Coupled particle methods for the simulation of single-lip deep-hole drilling processes

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ABSTRACT

For many industrial applications the process of single-lip deep-hole drilling is applied, e.g., for the production of small bores that have a high length to diameter ratio. Especially the tools life, the evacuation of chips and the quality of the resulting bore are strongly depending on the cooling and lubrication of the machining zone. Hence, a coupled particle approach is used for the simulation of a single-lip deep-hole drilling process, including the cooling lubricant supply and particle transport.

The physical particles are described by the Discrete Element Method and the cooling lubricant is described by the Smoothed Particle Hydrodynamics method [1]. Discrete Element multispheres are used for the discretization the chips produced in the drilling processes. The performed simulation show that the flow field as well as the evacuation of chips can be described with the coupled particle method. Furthermore, the performed simulations show a velocity sink behind the cutting edge at the tip of the drilling tool that could lead to a lack of mass exchange suggesting an optimization of tool geometry in order to get a better cooling behaviour and to increase the tool life.

Considering the drill diameter which is only 2 mm, and inlet pressures above 20 bar, the presented process is a very challenging system with particle velocity above 100 m/s. Nevertheless, the results of the simulations presented show a great potential for the application of coupled meshless methods. Due to the ability to describe the transient system without a special treatment of free-surfaces and interfaces that experience great changes, the SPH method is a very interessting alternative compared to mesh based methods. Especially for simulation that do not assume that the V-channel is entirely filled with cooling lubricant, the coupled particle method is greatly benefiting from its meshless nature.

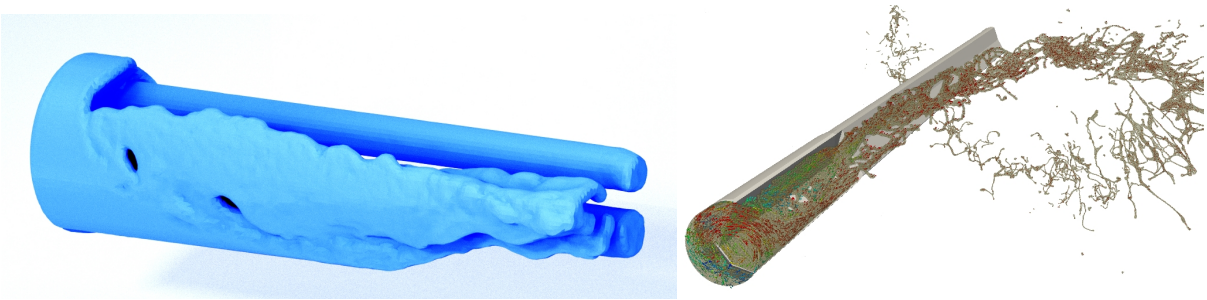

Figure 1: Free-surface within V-channel as well as the two cooling-lubricant channels for cooling lubricant supply (left) and velocity-field (right) of cooling lubricant in single-lip deep-hole drilling simulations, color-coded from blue (slow) to red (fast)

References

[1] Monaghan, J.J.: Smoothed Particle Hydrodynamics and its Diverse Applications. Annual Review of Fluid Mechanics, Vol. 44, pp. 323-346, 2012.