Simulation of Solid Particle Passage in Constrained Microfluidic Channel

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Introduction: Recently, particle passage through constrained square microchannels has been proposed to characterize particles based on their passage velocity. Nevertheless, there is no clear understanding of how the physics in this system interact. Here we quantify the effects of the gap flow by simulating the passage of a solid deformed particle moving at different velocities in a microfluidic channel.

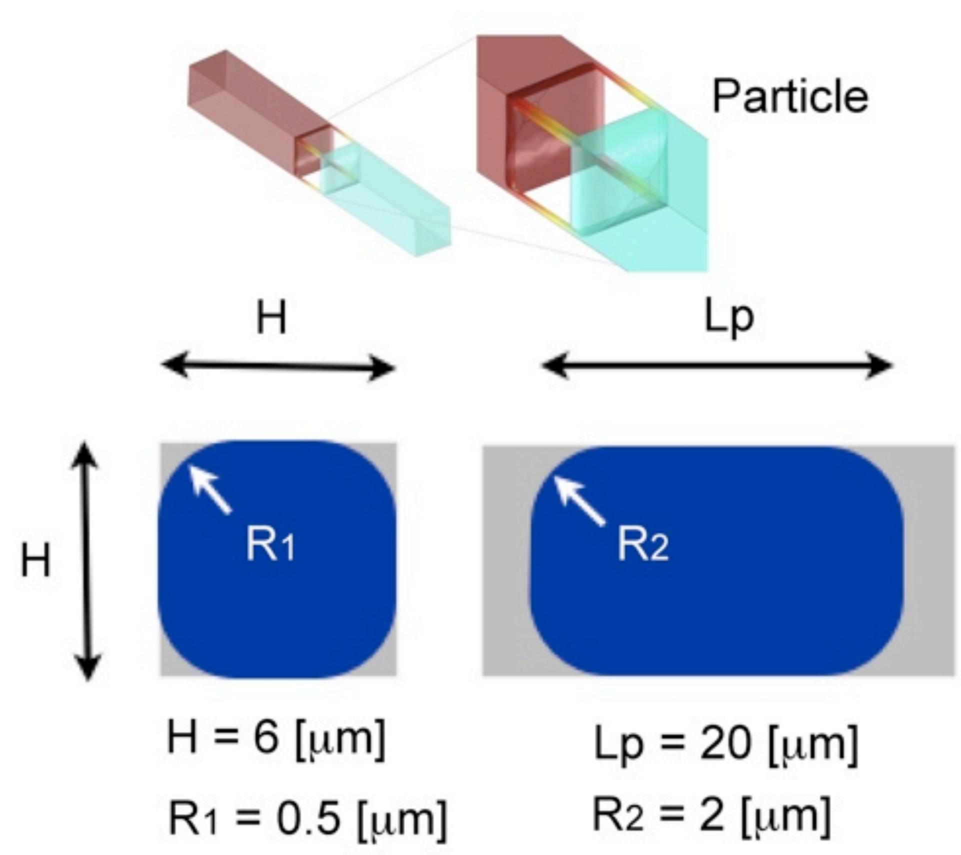

Figure 1. Particle model with round gap.

Computational Methods: The equations used are the full Navier-Stokes equations:

$$\rho\frac{\partial \mathbf{u}}{\partial t}-\nabla\cdot\eta\left(\nabla\mathbf{u}+\left(\nabla\mathbf{u}\right)^T\right)+\rho\left(\mathbf{u}\cdot\nabla\right)\mathbf{u}+\nabla p=0$$

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

The effects of the particle moving at a non-zero velocity, were implemented by setting

$$u_{wall}=-u_{particle},$$

$$u_{particle\_wall}=0,$$

$$u_{inlet}=u_{fluid}-u_{particle}.$$

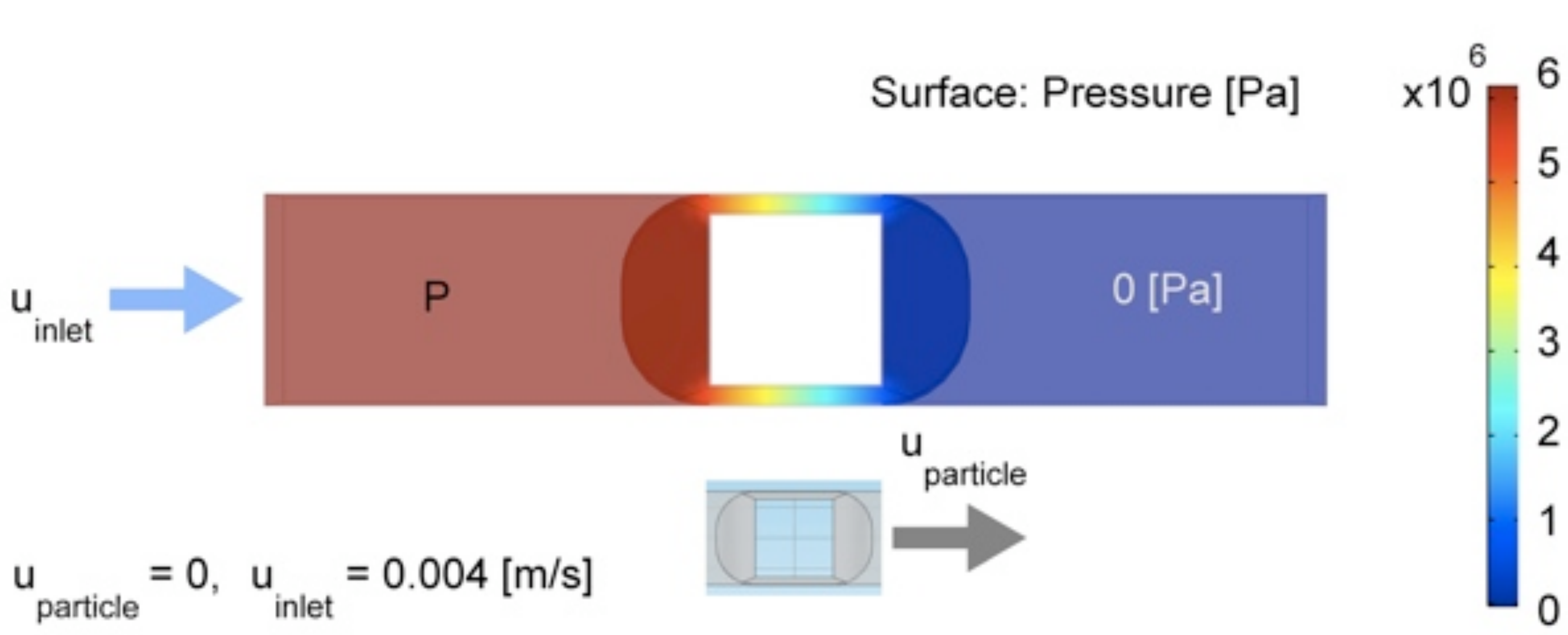

Figure 2. Representative pressure field distribution and boundary conditions applied to a static particle inside a square channel.

Results: We studied the effects of the variation of the particle's dimensions and velocity. A representative plot of the pressure distribution is shown in **Fig. 2**. A summary of the geometrical and velocity variations are presented in **Fig. 3** and **Fig. 4**.

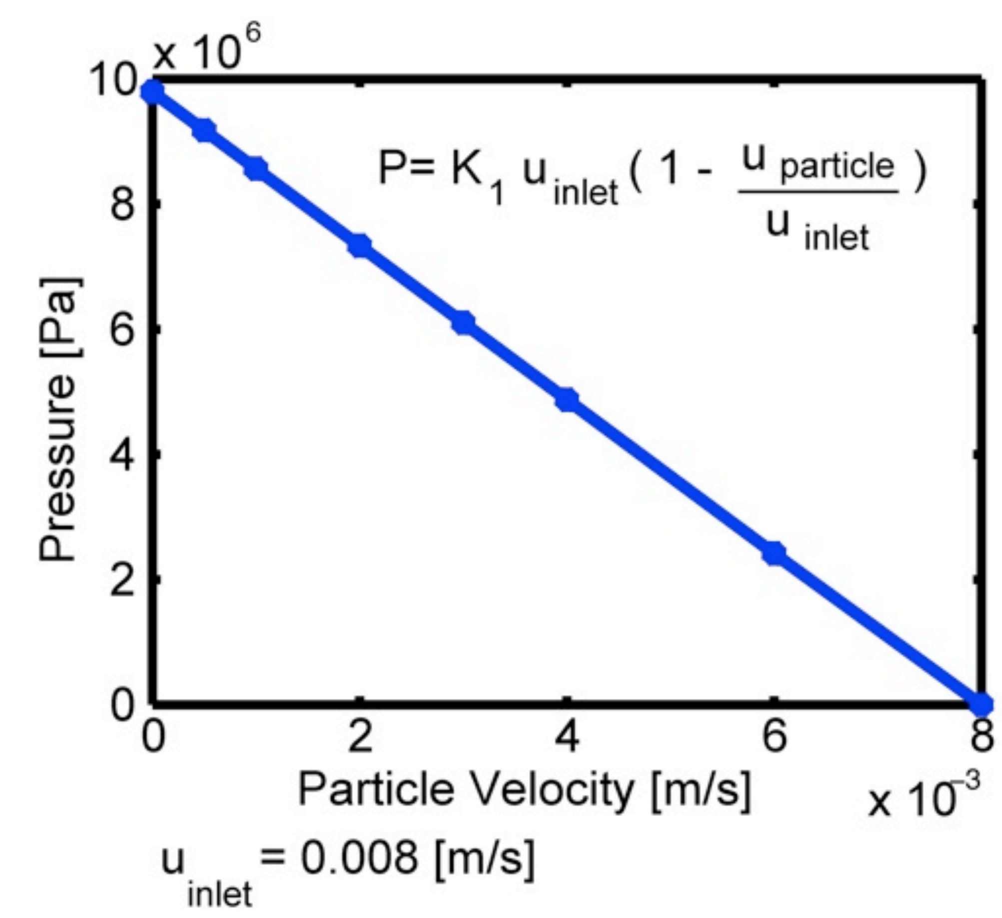

Figure 3. Pressure difference between the back and front ends of the particle with round gaps (static particle) as a function of particle velocity.

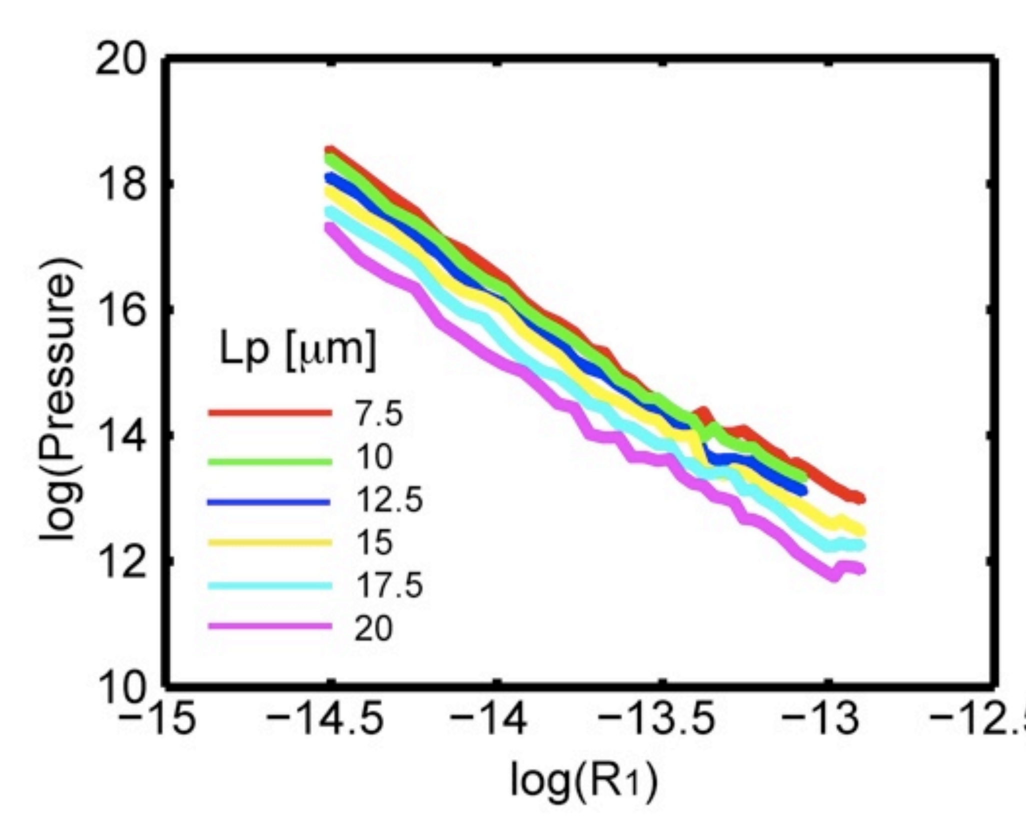

Figure 4. Pressure difference between the back and front ends of the particle with triangular gaps (static particle) as a function of gap size and particle length.

Conclusions: At least, up to Reynolds ~0.2, the system can be described as a highly viscous problem without significant departures caused by inertia. Further, the geometry of the front and back ends of the particle does not modify significantly the pressure drop across the particle. Hence the induced pressure drop is directly proportional to the particles length and inversely proportional to the gap size.