# Simulation of particle deposition in a non-uniform pipe

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*The MOFPHET-C project aims at providing a better understanding of the phenomenon of particle deposition and fouling. For this purpose, several numerical models for polydispersed two-phase flow simulations have been developed. These tools are based on a PDF approach for the simulation of particle motion and on a standard-moment description for the computation of the fluid phase. They are integrated in Code_Saturne through the lagrangian module. The following results are part of a study, carried out in the GVSCOPE project. This study is a simulation of the flow and the particle deposition in the EMILIE experimental loop. This loop has been designed by Areva-NP to be as representative as possible of a broach hole in a tube support plate of a steam generator.*

*The complete simulation consists in two steps:*
*- the fluid mean fields are first approximated using Code_Saturne standard turbulence models ;*
*- particles are then injected in the flow (the number of particles is high enough from a statistical point of view) .*

**Computations** :

The computational domain is an axysymetric pipe with a sudden contraction of the cross section (see fig. 1). The thermodynamical conditions are almost the same as in a steam generator (pressure: 58 bar, temperature: 273°C, density: 768 kg/m³, inlet velocity: 2 m/s, particle density: 5180 kg/m³).

Once the simulated fluid flow reaches a steady state, particles are injected. Only one class of particles with a diameter of 1µm is considered. As a first step, a coarse deposition model is used: particles are collected when they touch walls; the description of the boundary layer is simple; we do not account for electro-chemical interactions between walls and particles.

**Remarks on the flow results** (fig. 2) :

- There is a recirculation zone downstream of the leading edge.
- The streamlines become strongly curved upstream of the leading edge and around the recirculation zone (in particular near the reattachment point).

**Remarks on particle deposited mass flow-rate** (fig. 3) :

- The mass flow-rate reaches two maximums, one near the reattachment point and the second in front of the leading edge.
- The mass flow-rate is negligible just after the leading edge an increases up to the local maximum at the reattachment point.

**Conclusion** :

In spite of the simplicity of the deposition model, qualitative results provided by the lagrangian module are very satisfactory. They are in good agreement with the observations of the deposition features in the EMILIE experimental loop (see fig. 4). Nonetheless, several issues are currently addressed to upgrade the model and improve the predictions:
- refined description of the flow near the walls (nearly completed);
- physico-chemical particle-wall interactions (already available);
- resuspension (nearly completed);
- particle-particle interactions and agglomeration (long term).

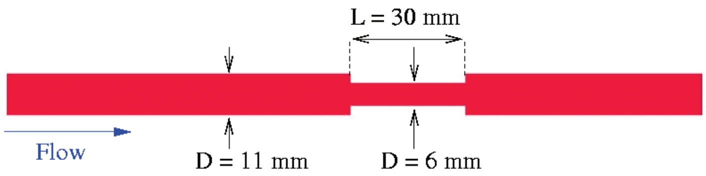


*Fig. 1* : Profile of the domain and its dimensions.

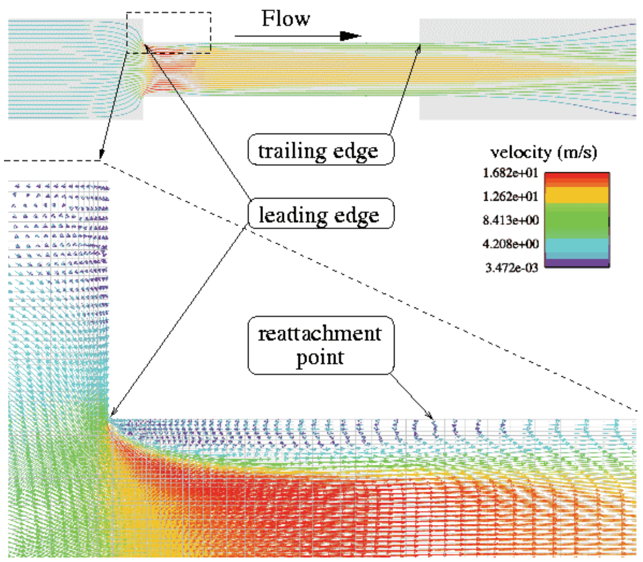


*Fig. 2* : Velocity field around the sudden contraction and the streamlines. A fluid recirculation behind the leading edge can be observed.

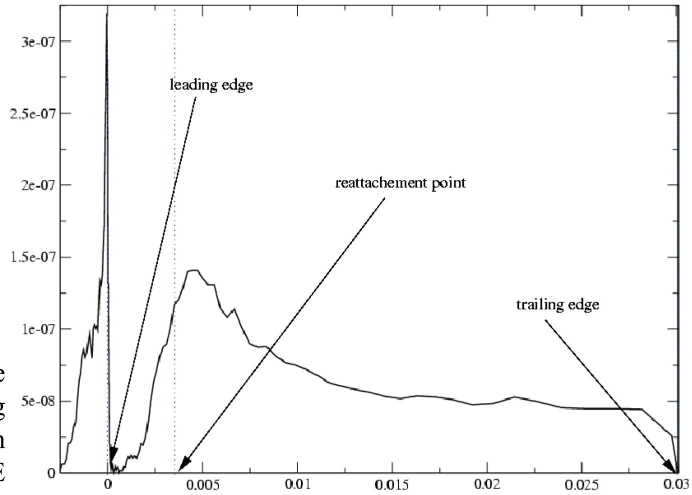


*Fig. 3* : Mass flow-rate (kg/m²/s) of particles along the walls of the pipe near of the sudden contraction. The data are normalized for 1ppb of particles.

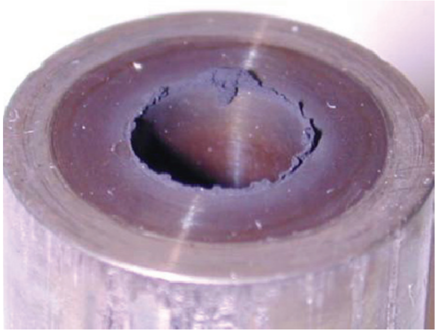

*Fig. 4* : Observation of the deposition on the leading edge of the sudden contraction on EMILIE (experimental loop at Areva-NP–Centre technique).