Computational Fluid Dynamics
with HyperWorks

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AcuSolve – Better Technology, Better Solution

- Fluid-Structure Interaction
- Thermal Management
- Computational Aero-acoustics
- Non-Newtonian Flow Simulation
- Electronic Cooling
- Aerodynamics

Multiphysics Analysis and Optimization

- General purpose CFD solver
- Unique formulation based on Finite Element method
- Robustness & Accuracy
AcuSolve Features

- **Physics:**
  - Incompressible & weakly compressible Navier–Stokes
  - Thermal analysis
    - Conjugate heat transfer
    - Multi–layered thermal shell
    - Enclosure radiation – View factors
    - Solar radiation
  - Multi–species transport equations
  - Sliding Mesh (Rotary Machines)

- **Turbulence:**
  - Spalart–Allmaras RANS model; k–w, SST
  - Dynamic subgrid LES models
  - Hybrid RANS/LES (DES) model & (DDES)

- **Time Accurate Transient Simulation:**
  - Coupled with control systems
AcuSolve Overview

Flow solver

- CAD Package
  - Third Party Mesh Generator and/or Input File Writer
  - Pre-Processor
    - AcuConsole
  - Analysis
    - AcuSolve
      - Acoustic Analysis
      - CAA Output
      - Translators / Direct Readers
      - Third Party Post-Processor
      - Direct Coupling Fluid/Structure Interaction
      - Structural Solver
AcuSolve Overview

- **Markets using AcuSolve:**
  - Automotive
  - Train aerodynamics
  - Renewable Energy
  - Boat design
  - Electronic cooling
  - Chemical mixing
  - Home Appliances
  - Medical and medical equipment
  - Oil/Gas and offshore
  - Universities
  - National labs
  - Etc. . .
Flows in Rotating Machinery

- **Rotating reference frame**
  - Steady state simulation
  - Rotational body forces appear as source term in
  - No special user input on the interface (rotating, stationary)
  - Less CPU time than transient

- **Sliding mesh**
  - Transient simulation
  - Rotating and stationary mesh
  - Accurate but higher CPU time
Engine and Powertrain cooling *(components)*

- **Heat Exchanger Component**
  - Simplifies the device to a modeled pressure drop and heat source

- **Fan Component**
  - Simplifies the device to a modeled pressure rise and swirl
Thermal features

- Conjugated heat transfer
- Enclosed radiation
- Solar radiation
- Multi-layer thermal shell
  - e.g. electronic cooling, PCB (printed circuit board)
Thermal features

- Conjugated heat transfer
- Enclosed radiation
- Solar radiation
- Multi-layer thermal shell
- Convection

Transient thermal CFD analysis in car cabin
Scalar transport equations

• Species transport equation

\[ \rho \frac{\partial \phi_i}{\partial t} + \rho u \cdot \nabla \phi_i = \nabla \cdot \Psi_i + \rho \sigma_i \]

• Solve up to 9 advective diffusive transport equations

• Useful for modeling multiple miscible fluids and concentrations

Air/methan mixing (premixer of gas turbine)
Sliding Mesh & Rigid Body Valve Motion

- No remeshing
- Sliding mesh
- Changing BC
- Mesh distortion
Fluid Structure Interaction (FSI)

- **Rigid Body Dynamics Coupling**
  - 6-DOF rigid body solver

- **Practical FSI (P-FSI)**
  - Modal analysis in structural code
  - N modes as input for AcuSolve
  - Structural displacement computed by AcuSolve
  - Limited to linear structural displacements

- **Directly Coupled FSI (DC-FSI)**
  - Two codes run in tandem
  - Data exchange managed by AcuSolve
  - No intervening middleware required
Fluid Structure Interaction (FSI)

- **AcuSolve/MotionSolve Coupling**
  - AcuSolve/MotionSolve communicate using AcuSolve’s code coupling interface
  - Wetted surfaces are “paired” with rigid bodies
  - Loads/displacements exchanged at run time
Fluid Structure Interaction (FSI)

- **AcuSolve/MotionSolve Coupling**
  - Rigid bodies only
    - No flex body support at the current time
  - Suitable for loosely coupled applications
    - AcuSolve’s Multi-Iterative Coupling (MIC) functional, but will be improved in MotionSolve V13.0.210
**Fluid Structure Interaction (FSI)**

- **AcuSolve/MotionSolve Coupling**

- **Full system dynamics**
  - Maneuvering+aero
  - Tank sloshing
  - Complex motions

- **Complex interactions**
  - Not possible with AcuSolve’s internal 6-DOF solver
HyperMesh 13.0 *(general)*

- **Geometry**
  - All major CAD systems supported *(Catia, ProE, …)*
  - Geometry creation / repair / cleanup

- **Meshing**
  - CFD specific surface & volume meshing
  - Advanced boundary layer generation *(squeeze & collapse)*
  - Mesh optimization
  - Fluid & solid meshing

- **Import/export**
  - All major CFD solver supported *(Fluent, CCM+, CFX, Exa, …)*
**HyperMesh 13.0 (BL generation)**

**BL Propagation Controls**
Imprint angle & max layer difference

**Proximity Controls**
BL control in narrow regions

**Quality Controls**
BL layer collapsing based on elem. criteria
HyperMesh 13.0 *(octree based mesher)*

- A faster tetra mesher
- Smooth element transition
- Good quality tetras due to smoothing
HyperMesh 13.0 (*wrapping*)

- Variable element size
- Automatic hole/gap patcher
- Maintain close proximity between pair (*e.g. wheel and fender*)
- One click solution

*before*  
*after*
CFD Post–Processing: HyperView

HyperWorks Desktop

- HyperView and HyperGraph
- Visual Data Interactively
- Capture and Standardize Post–Processing Process
- Results in AcuSolve Format, H3D or EnSight file format
**Features**

- Contour plots
- Vector plots
- Cutting planes
- Stream lines
- Moving meshes
- Animations
CFD Analysis Workflow in HyperWorks

HyperMesh - AcuConsole
AcuSolve
HyperView

Geometry Cleanup
Meshing
Morphing
Simulation (Solver)
Visualization

Optimization & DOE

HyperStudy
HyperStudy

- DOE (Design of Experiment)
  - Parameter study, sensitivity analysis, dependencies
  - Approximation of response surface

- Optimization
  - Variation of the Design Variables (DV)
  - Min/Max the objective function
  - Satisfy restriction

- Robustness studies
  - IN: Stochastic distribution for the DV
  - OUT: Stochastic distribution of the system response
Morphing
Case Study #2: Optimization of an exhaust tube

Flow velocity

initial

optimized

\[ \gamma: +12\% \]
\[ \Delta p: -16\% \]
Virtual Wind Tunnel

- Virtual Wind Tunnel
  - Environment for external automotive CFD analyses
  - Reduces user input to minimum

- Strength
  - Automatic and fast tetra mesher
  - One environment (meshing, setup, cluster submission)
  - Automatic reporting
  - Easy access to high end technology
  - Transient and steady state

- CFD solver AcuSolve
  - Finite-Element based CFD solver
  - Accurate, robust and scalable

Remark: Cluster westmere Xeon processors, 2.53GHz
Virtual Wind Tunnel in One Minute
HyperWorks for CFD

**Complete CFD workflow supported by HyperWorks**

**AcuSolve, next-gen CFD solver integrated in HyperWorks**

**Advanced FSI capabilities available in AcuSolve**

**One CAE platform for structural and CFD analysis**
Thank You!