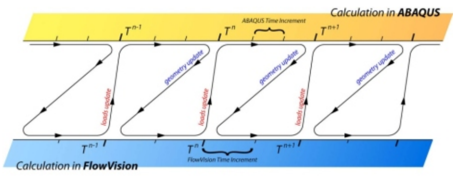
Fluid-Structure-Interaction SIMULIA/Abaqus FEA- FlowVision HPC

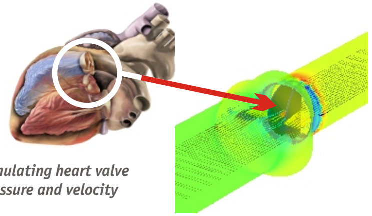
FlowVision-HPC combined with SIMULIA/ ABAQUS offers unique co-simulation capabilities for solving heavily coupled fluid-structure-interaction problems. The SGGR based implementation provides natural link between the fluid and FEA domains. The “wetted interface” is automatic established and can involve moving object with arbitrary complexity. The MPM (Multi-Physics-Manager) controls both FlowVision and ABAQUS during the simulation process. The data is exchanged through ABAQUS Direct Coupling Interface providing optimal and accurate data transfer rates and support of parallel processing significantly speeding up the simulations. The most complex FSI problem can be solved now in realistic time (e.g. hydroplaning of automotive tire < 20 hours).

- Simple set-up, control and monitoring with MPM
- Automatic coupling of not matched meshes (fluid-structure)
- Inclusion of highly deformable and moving structures
- Free surface tracking
- Socket based communication
- Full parallel processing with ABAQUS (explicit/implicit)
- Distributed computing
(Abaqus, FlowVision on different computers, locations)

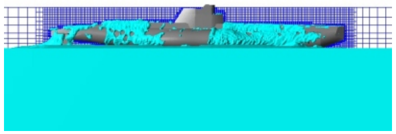
Co-simulation Abaqus-FlowVision



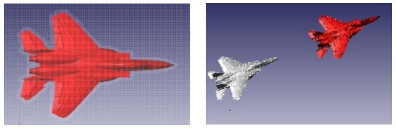
Data exchange Abaqus-FlowVision



Simulating heart valve
Pressure and velocity



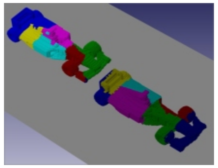
Hydrodynamic loads



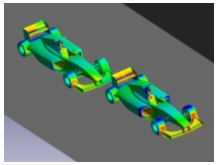
Aerodynamic characteristics (formation)

Parallel calculations

The FlowVision-HPC parallel solver operates on Microsoft Windows or Linux operating systems and offers high level of scalability speeding up the most complex simulations from weeks to days. Results: realistic simulations without simplifications, more accurate results through use of automated multi-parameter and multi-criteria optimization procedures.



Automatic domain decomposition on



Simulation 12.000.000 cells

Supported platforms

- Windows 2000/XP/2003/ Vista/Compute Cluster Server
- Unix and Linux clusters: SUSE, RedHat
- Windows, Linux: 32/64-bit
- Intel Cluster Ready Program

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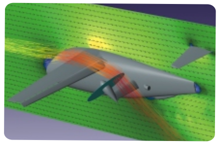
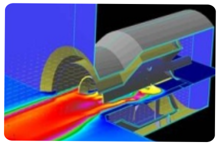
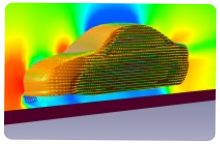
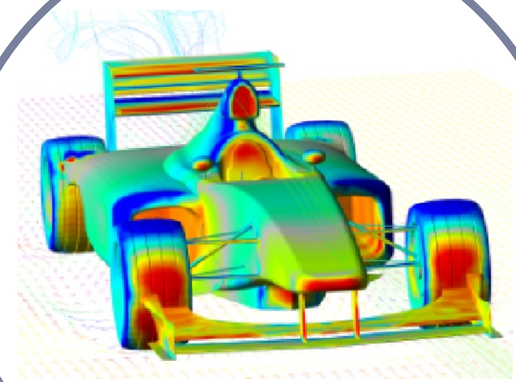
FlowVisionHPC

Computational Fluid Dynamics and Multi-physics









Pressure distribiution

FlowVision-HPC - is general purpose Computational Fluid Dynamics (CFD) simulation software for modeling complex 3D laminar and turbulent gas/fluid flows. The FlowVision-HPC solver uses the Finite-Volume formulation and robust physical models, implemented on the parallel architecture using highest-accuracy and highest- efficiency numerical schemes. FlowVision-HPC is easy to use all-in-one CFD software with intuitive and straightforward user interface. Automatic grid generation operates directly on CAD models with arbitrary complexity (parts and assemblies). The original boundary curvature is fully maintained even on the coarse grids (SGGR). The integrated on-line post-processing provides graphical monitoring of simulation results starting from the first iteration.

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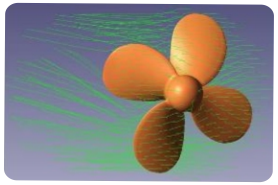
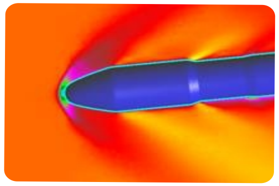
Features:

- Ease of use -all-in-one environment: pre-processing, solver, post-processing
- Automatic immersive grid generation based on SGGR (Sub-Grid-Geometry-Resolution)
- Exact CAD model boundaries representation
- One solver for all Mach numbers operating on grid with arbitrary cell shape
- Moving bodies: hydrodynamics determined or user defined motion
- Unique approach for dimensionality problems in simulation domain (clearance model)
- Advanced VOF method for free surface tracking
- Co-simulation with Abaqus for complex bi-directional fluid-structure-interaction
- Parallel processing on multi-core (OpenMP) and multi-node (MPI) clusters
- Extensive substance and materials database
- High level of customization with templates and plug-ins
- Open architecture and C++ implementation





Simulation capabilities

Mesh generation

- Import of CAD/FEM geometry: VRML, STL, INP-Abaqus FEA, NASTRAN, ANSYS, IGES, STEP, VDAFS, PARASOLID, ACIS, CATIA V4/V5, Pro/E, UGS, SolidWorks
- Sub-Grid Geometry Resolution (SGGR) method: resolution of curve-linear surfaces boundary with arbitrary complexity (natural truncation of hexahedral cells by triangulated geometry)
- Easy grid definition and fast automatic grid generation
- Automated dynamic grid adaptation to geometry and solution

Pre-processor

- Definition of substances, phases, and phase interactions
- Selecting physical processes and models
- Definition of initial and boundary conditions
- Definition of initial grid and adaptation criteria

Navier-Stokes solver for all Mach numbers and flow regimes

- Simultaneous presence of regions with M<<1 (incompressible flow) and M>>1 (supersonic or hypersonic flow) in the computational domain
- Single numerical algorithm applied throughout the entire computation domain

Stationary and non-stationary flows

- Single time marching procedure for obtaining steady and unsteady solutions

Moving bodies

- Easy import of bodies into the computation domain
- 6 degrees of freedom motion
- Accurate and fast Euler method for computing body kinematics: user-defined motion laws
- Body dynamics: gravity, hydrodynamic, or user-defined forces
- Calculator for complex math expressions
- Coupled simulation of the body motion and evolution of free surfaces

High-accuracy VOF method for free surface tracking

In a partly filled cell the free surface is reconstructed using SGGR method. The shape of the free surface is reconstructed considering the distribution of fluid around this cell. Mass, momentum and energy fluxes are accurately balanced in the neighbor cells.

Fluid-structure interaction (FSI)

- Two-way coupling with FEA systems,
- Automatic data exchange
- Fast explicit coupling procedure
- MPM Manger controlling co-simulation

Heat transfer models of

- Molecular thermal conductivity
- Turbulent thermal conductivity
- Free and forced convection
- Conjugate heat transfer

Turbulence models k-Epsilon "standard"

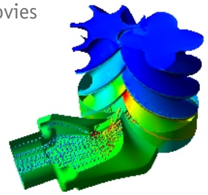
- k-Epsilon low-Reynolds AKN
- k-Epsilon quadratic
- Shear Stress Transport (SST) k-Omega
- Spalart-Allmares

Numerical algorithms

- Unstructured polyhedral Cartesian grid
- Finite Volume approach
- Velocity-pressure split algorithm for integration of the Navier-Stokes equations
- High-accuracy non-skew and skew schemes
- Explicit and implicit time integration
- Lanczos method with second order incomplete ILU (ILU2) factorization
- Modified successive point over-relaxation (SOR) method for solving nonlinear systems of equations
- Newton method

Post-processor

- Vectors on a plane or surface
- Isolines on a plane or surface
- Color contours on a plane or surface
- Plots
- Isosurfaces
- Integral volumetric or surface characteristics
- Integral cross-section characteristics
- Semi-transparency
- Saving history of simulation
- Possibility to create movies



Flow characteristic of a compressor

Application Areas

Aerospace

- Air flows around airplanes, rockets, wings, intakes, etc.
- Gas flows in compressors, turbines, and jet engines

Automotive

- Car body aerodynamics
- Engine cooling
- Oil flow in lubrication systems (seals, bearings, differential gears, etc.)
- Ventilation and conditioning of the car compartment
- Water flow near a moving wiper

Power Production

- Heat exchange in the nuclear reactor cooling system

Construction and architecture

Medical applications

- Blood flow in arteries
- Blood flow in a heart valve
- Air flow in the respiratory tract

Oil & gas Industry

- Oil or gas flows in ducts, reservoirs, and pumps

Electronics

- Thermal analysis of electronics
- Ventilation of electronic devices

Shipbuilding

- Water flow around the hull of a high speed boat
- Ship resistance calculation
- Putting a ship afloat
- Ship screw propeller hydrodynamic analysis
- Ship propeller and hull interaction

Turbomachinery

- Definition of the head-flow characteristic of a pump, compressor, or turbine
- Estimation of thermal and flow loads on turbine blades
- Air flow around a wind machine

Natural disasters

- Water dam breaking followed by flooding a landscape