The Collection Efficiency of Particles on a Ribbon in a Turbulent Flow

Ranjith Divigalpitiya

3M Canada Company

Outline

- Need: turbulent flow analysis
  - RANS: k-ε model
- Experiment from literature
- Particle trajectories
- Collection efficiency
- Comparison with data

Experiment

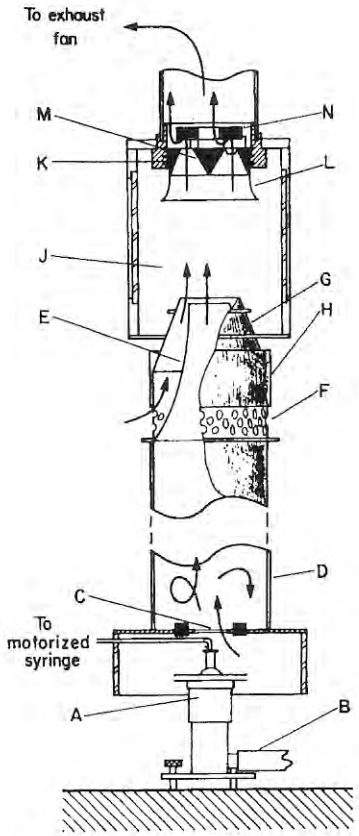


FIG. 1. Vertical section through wind tunnel. The overall height is about 7 ft.

A - aerosol generator

J – collection chamber

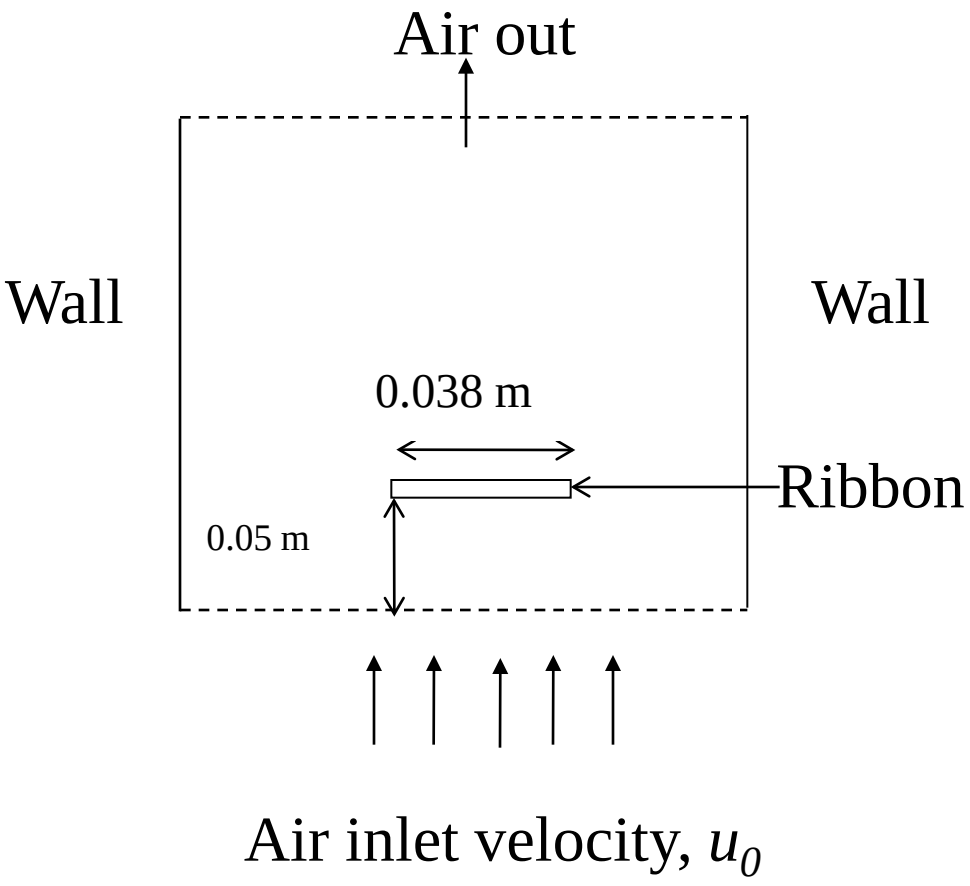
20 cmx 20 cm x 30 cm

U_0 : 2.2 – 6.2 m/s

Re: 200 - 8500

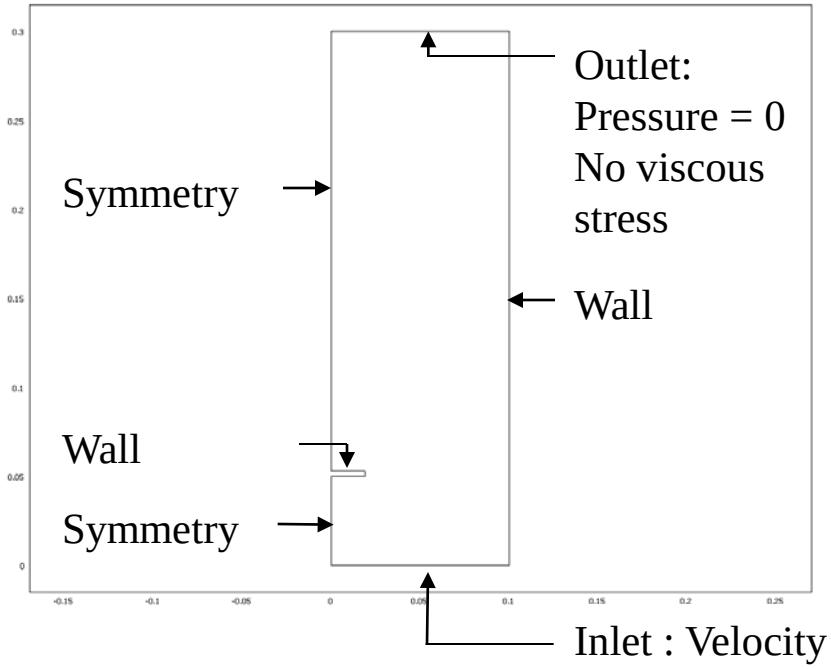
May &Clifford. 1967, Ann. Occup. Hyg. 10, pp.83-95.

Schematic of problem



Boundary Conditions

- Chemical engineering
- Turbulence k-ε model - Stationary



Equations

Eqn. of motion: $m_p \frac{du_i}{dt} = F_{KR} + F_B$ (0)

$$F_{KR} = \pi r_p^2 \rho (u - u_p)^2 [1.84 \mathrm{Re}_p^{-0.31} + 0.293 \mathrm{Re}_p^{0.06}]^{3.45}$$

$$\mathrm{Re}_p = (u - u_p) 2 r_p \rho / \mu$$

$$Stk\# = \frac{\rho_p U_o d_p^2}{18 \mu h}$$

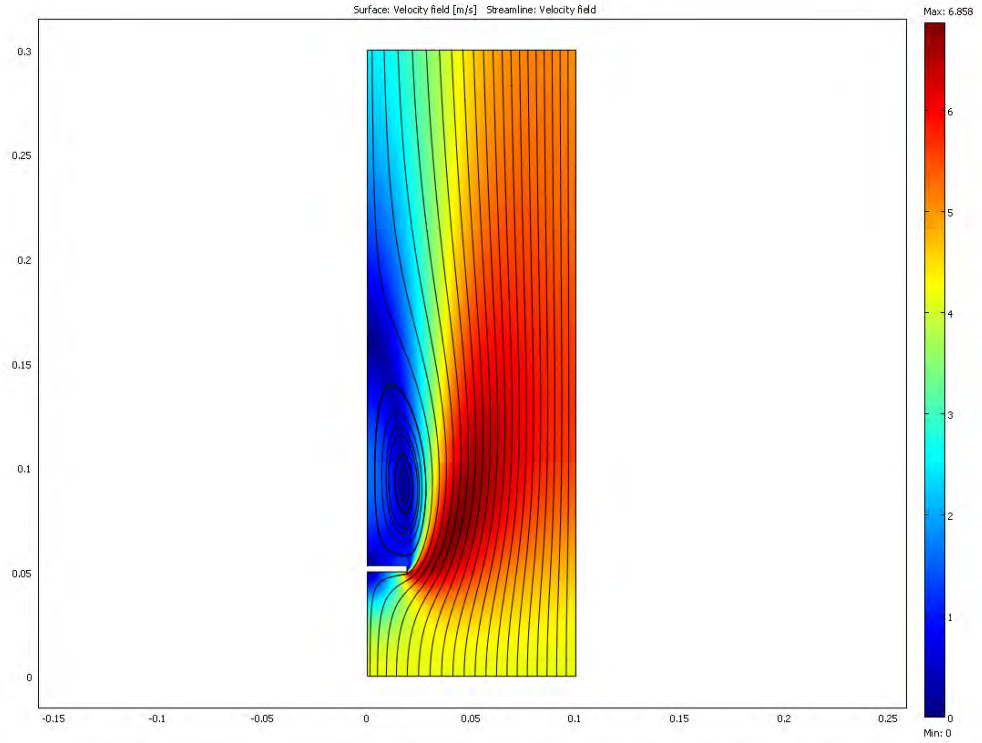
$$E = \frac{\text{Flux of particles deposited on the ribbon}}{\text{Flux of particles entering the projected area of the ribbon}}$$

Parameters

Parameter	Value	Unit
Density of air ρ	1.2	kg/m^3
Viscosity of air μ	1.8×10^{-5}	Pa.s
Density of butyl phthalate particles ρ_p	1050	kg/m^3
Range of radius of particles *partr*	10 – 130	micron
Velocity of free-air u_0	4.2	m/s

Velocity Field & Streamlines

Re = 5200



Particle Trajectories

Input for Khan & Richardson Force term

- Particle size (*partr*)
- Particle density (*rho_chns*)

Release particle

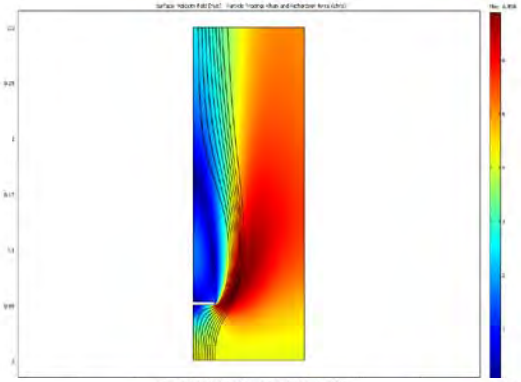
- 100 particles of same size at the bottom equally spaced apart
- Initial velocity (*u,v*)

Trace trajectories

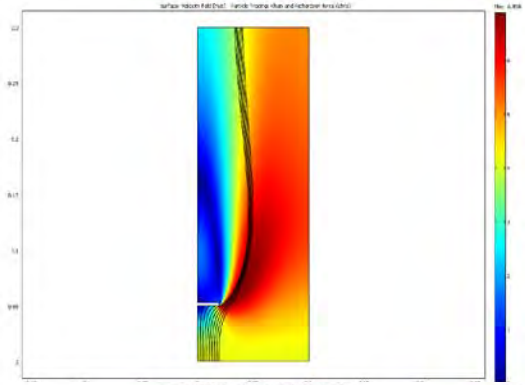
- Use MATLAB to repeat at different Stokes numbers
- Count how many meet ribbon using *endpts.1*
- Collection efficiency

Effect of *Stk*

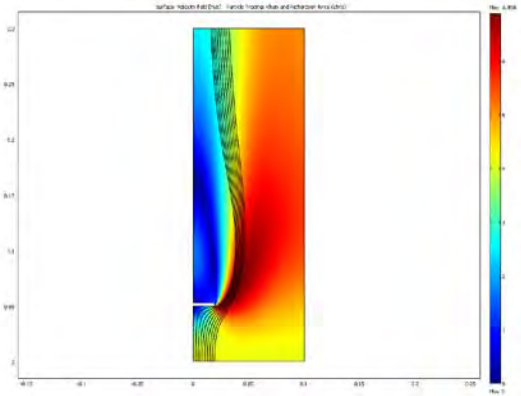
Stk = 0.006



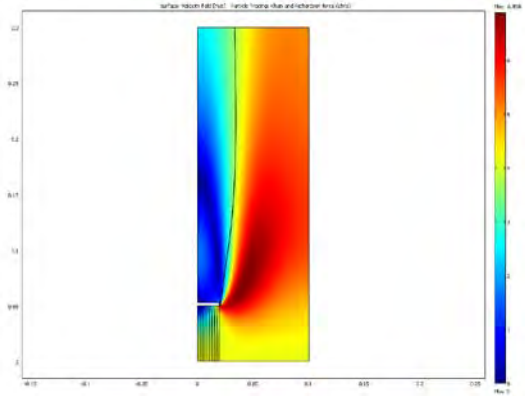
Stk = 0.04



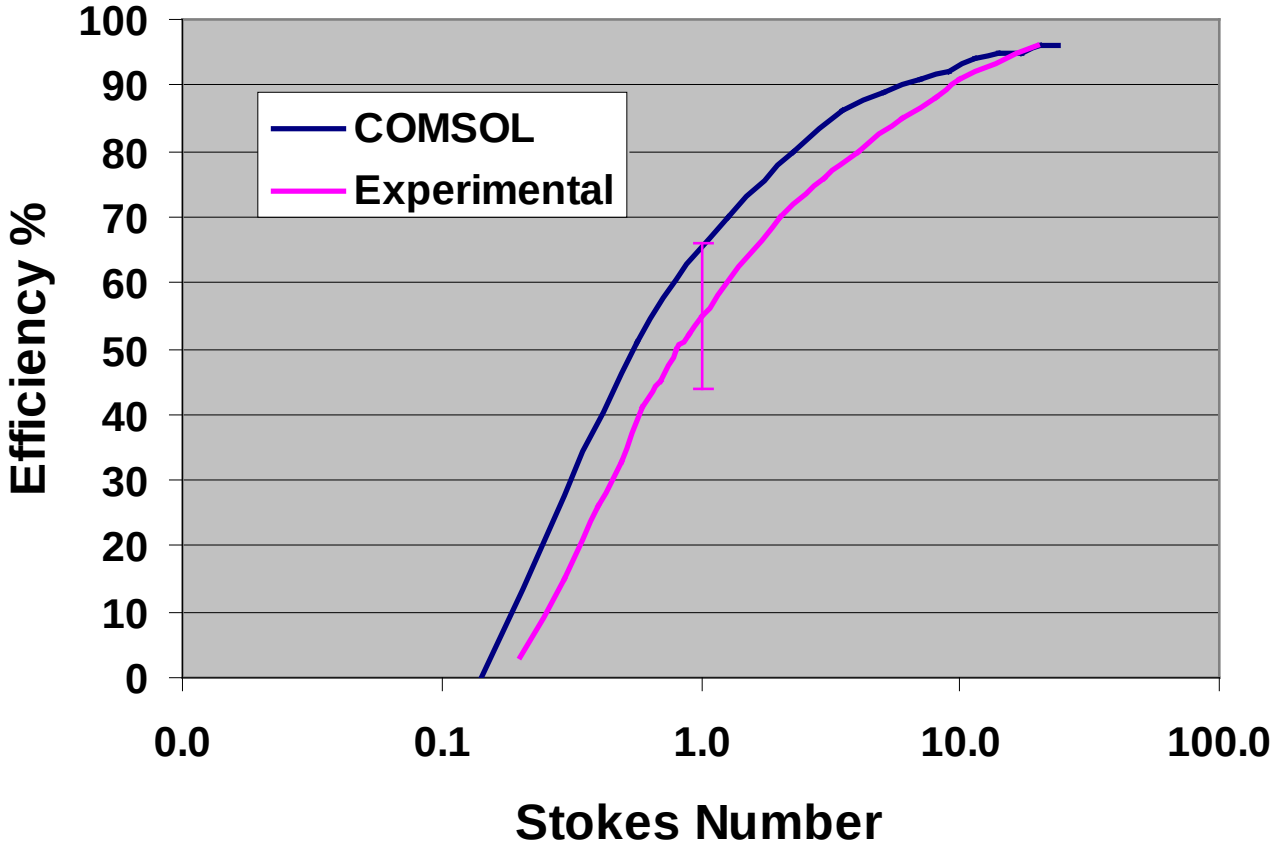
Stk = 0.01



Stk = 10.0



Comparison with data



Reference: *May &Clifford. 1967, Ann. Occup. Hyg. 10, pp.83-95.*

Conclusions

- k-ε model captures the flow behavior
- MATLAB facilitates iterations
- COMSOL results agree with published data
- Convenient method to extend to other geometries