Particleworks 8: the most advanced mesh-less fluid dynamics simulation software

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The latest version of Particleworks, the particle-based fluid dynamics simulation software that uses moving particle simulation (MPS), is now available with a wide range of features and improvements that complete the solver's ability to manage integrated physics (it includes a thermal solver), and make simulations faster due to its multi-resolution (MR) and multi-GPU (graphic processing unit) support.

Local particle-size refinement

One of the most exciting features of Particleworks 8 is the introduction of refinement zones. These allow the user to reduce the particle size (used to discretize the fluid being analysed) in specific areas of the domain, thus increasing the accuracy of the simulation without affecting calculation time.

Previously, the entire fluid domain (and the air when present) was discretized using a single particle size. Now it is possible to define specific regions in the domain (boxes, custom domains, or offsets of the geometric elements of the model) with smaller particle sizes.

This creates possibilities for more detailed analyses of the lubrication and cooling of bearings that feature small gaps or flows through an electric motor's windings. For example, particle refinement has been used to evaluate the flows in the channels of an electric motor's cooling system. With the MR function, the flow in a narrow channel is solved with a particle size of 0.1mm, while the rest of the fluid domain is discretized with particles of 0.3mm.

Advanced modelling of grease, snow, and chocolate

It is also worth mentioning the introduction of a solver for high-viscosity fluids, resulting in significant improvements to the modelling of chocolate, grease, and snow flows. To handle these flows, the basic MPS algorithm has been extended with a "full-implicit" approach (moving particle full implicit - MPFI), whereby pressure and viscosity equations are solved in a coupled and implicit manner, increasing the accuracy of the calculations.

An increasingly integrated solver: air and thermal simulations

This version also expands the possibilities of the multi-phase simulations built into the software. The finite volume solver for air (based on a one-dimensional Cartesian grid) has been enhanced with a variable discretization lattice Boltzmann solver for more detailed analyses of external aerodynamics and vehicle contamination (e.g. interaction with puddles, rain, or mud).

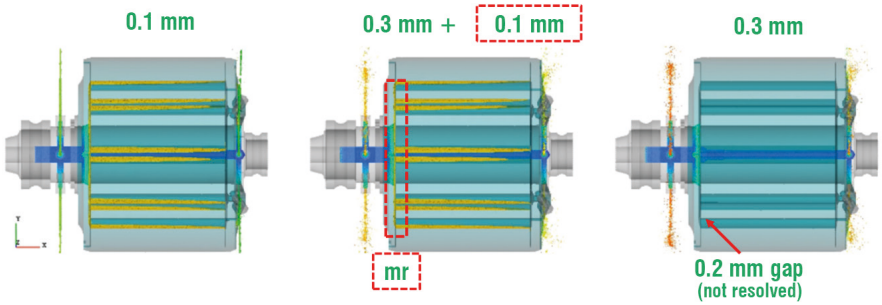

Fig. 1. Oil flow in the channels of an e-motor integrated in a rotor: by defining a multi-resolution region to resolve the small gap (dashed box), the particle size is only reduced locally, while the rest of the domain is discretized with a larger particle. This enables simulation times to be reduced by half.

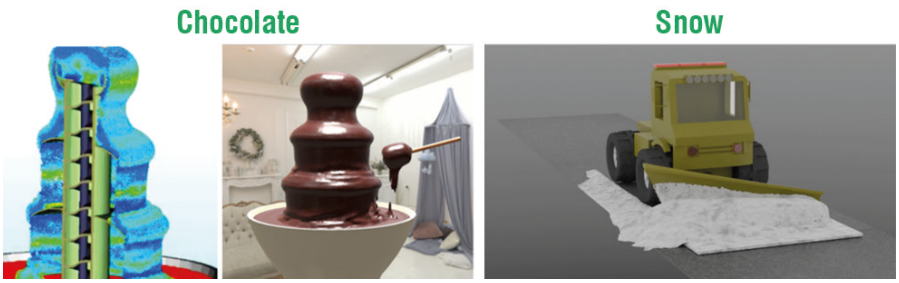

Fig. 2. The MPFI solver improves the simulation results for highly viscous fluids. Particleworks 8 also includes advanced snow models for more comprehensive analysis describing different snow textures and degrees of wetting.

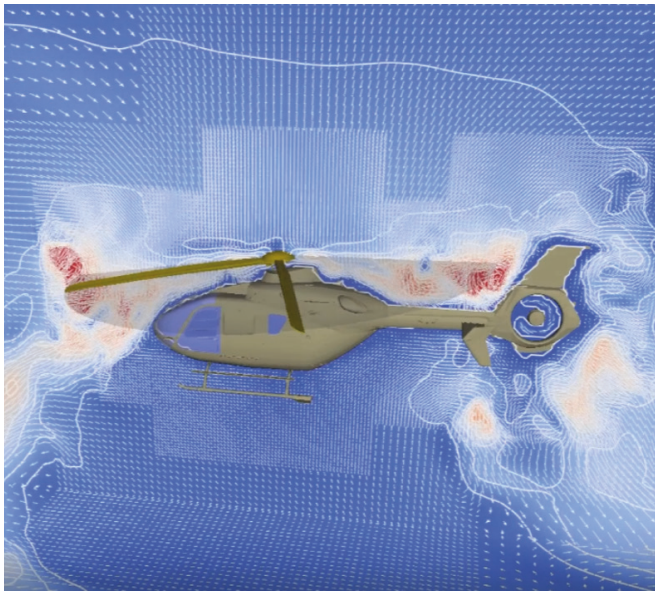

Fig. 3. Results from a lattice Boltzmann simulation of a helicopter take-off.

This mesh-less approach does not require the configuration of the calculation grid, simplifying external aerodynamic analysis without the need for geometric simplifications or for dealing with complex kinematics, such as the rotation of a helicopter rotor or the intricate dynamics of a damped vehicle.

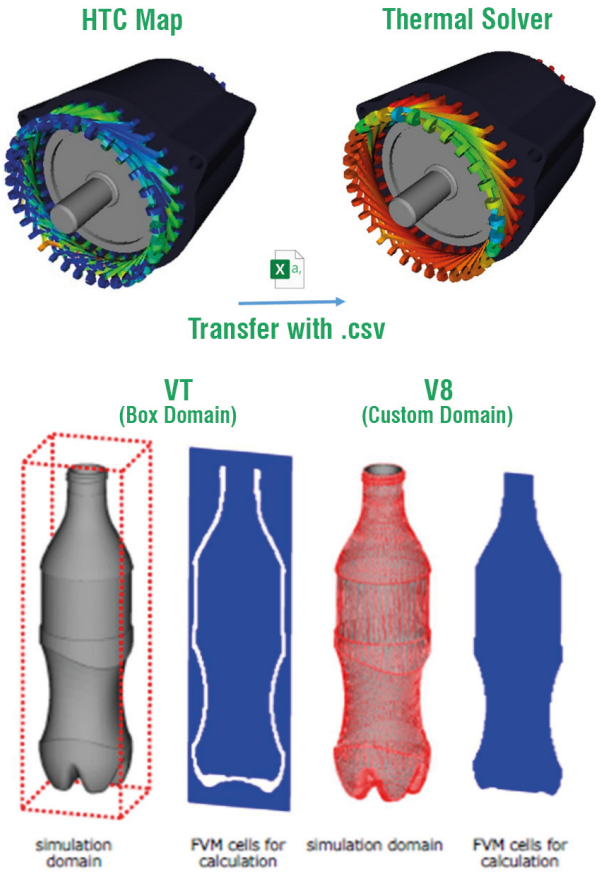

Fig. 4. Text files (.csv) can now be defined as boundary conditions for HTC (heat transfer coefficient) and temperature maps in the Particleworks thermal solver. Moreover, it is also possible to define customized simulation-domain shapes (.stl files).

More control over boundary conditions

As far as boundary conditions are concerned, the finite element thermal solver (already present in the previous version) now allows the user to set temperature and heat exchange boundary conditions on specific surfaces using .csv files.

The simulation domain can be defined with a customized file limiting the areas initialized with Cartesian grids for the air phase only to the area of interest (e.g. inside a bottle or engine compartment).

Efficient hardware scalability and other improvements

Compared to CPU core-based computing, running Particleworks on GPUs can provide significant advantages as shown in Fig. 5. It is worth noting that a single GPU running on a workstation can provide

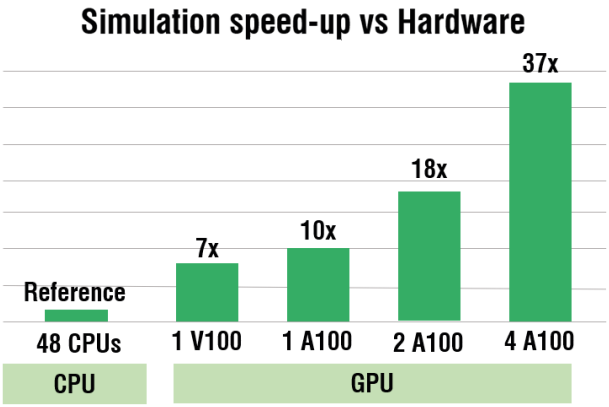

Fig. 5. Scalability analysis of Particleworks on single and multi-GPU, as compared to 48 CPUs. By running on 4 GPUs the simulation times could be reduced by a factor of approximately 40.

as much computing power as 450 CPU cores, at a significantly lower price and without the need for a large IT infrastructure. In addition, Particleworks also supports multi-GPU computing. The scalability is almost linear, with simulation times approximately halved when doubling the number of GPUs.

This new version includes other noteworthy improvements, especially for handling large-scale models, turbulence modelling, Python workspace integration into the GUI, and the introduction of passive scalar to evaluate chemical diffusion in the fluid/air.

In conclusion, the new release of Particleworks allows users to tackle more detailed and complete analyses faster and without sacrificing calculation time.

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