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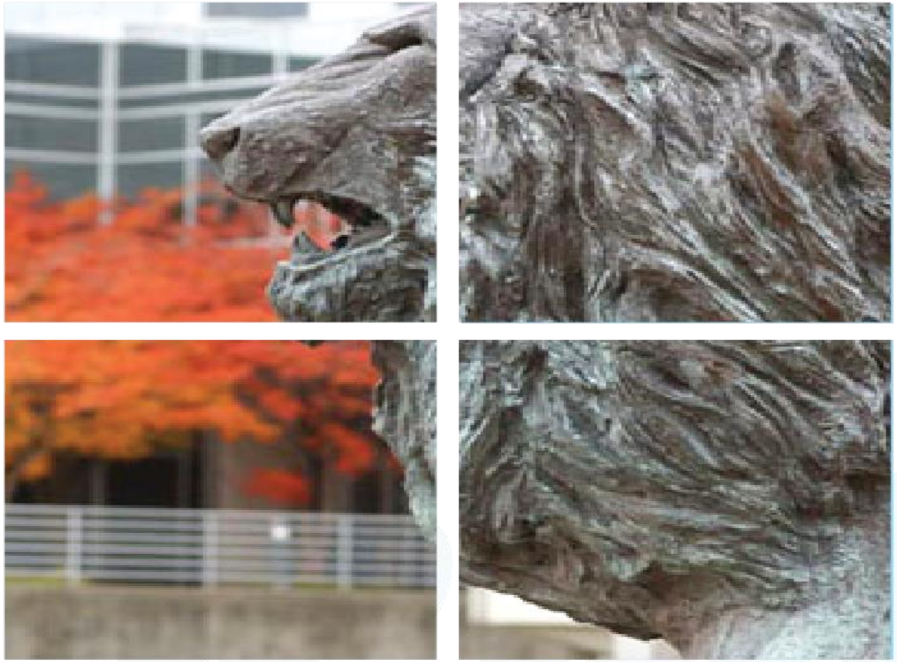
IDEA FUSION



Computational Fluid Dynamics Study of the Effects of Secondary Flows in 90-degree Pipe Elbow Erosion

COMSOL CONFERENCE 2020 NORTH AMERICA

October 7-8, 2020

CFD Session

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Introduction

Bends can be found in many industrial pipe layouts

- Presence of secondary flows
- If particles ➔ erosion might be found

- Current state of the knowledge is still far from having a full picture of the erosion phenomena

- Still using old erosion models based on material properties (or simple modifications of them)
  (Finnie, 1958; Bitter, 1963; Tilly, 1973, Nesic, 1991; Chase *et al.*, 1992; Jordan, 1998; Shirazi, 2000))

- It has been recognized that fluid-particle interactions play an important role
  (Humphrey J.A.C, 1990 and 1993)

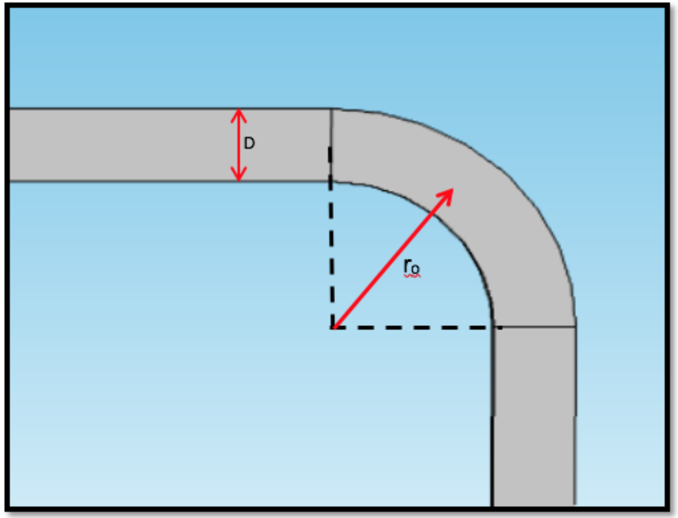
Physical Model

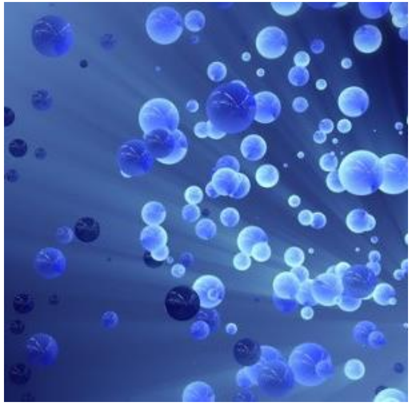
- Radius of Curvature (RC)

  1.0, 1.5, and 2.5

- Reynolds Number

  1,000 and 10,000





- Stokes Number $$S_t = \frac{\tau_p V}{L} = \frac{\tau_p}{T_k}$$

  0.01, 0.1, 0.5, 1.0, 5.0, and 10.0

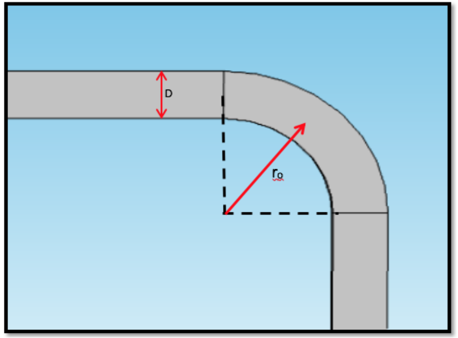
$$\tau_p = \frac{\rho_p d_p^2}{18\mu_f}$$

Mathematical and Numerical Model

$$\rho\frac{\partial \mathbf{v}}{\partial t} + \rho\mathbf{v}\cdot\nabla\mathbf{v} = \mu\nabla^2\mathbf{v} - \nabla P$$

$$\nabla\cdot\mathbf{v} = 0$$

k-*ε* model



- INLET — Velocity profile
- OUTLET — Constant pressure
- WALL — Non-slip or Wall functions
- STRAIGTH PIPES — Long enough (sensitivity)

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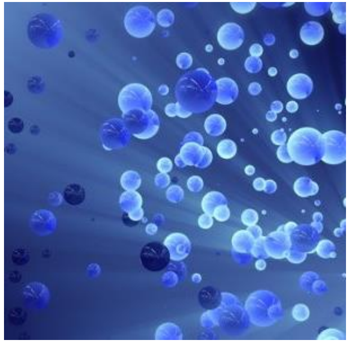
MESH SENSITIVITY
(normal mesh→5% diff, y^+~12)

VALIDATION
(Niazmand and Jaghargh, 2010)

Mathematical and Numerical Model

$$\frac{d\mathbf{q}}{dt} = \mathbf{v}$$

$$\frac{d}{dt}(m_p\mathbf{v}) = \sum \mathbf{F}$$



- Schiller-Naumann Drag model
- One-way coupling
- Wall set to freeze (required condition to compute erosion)
- Particles introduced through 50% concentric reduce area
- Finnie’s model for erosion
- **The “fluid flow velocity components” felt by particles in elbow was modified**

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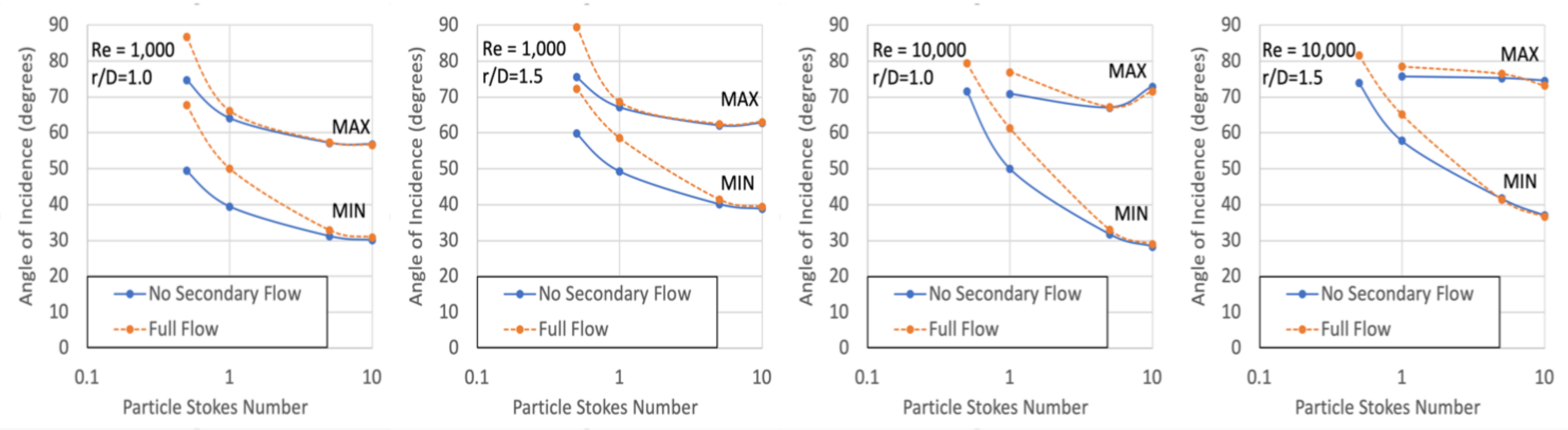
Results

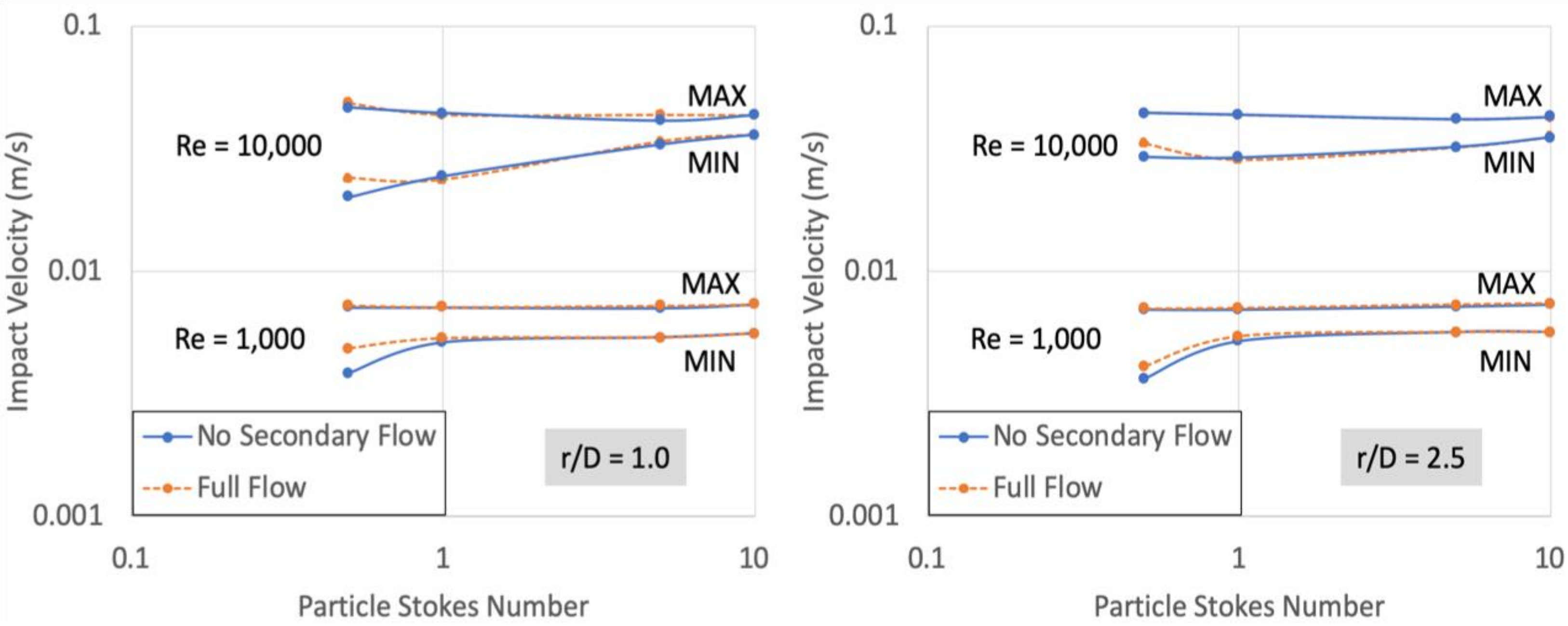
① Angle of Incidence for the “No Secondary Flow” and the “Full Flow” Cases



The Case for r/D=2.5 Shows Similar Behaviors

Results

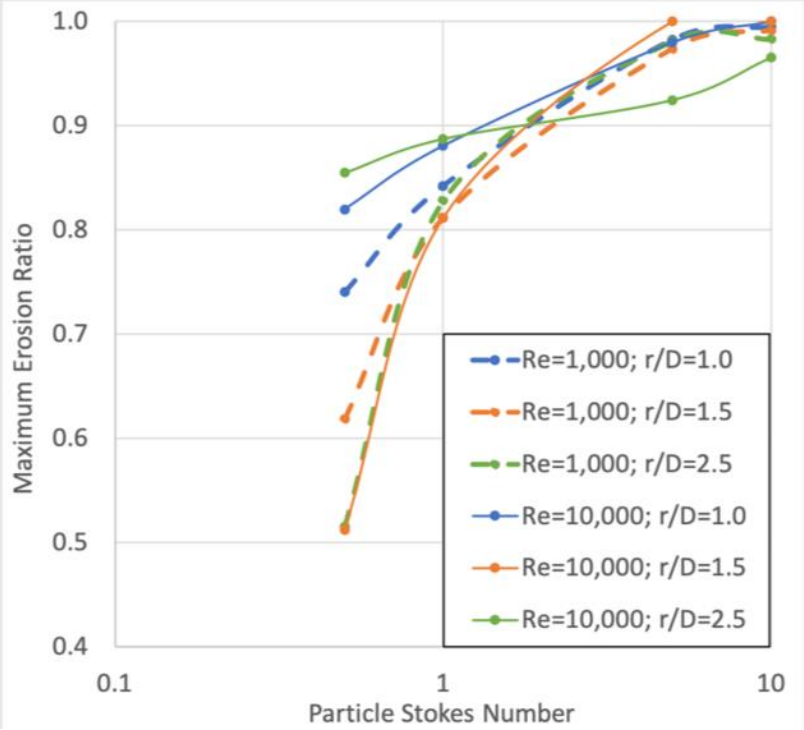
② Impact Velocity for the "No Secondary Flow" and the "Full Flow" Cases



The Case for r/D=1.5 Shows Similar Behaviors

Results

③ Ratio of the "No Secondary Flow" Case Maximum Erosion to the "Full Flow" Case Maximum Erosion



Conclusions

- Secondary flows do not affect much the erosion when the particle Stokes number is high (close to 10).
- A significant 20% to 50% reduction on the erosion is observed when Stokes number is less than one. Angle of incidence effect.
- The magnitude of the erosion reduction depends on the Reynolds number and radius of curvature.
- This study serves as a preliminary insight to the effects of curvature ratio, Stokes number, and Reynolds number in relation to the significance of secondary fluid flow on erosion in a 90-degree pipe elbow.