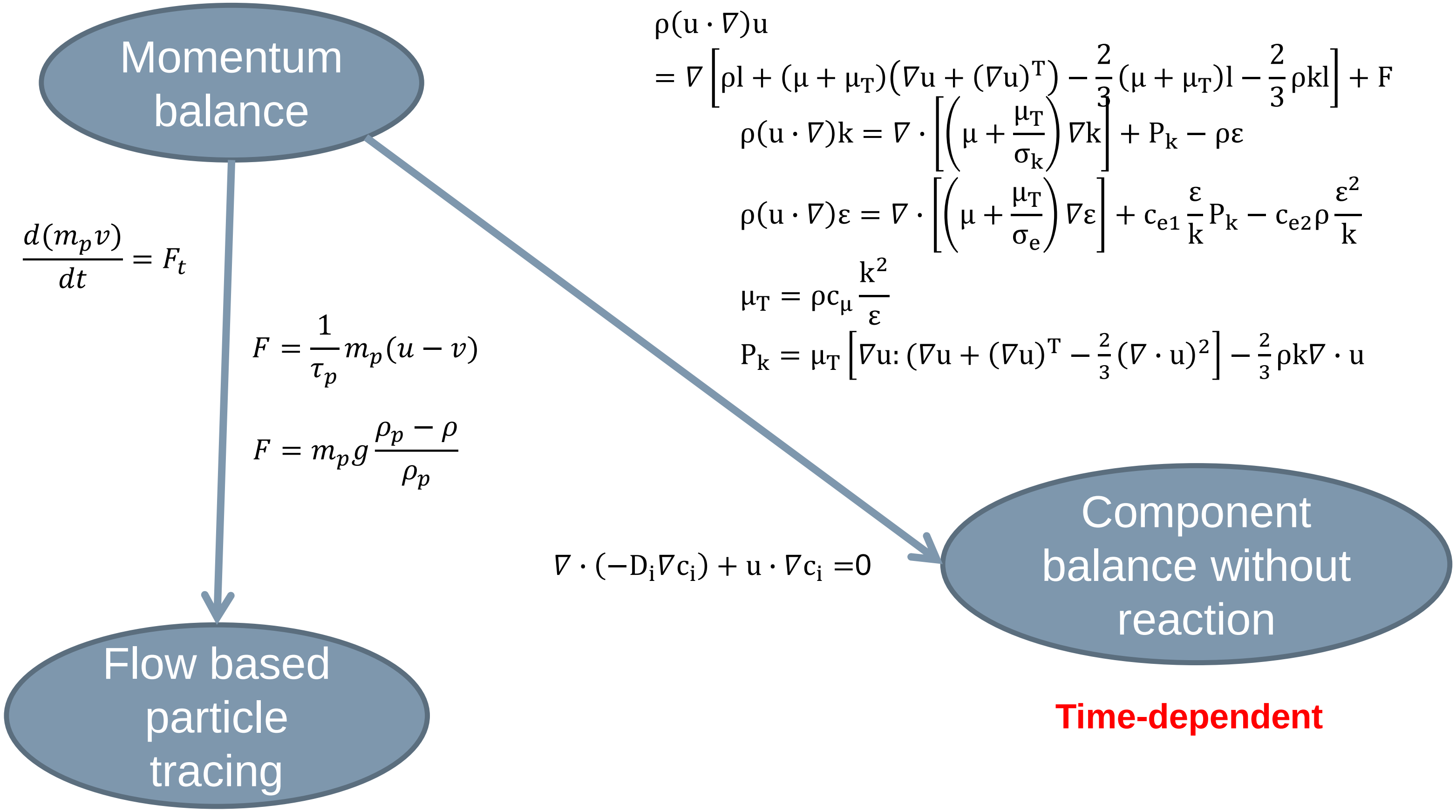
- Mixing is one of the most used operations
- Mixed equipments can be classified by:
  - Operation of the vessel
    - Batch, Semi continuous, Continuous
  - Thermal operation
    - Isothermic, Adiabatic
  - Type of mixing
    - Mechanical, Static, Jet (or disperser)
- **The main goal is the geometric optimisation of a tube type disperser**

Problem definition

- The device is a „tube inside the tube” disperser
- There are two inlets, and one outlet of the vessel
- The mixing taking place in the short „reaction zone” after the nozzle
- Different nozzles can be used to achieve better phase homogeneity, and better conversion



Model development governing equations



Stationary

$$\rho(u \cdot \nabla)u$$
$$= \nabla\left[\rho l + (\mu + \mu_T)\left(\nabla u + (\nabla u)^T\right) - \frac{2}{3}(\mu + \mu_T)l - \frac{2}{3}\rho k l\right] + F$$
$$\rho(u \cdot \nabla)k = \nabla \cdot \left[\left(\mu + \frac{\mu_T}{\sigma_k}\right)\nabla k\right] + P_k - \rho\varepsilon$$
$$\rho(u \cdot \nabla)\varepsilon = \nabla \cdot \left[\left(\mu + \frac{\mu_T}{\sigma_e}\right)\nabla\varepsilon\right] + c_{e1}\frac{\varepsilon}{k}P_k - c_{e2}\rho\frac{\varepsilon^2}{k}$$
$$\mu_T = \rho c_\mu \frac{k^2}{\varepsilon}$$
$$P_k = \mu_T\left[\nabla u : (\nabla u + (\nabla u)^T - \frac{2}{3}(\nabla \cdot u)^2\right] - \frac{2}{3}\rho k \nabla \cdot u$$

$$\frac{d(m_p v)}{dt} = F_t$$

$$F = \frac{1}{\tau_p} m_p (u - v)$$

$$F = m_p g \frac{\rho_p - \rho}{\rho_p}$$

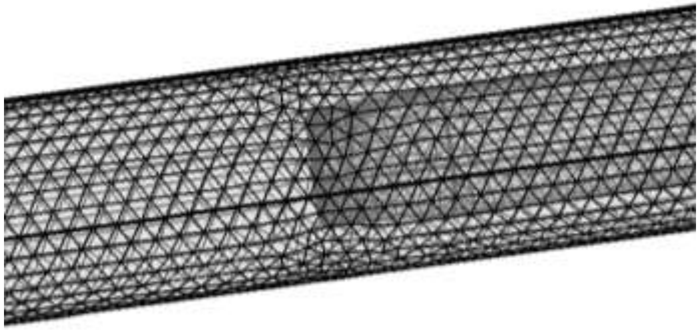
$$\nabla \cdot (-D_i \nabla c_i) + u \cdot \nabla c_i = 0$$

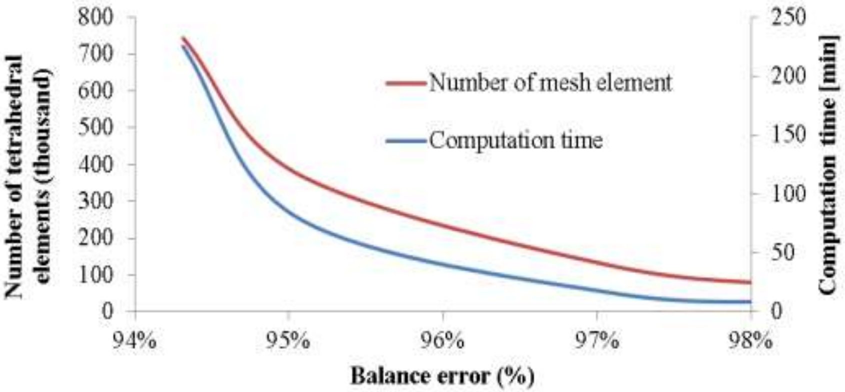
Time-dependent

Time-dependent

Mesh independence, time step

- Mesh independence study was done with four different meshes
  - Coarser
  - Coarse
  - Normal
  - Fine





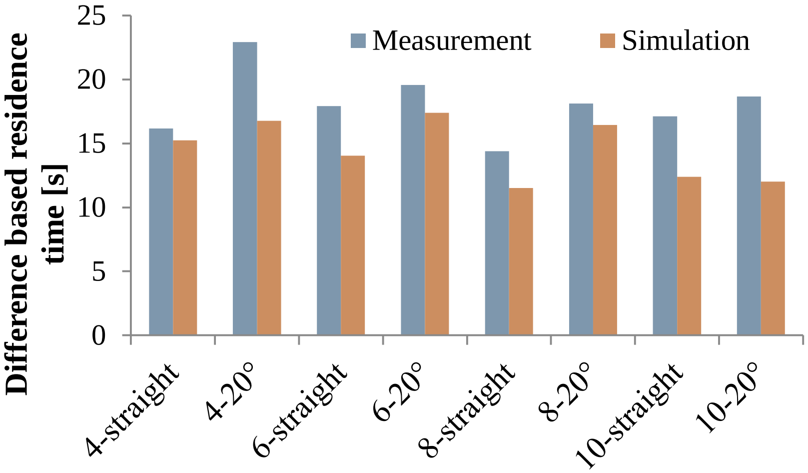
$$C = \frac{u\Delta t}{\Delta x} \le C_{\max}$$

Δt=0.01 s

- The time step was defined based on Courant number

Model validation

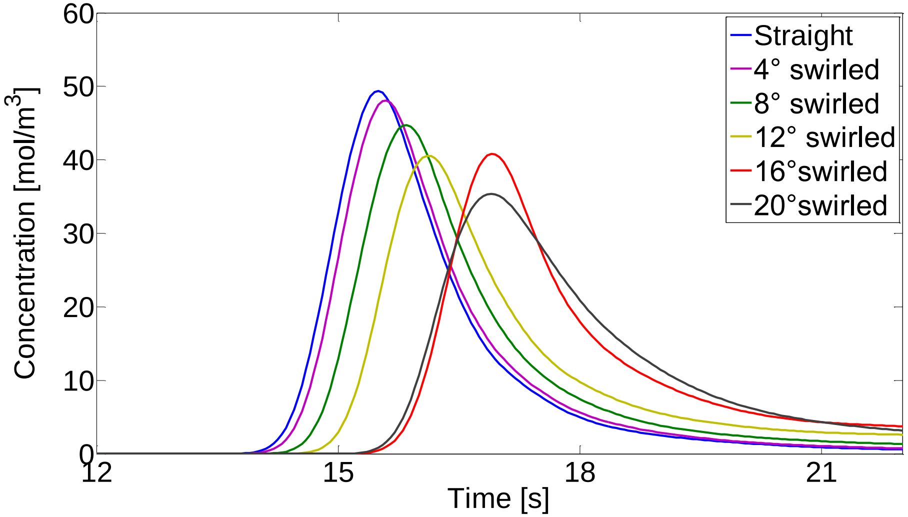
- An experimental apparatus was created for model validation
- An indicator injection was measured inside a trasparent laboratory scale device
- Video recording based processing was used to calculate residence time with different hole number

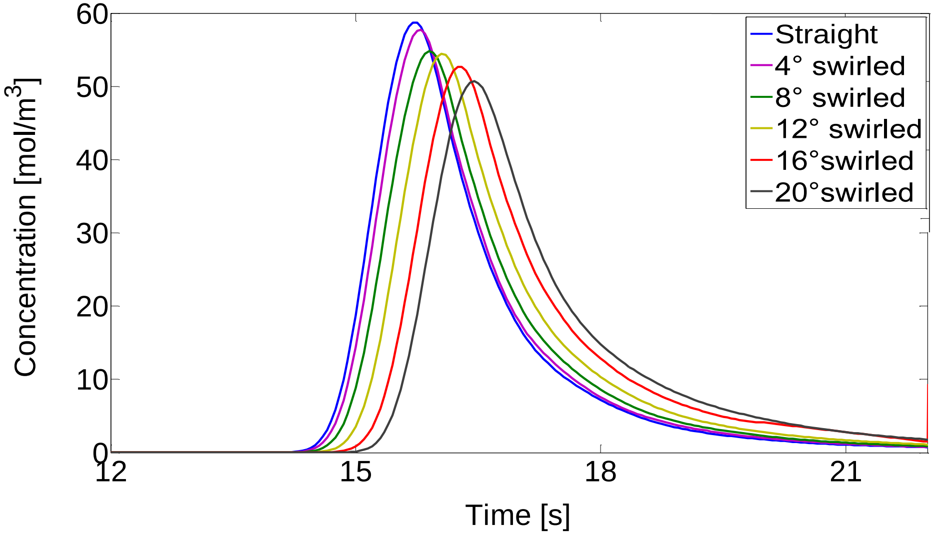


- A stationary momentum balance was calculated
- Rectangle function was applied for a time-dependent component balance

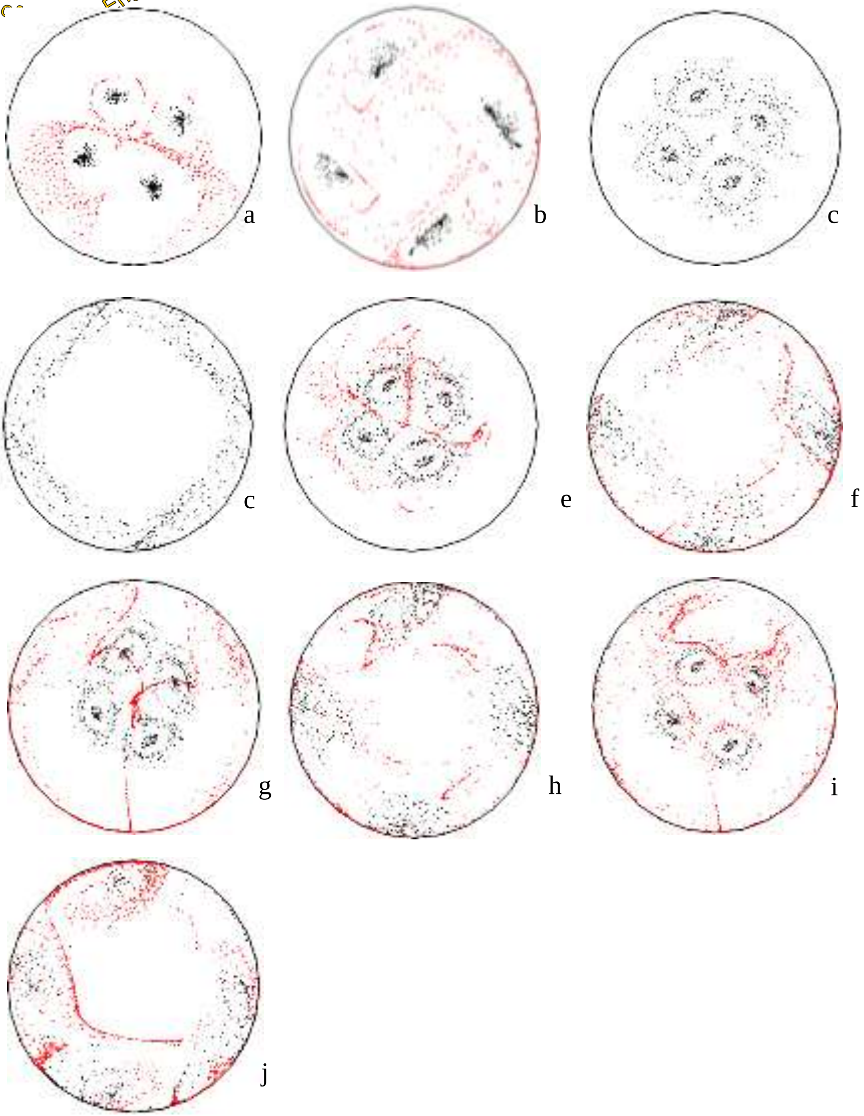
Residence time results

- Different angles from straight to 20°
- Different number of holes from 4 to 10
- Time dependent component balance based on sationary momentum balance results
- Concentration integrated at the outlet boundary



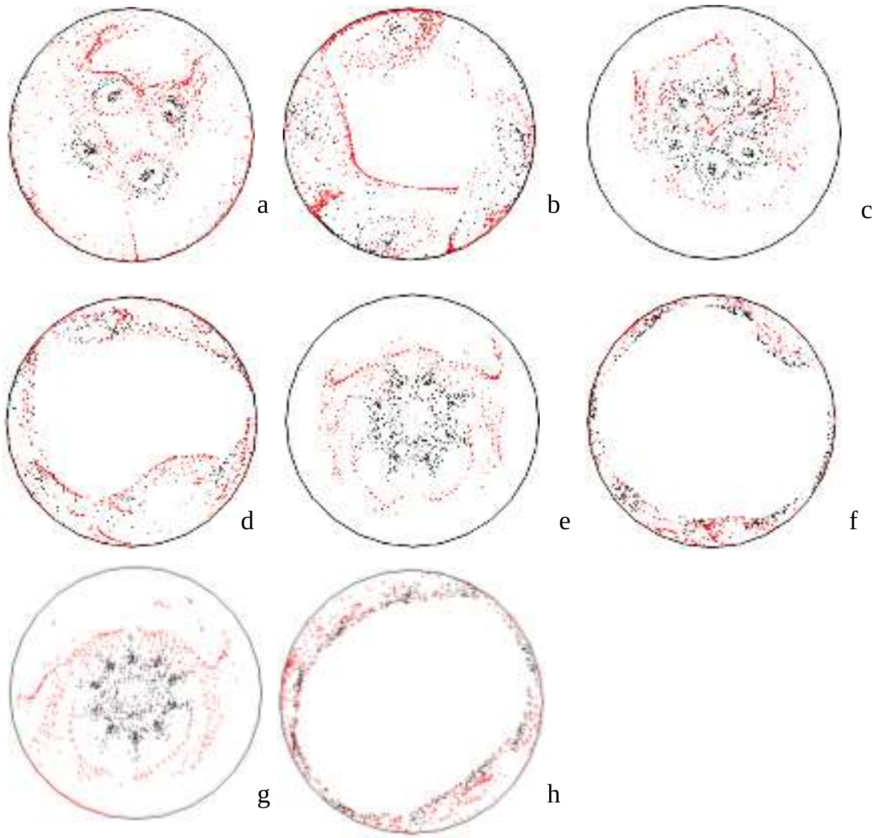


Particle tracing results



- Flow field based particle tracing
- ~900 particles originated at the inner inlet (black), and the outer inlet (red)
- Bounce boundary at walls, and freeze boundary at the outlet
- Poincaré plots were used to evaluate the resuls
- Different flow rates were applied

Particle tracing results



- Flow field based particle tracing
- ~900 particles originated at the inner inlet (black), and the outer inlet (red)
- Bounce boundary at walls, and freeze boundary at the outlet
- Poincaré plots were used to evaluate the resuls
- Different constructions, hole numbers, diameters

Conclusions

- A detailed CFD model of a tube type disperser was created. Different simulation studies were performed including residence time distribution and particle tracing studies.
- An experimental device was proposed and built, and the developed CFD model was validated based on residence time measurements. A good agreement was found between the experimental and simulation results.
- The disperser configurations were evaluated based on the results and the swirled configurations were found better.

THANK YOU FOR YOUR ATTENTION!

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