K1-MET

Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development

Main location	Linz, Upper Austria
Other locations	Leoben, Styria
Thematic field	K1-MET has its focus on the modelling and simulation of metallurgical processes, including metallurgical raw materials and refractories with the goal of an optimal process control with respect to product quality, zero waste and the minimization of energy and raw materials.

Success story summary

Making LES Simulations feasible

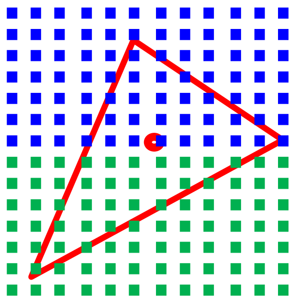
By implementing an embedded Lattice-Boltzmann based Large Eddy turbulence model (LB-LES) into a finite volume CFD code an enormous speed-up of highly resolved simulations is possible. A first application to a box shaped Submerged Entry Nozzle (SEN) delivered very promising results. Embedded LB-LES simulations agreed to previous measurements at very low computational costs.

Success story

Making LES Simulations feasible

The results obtained for highly turbulent flows by using RANS (Reynolds Averaged Navier Stokes) simulation models are generally poor. The overall flow situation might be calculated correctly, but for example instabilities triggered by turbulent fluctuations can not be captured. Large Eddy Simulations (LES) are based on very fine grids and resolve the larger scale turbulent motions. As a drawback, if LES is used in a finite volume (FV) based code the computational effort is very high and therefore LES simulations are unfeasible for industrial applications.

However, the LES turbulence model can also be implemented on Lattice-Boltzmann (LB) based formulation and embedded into the FV code. As the LB method can be considered as a cellular automata the computational speed is very high. The achieve the highest possible speed-up the LB code and the communication oft he FV and LB code hast o be fully parallized (Fig. 1).



FV processor communicates with
LB processor and LB processor

Fig. 1: Communication of FV cells and the LB grid on multiple processors.

In the frame of project 3.2 this method has been applied to a submerged entry nozzle (SEN) as shown in Fig. 2(a) in a water model. The observations from the water model indicate that the horizontal vortices are unsteadily fluctuating and occasionally change their sense of rotation. This effect can not be obtained by RANS based simulations. The LB-LES simulation (Fig.2(b)) is able to capture this behaviour.

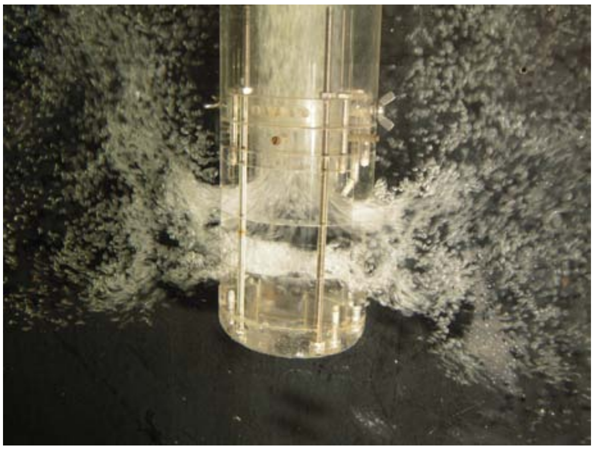
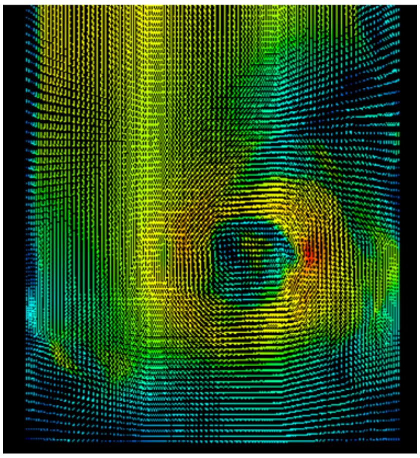
(a)  (b) 

Fig. 2: (a) Water model of a submerged entry nozzle, (b) results of LB-LES simulation.

Table 1 shows a comparison of simulations with different turbulence models and grid sizes. It is interesting to note, that while ordinary FV based LES simulation deliver a single vortex orientation, the embedded LB-LES simulation is the only combination which is able to capture the alternating vortex seen in the experiments.

	Grid size	CPU time	Results
RANS	125k cells	1	steady secondary vortex, single vortex orientation
RANS + embedded LB-LES	125k cells 100k lattice	1.08	unsteady motion of sec. vortices, alternating vortex orientation
RANS+ embedded FV-LES	125k cells	1.03	unsteady motion of sec. vortices, single vortex orientation
RANS+ embedded FV-LES	350k cells	1.86	unsteady motion of sec. vortices, single vortex orientation
SAS	125k cells	1.06	unsteady motion of sec. vortices, single vortex orientation
LES	2.8m cells	(23)	unsteady motion of sec. vortices, single vortex orientation

Tab 1: Comparison of simulation results

Impact and effects

The described method opens new fields for the application of Large Eddy Simulations in an industrial context. Especially for highly turbulent and unsteady flow phenomena it offers better simulation results at a much lower computational cost.

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