
SIEMENS
Ingenuity for life
Version
2020.2
Siemens Digital Industries Software
Simcenter STAR-CCM+
New features and enhancements
Engineer Innovation
www.siemens.com/mdx

New Features and Enhancements in Simcenter STAR-CCM+ 2020.2

Realism

- Increase model sophistication
- Include all relevant physics
- Elevate confidence in results

Productivity

- Save engineering time
- Increase simulation throughput
- Improve hardware utilization

Exploration

- Explore more designs
- Gain analysis insight
- Accelerate design decisions

Continuity

- Implement best practices
- Enable enterprise collaboration
- Facilitate closed-loop design

Top new features and enhancements for this release are:

- Grouping of Field Functions [1]
- Model based adaptive mesh refinement for combustion
- Energy averaging on shrouds in rotating machines
- Mesh morphing with DEM [1]
- Mechanical contact for computational solid mechanics [1]
- RNG k-ϵ Turbulence for In-Cylinder
- Bubble plots [1]

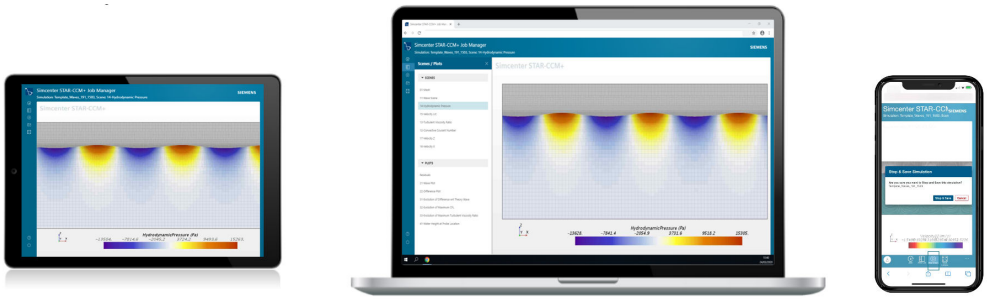
1 Posted on IdeaStorm
A total of 29 new features and enhancements from IdeaStorm in this version.

Enhancements to Simcenter STAR-CCM+ 2020.2 are presented by category:

Platform

Deployment

- **Web Monitor for simulations submitted with Job Manager**
  - Anytime, anywhere, any device access to your jobs through a web interface
    - Monitor progress of simulations submitted using Job Manager
    - No installation required on connecting devices
    - Web responsive and streamlined user interface
    - No convoluted cluster connection process
  - Immediate grasp of simulation status with interactive access to simulation progress indicators
    - View live updates to plots and scenes
    - Explore scenes to deepen understanding: zoom, pan, rotate
    - Consult output log for complete details or troubleshooting purposes
  - Take action on the go, save time by stopping the simulation if needed
    - Immediately free up hardware and license resources from a review of your simulation progress indicators
    - Either stop and save the simulation, or abort it instantly

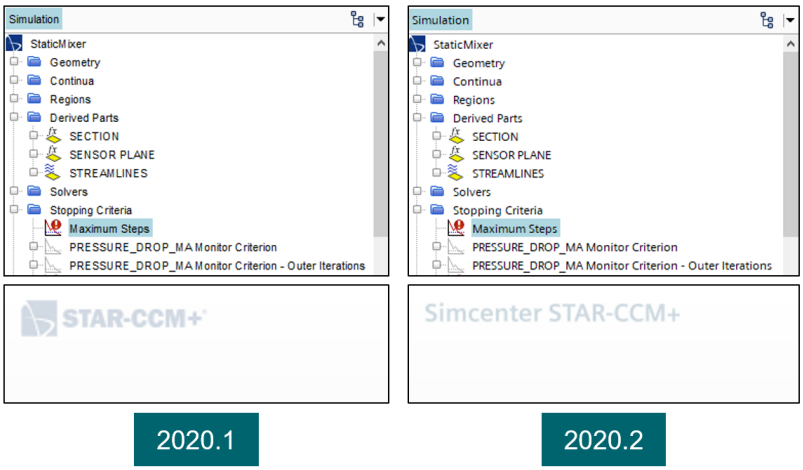


  - Limitations:
    - No support for plot interaction
    - Uses server rendering with a single thread: the graphics capabilities of the machine where the master process is running are used. Activities depending on hardware graphics or multiple render threads for best performance may suffer: for instance, opening a scene with advanced rendering can result in long delays before the first frame displays.

- **Job Manager updates**
  - SLURM scheduler now compatible
  - LSF scheduler now compatible
  - Support of Job Manager instances for simulation submissions on HTTPS (SSL)
- **Newly certified operating systems (OS)**
  - CentOS 7.7
  - RedHat Linux Enterprise (RHEL) 7.7
- **Retiring operating systems (OS) in 2020.3 (15.06)**
  - CentOS 6.10
  - Red Hat Linux Enterprise (RHEL) 6.10
- **Newly certified Message Passing Interface (MPI) versions**
  - Intel MPI 2019.5
  - Open MPI 3.1.5 (planned as new default for 2020.3 (15.06))
  - MS MPI 10.1.1 (now included in release distribution)
- **Newly supported Message Passing Interface (MPI) versions**
  - Open MPI 4.0.2
- **Retired Message Passing Interface (MPI) versions**
  - Intel MPI 2018.1
  - Open MPI 3.1.3
  - MS MPI 8.1.1, 10.0

User Experience

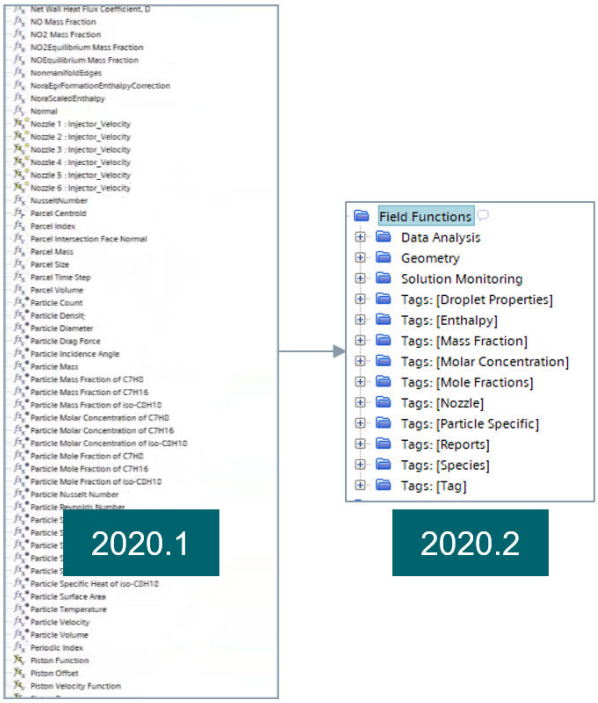
- **User interface updates to font and default scene logo**
  - Clear, common and coherent user experience across products in Siemens Digital Industries Software portfolio
  - Font of user interface updated to Siemens Sans Global on both Windows and Linux
  - Update of the default scene logo



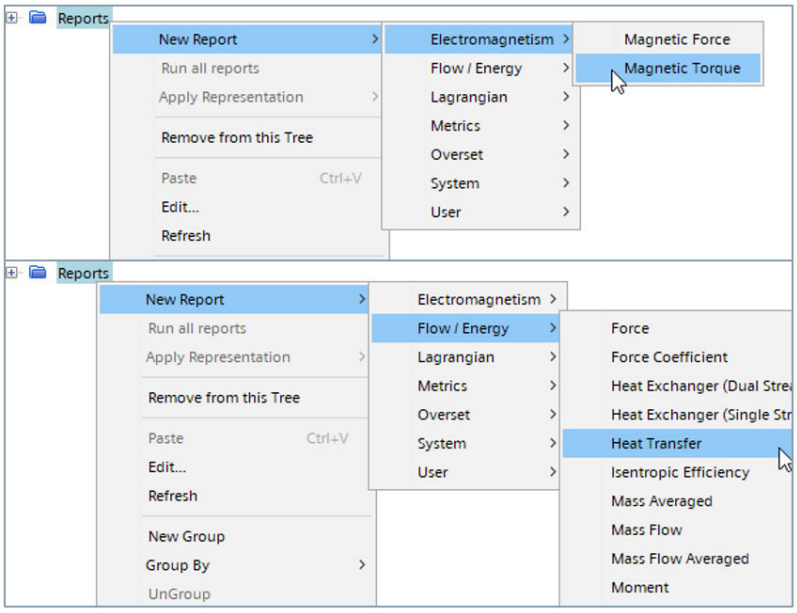
- **Grouping of Field Functions D976**
  - Improved ease of use through groups of field functions
    - Find field functions faster with less scrolling, less clicks
  - Reduced thinking time to process large amount of similar data sets with automatic and custom groups

- Either create your own custom groups
- Or choose the automatic grouping from attributes shared between field functions: dimensions, value type, tags

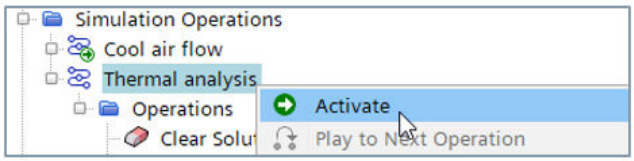
◦ Limitation: groups for field functions are not yet available in the object selector, in the scenes pull-down menu, and in the expression editor



- **New ordering for creation of reports**
  ◦ Faster access to the right report type with groups



- **Simulation Operations activate from context menu**
  ◦ Activate in-situ, no need to resort to toolbar



CAD Integration

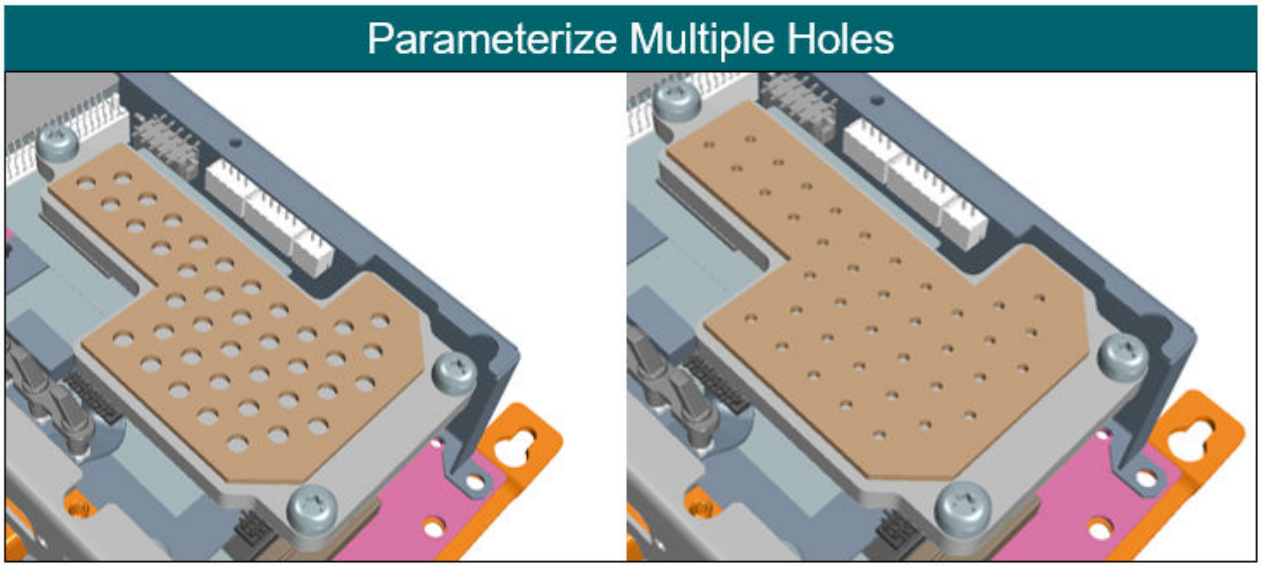
CAD-Clients

- **Client for NX version upgrade**
  - Support added for
    - NX 2019.2 (1872 series) and NX 2020.1 (1899 series)
    - Simcenter 3D 2019.2 and Simcenter 3D 2020.1
  - All functionality and user interface stay the same as previous versions
- **Important Note: Planned removal of CAE Mode for CAD Clients**
  - The capability to setup simulations (physics parameters, mesh settings etc) within the CAD environment is planned to be removed for all tools apart from CATIA V5 from Simcenter STAR-CCM+ 2021.1
  - CAD Clients will continue to focus on
    - Direct geometry import
    - Bi-directional parameter transfer
  - Please contact your Simcenter customer support representative for further information

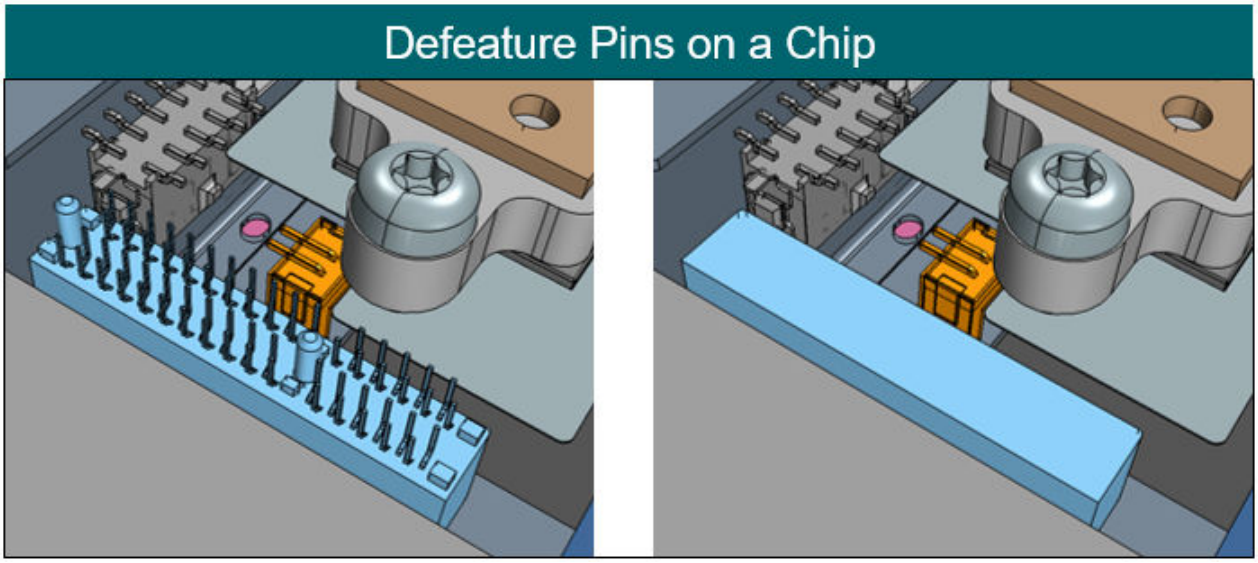
Geometry

3D-CAD

- **Extend Solid D5128**
  - Allows easier parameterization through the extension of existing faces of solid body
    - Parameterize dumb CAD with a few clicks
      - Example: Enlarge or reduce multiple holes
  - Extend one or more faces along the face normal, linear, or angular direction
    - New "Extend Solid" option is added to the right-click menu in the scene
  - No need to unite the new faces to the base body
  - Limited to solid faces
  - Supports multiple faces in a single feature

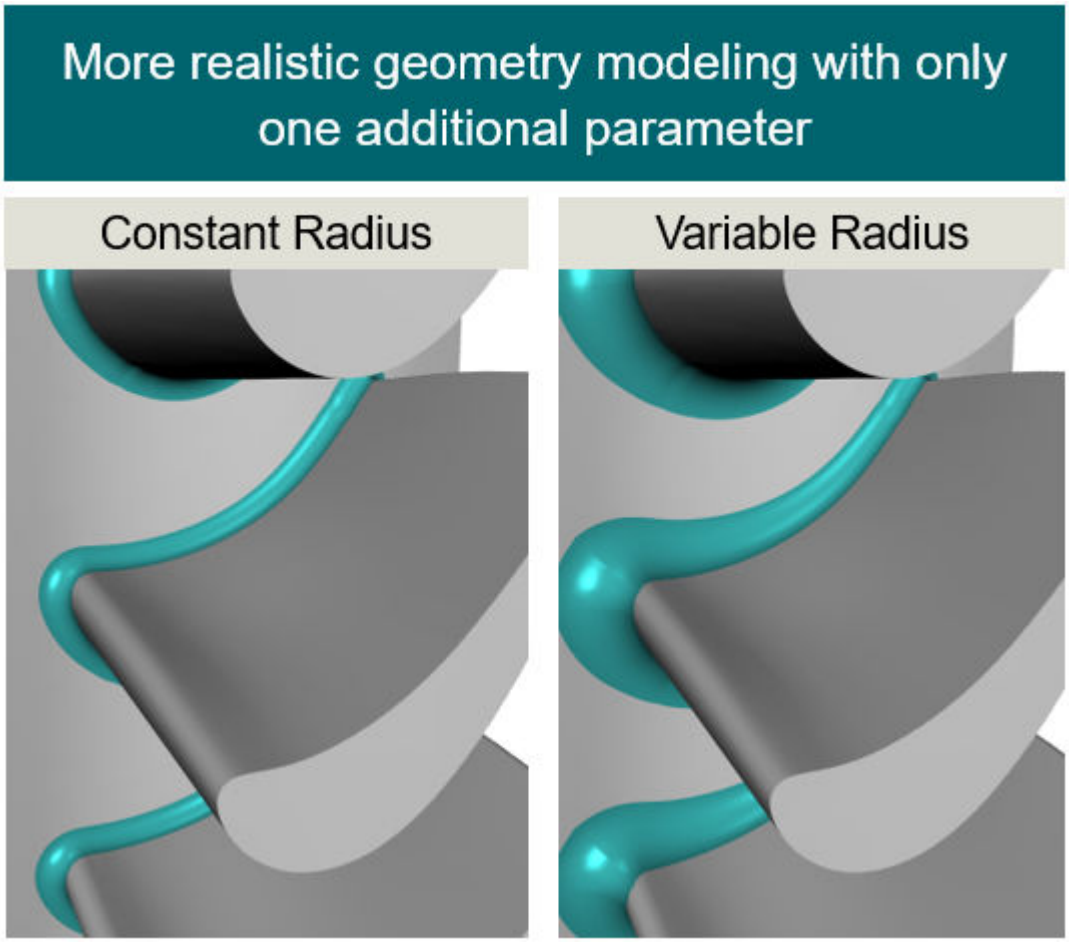


- **Defeature Faces - Delete Interior Faces**
  - Enables easy removal of unwanted internal faces that are not required for analysis
    - Delete embossed features from a body
    - Defeature circuit board and chips
    - Remove interior details of the engine block
  - Defeature Faces operation is enhanced to support “Delete Interior Faces”
    - Supports both solid and sheet bodies
    - Off by default
  - *Limitation: Cannot handle interior faces spanning more than one face*

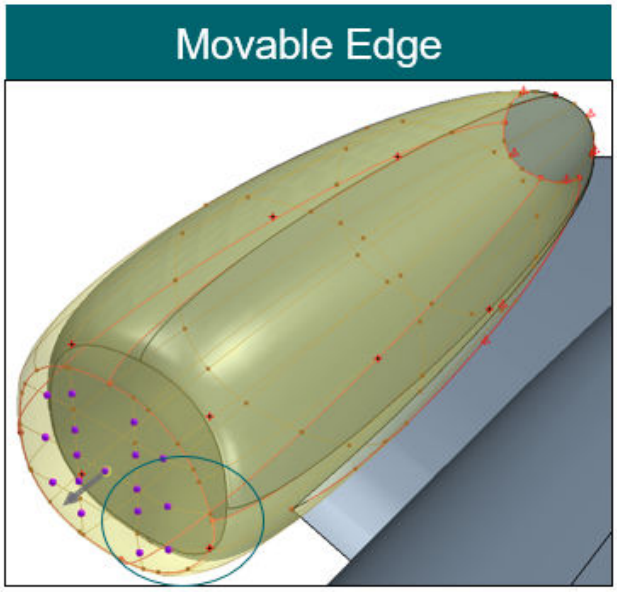


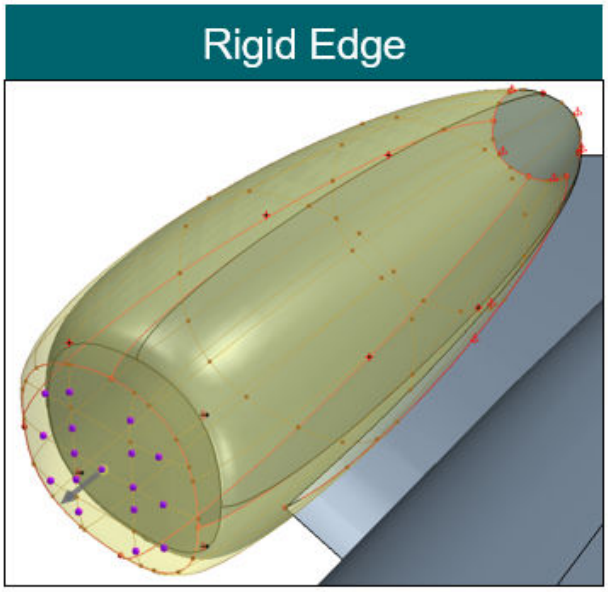
- **Variable Radius Fillet D5260**
  - Enables creation of more realistic models with variable fillet along the edges
    - Fillet operation now supports variable radius
    - Supports connected edges of a single body
    - Manually add extra points on the edges with “add points on edges” option
    - Add Points on edge with a slider control

- The fillet shape can be either circular or conic

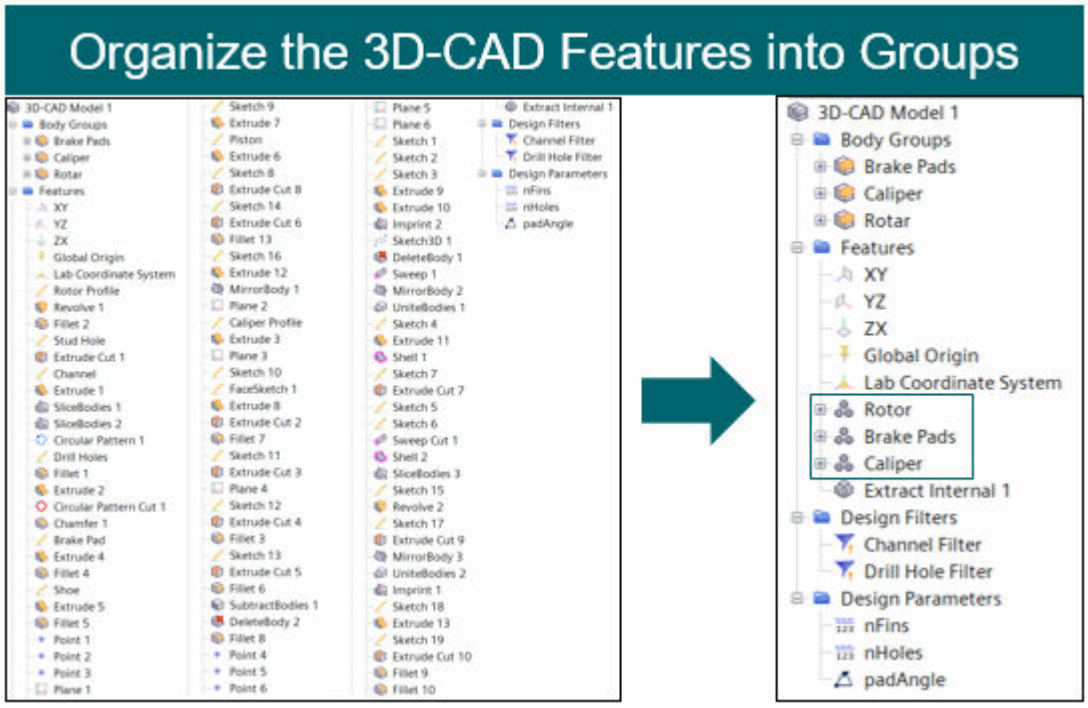


- **Freeform – Rigid Edge Constraints**
  - Provides better control over organic shape changes in design studies through defining constraints on edges
    - During freeform, user can retain the shape of the internal and laminar edges
    - Rigid constraint for free and internal edges
    - Fixed constraint for internal edges
    - New icon **Display Interior Edge Constraints** is added in display options
    - Off by default

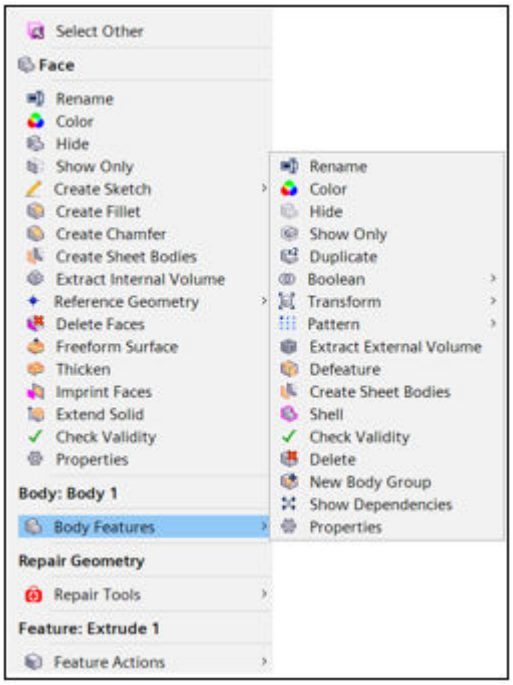




- **Search tool enhancement**
  - Search Tags set to Body, Body Group, Face and Edges
    - Allows you to select entities assigned with Tags to feature via filters
  - Support Body Group in predicates
    - Search Body Group by Area, Volume, Name, and Tag
  - Filter support for sketch imprint, color and rename features
  - Repair features are added to the Design Filter feature pop-up menu
- **Easier navigation in feature tree through grouping D4222**
  - Right-click option “Group Feature”
  - Introduces a new folder name, “Group” in the feature tree
  - Supports drag-and-drop of features into the group folder



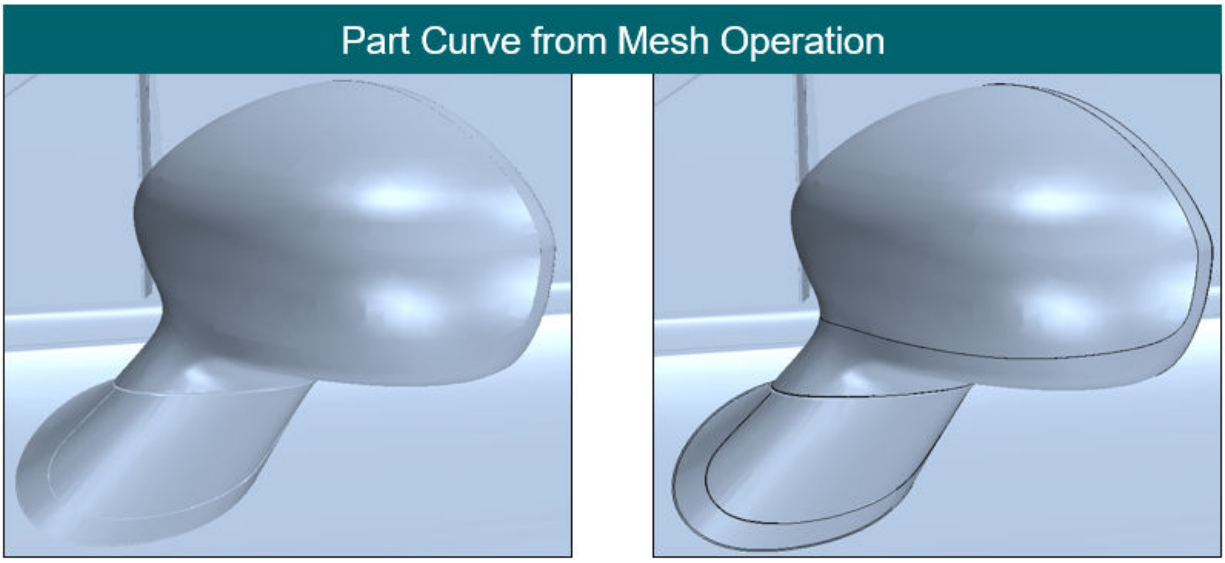
- **3D-Sketch enhancements**
  - Accurate creation of point, line, and spline on geometry in 3D sketches through icon **Pick on Geometry**
    - ON by default
    - Display other 3D-Sketches in a different color
- **Context Menu**
  - The Body features in the 3D-CAD scene right-click menu are collapsed to a sub-folder



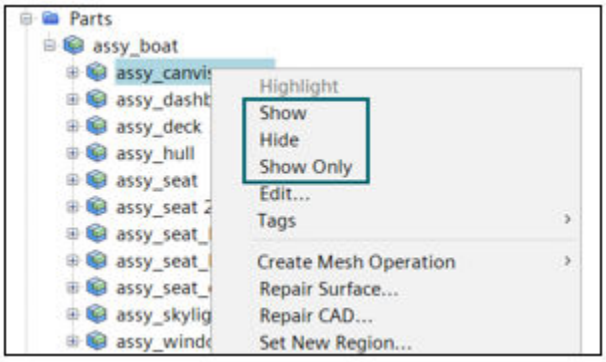
- **Feature Panel Changes**
  - Support drag-and-drop of bodies between the group boxes in a Feature Panel. For instance, in the Unite Operation Feature Panel, you can now drag and drop a body between the target and tool bodies group box.
  - When editing a feature, removed the focus on the top group box to avoid any mouse click in the scene that can remove the entity already selected in the group box.
  - The feature name now appears in the title of a feature edit panel.
  - **Enable-Feature Preview** option added to the **Tools** > **Options** > *3D-CAD* panel for switching off the preview in the feature panel.

Parts

- **Part Curve Creator Operation D2582, D5292**
  - Java macros are no longer needed to mark feature curves thanks to new mesh pipeline operation
  - Part Curve Creator operation provides the ability to:
    - Mark Sharp Edges, Free Edges, Non-manifold Edges, Perimeters
    - Automatically Fix Errors
    - Maintain Existing
    - Delete Empty



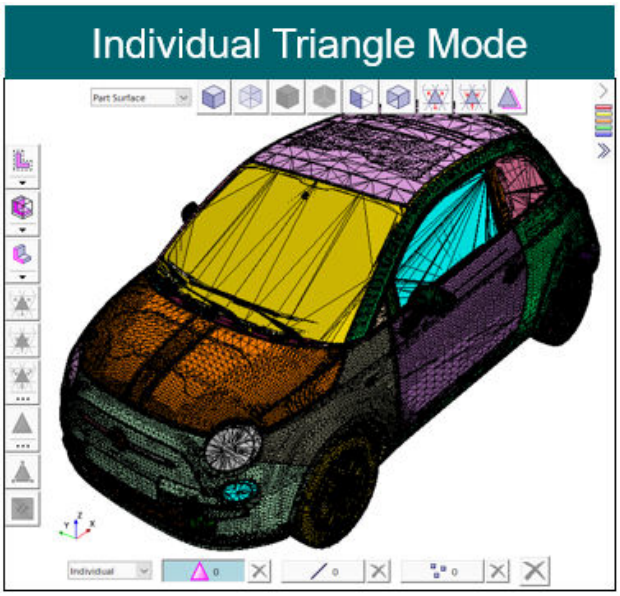
- **Show/Hide/Show Only through right-click menu in simulation tree**
  - Edit visibility of composites or parts in the active scene directly from simulation tree
    - No need to manually drag the composite or parts to the scene

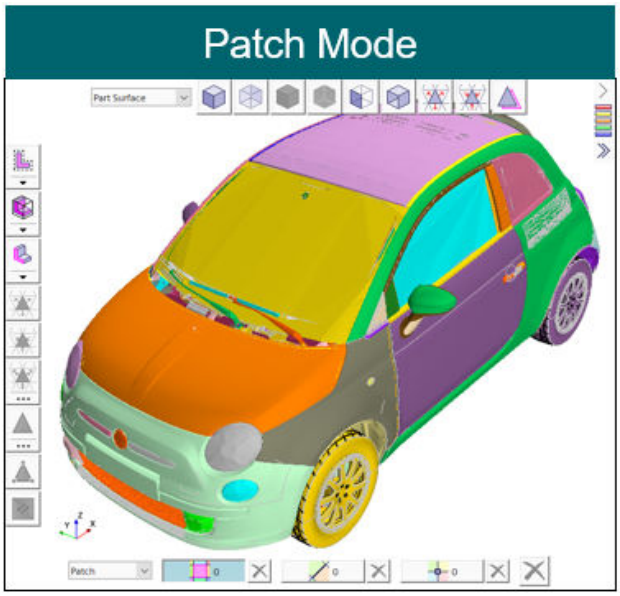


Mesh

Surface Repair

- **Surface Repair – Patch mode**
  - Improves turnaround time during model preparation by interacting with a patch instead of triangles
  - Geometry represented as patches instead of triangles.
    - A mouse click will select entire patch or patch bounding edge instead of individual triangles or edge
    - All repair operations accept patches
    - Toggle button to switch between patch and triangle mode





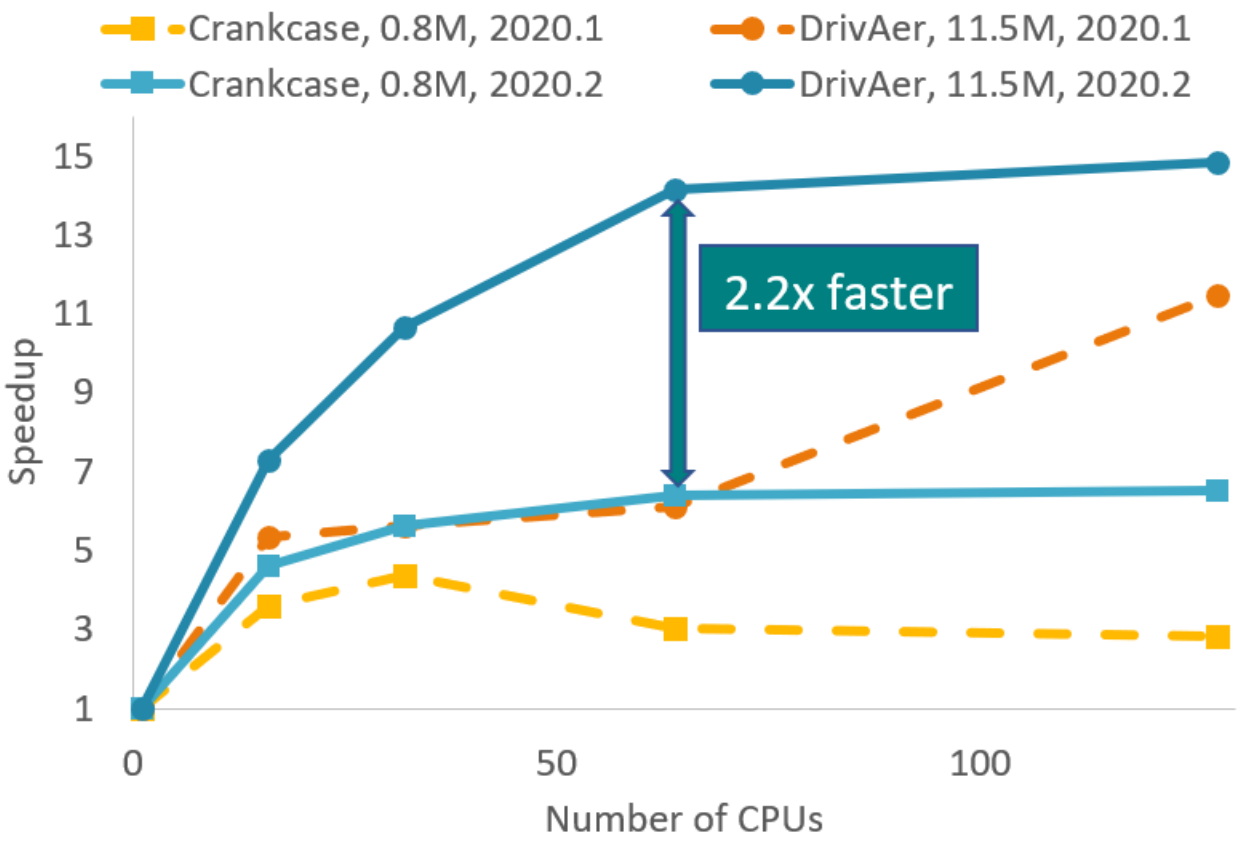
- **Repair input surface**
  - Easy access to repair Surface from mesh operation through right-click menu option **Repair Input Surface**
    - Opens Repair Surface with the input parts from the Mesh operation automatically selected
- **Remesh faces**
  - **Modify Free Edges** option allows you to maintain existing vertex placement and number on free edges when remeshing
    - To enable this behavior, deactivate the **Modify Free Edges** option

Surface Mesh

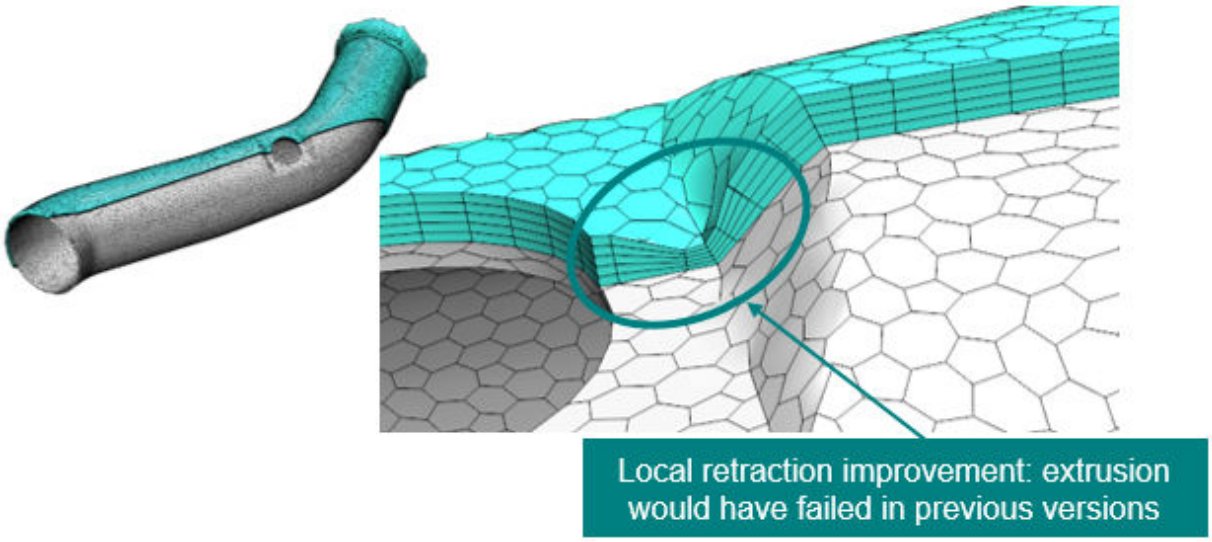
- **Surface Wrapper - Gap Closure**
  - Improved performance of surface wrapper on large cases that use gap closure
    - No change in the surface wrapper setup process
    - 1.2x speedup observed on full car wrap
- **Surface Remesher - Surface Growth Rate**
  - Now possible to specify surface growth rate as Fast, Default, Slow, or User Specified
    - Absolute value calculated based on mesh type and Surface Growth Rate
    - User Specified allows setting absolute value

Volume Mesh

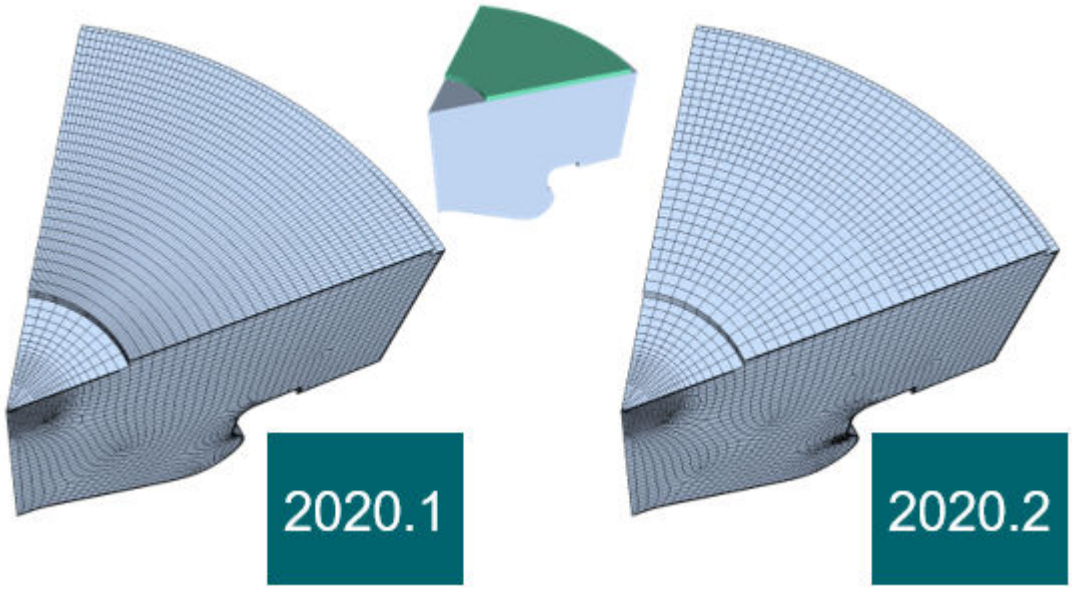
- **Improved performance for parallel polyhedral meshing**
  - Faster generation of tetrahedral and polyhedral meshes in parallel
    - 1.07-3.8x faster for 128 cores
    - Performance gain dependent on the deployed number of cores and is case dependent
      - Highest impact for high core counts & high surface area to volume ratios



- **Improved robustness for thin mesher**
  - Previously the mesher could fail in thin parts where a tiny zone of the part could not be thin meshed, because the zone was too small to mesh with polyhedral or tetrahedral cells
  - To avoid this, now the thin mesh surrounding the tiny zone is retracted, which gives enough space for the tetrahedral / polyhedral mesher
- **More robust meshing for abrupt prism layer transitions in convoluted geometries through improved layer transition algorithm**
  - Less meshing failures proven for geometries with transitions from many to few layers
    - For example vehicle underhoods which typically have transitions from 20 to 3 prism layers
- **More robust extrusion of non-planar part surfaces through local retraction D4688**
  - Previously parts-based volume extruder stopped if self-intersection in surface extrusion, and retracted globally in case of negative volume cells
    - Now extrusion is performed and retracts locally
    - Consistent with regions based meshing extrusion



- **Consistent rotational sweep coarsening across contacting parts**
  - Rotational sweep coarsening now also accounts for parts not connected to rotational axis



- **Improved parallel mesh equivalence for polyhedral and tetrahedral meshers**
  - Improved parallel mesh equivalence for a limited range of applications which contain thin gaps where the surface mesh size varies greatly between the two sides of the gap
- **Conformal tetrahedral meshes at interfaces between operations**
  - When using the "conformal between operations" option in tetrahedral meshing, conformality across interfaces is more aggressively enforced across contact interfaces.
    - May improve robustness in finite element simulations e.g. electric machines
- **Directed mesher robustness improvement**
  - Better resolution of curved geometries and less failures through improved handling of geometric features that do not need to be resolved by the mesh.

- **Important Note: Planned removal of Region-Based Meshing**
  - Region-based meshing has been deprecated in Simcenter STAR-CCM+ 2020.1 and is planned to be removed in version 2021.1
  - The recommended practice is to use parts-based meshing. See the section "Simcenter STAR-CCM+ > Pre-Processing > Meshing > Parts-Based Meshing" in the Simcenter STAR-CCM+ User Guide
  - Please contact your Simcenter customer support representative for further information

CAE Integration

- **Co-Simulation third party version support**
  - **Support added**
    - Simcenter Amesim 2019.2 (new recommended version)
  - **Support maintained**
    - Simcenter Amesim 17 and 2019.1
  - **Support ended**
    - Simcenter Amesim 16.1

Physics

CFD

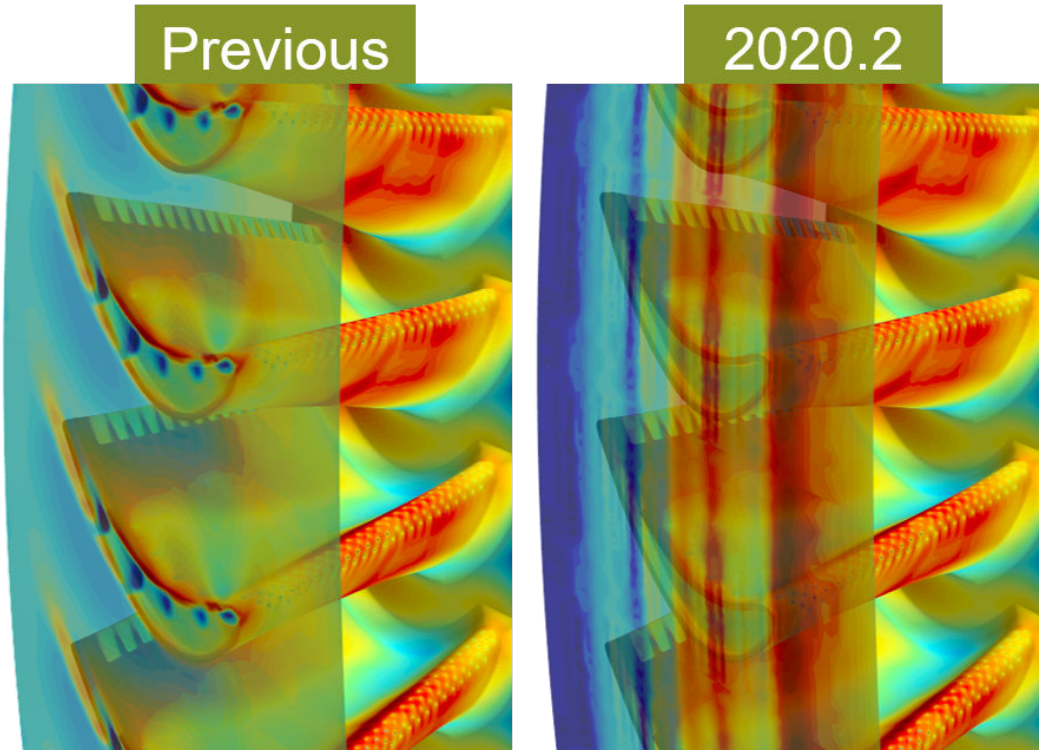
Flow

- **Treatment for species boundary conditions with reversed flow**
  - Improved robustness for reacting flow simulations with outlet recirculation where inflowing species mass fractions, combustion scalars, passive scalars, and temperatures are set at the boundary
    - These conditions may vary from interior values causing robustness issues
    - Using extrapolated values from the interior for the boundary values stabilizes the solution

Energy

- **Energy averaging for stationary surfaces in rotating media**
  - Improved physical realism of the shroud thermal profile
    - Improves physical realism of averaged results on the shroud for turbomachinery simulations with a moving reference frame

        - Boundary condition option for shroud wall allows separate reference frame to be specified
    - Easy to use workflow
        - Uses radial bins to average quantities in a similar manner to a mixing plane
        - Allows post processing using existing field functions
    - *Incompatible with EMP and non-equilibrium phasic porous media*



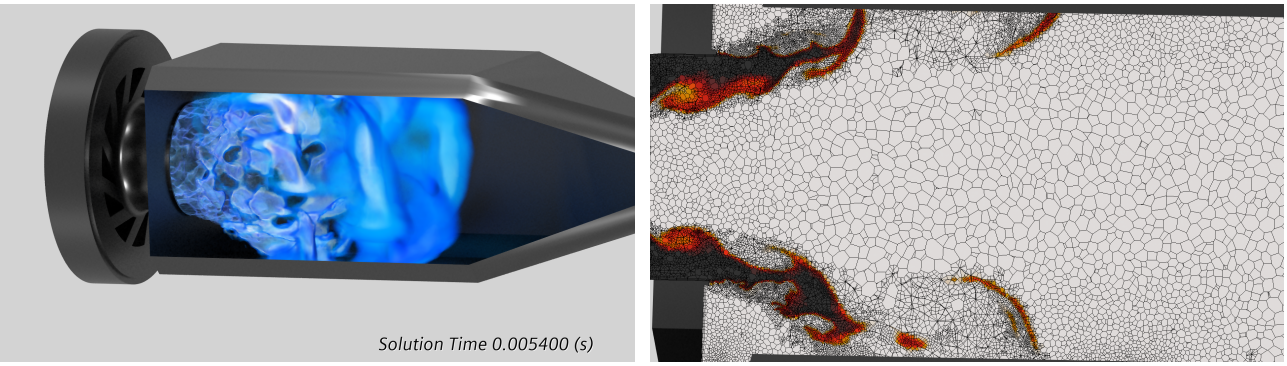
- **Improved ray tracing efficiency using packets and streams**
    - Up to 5x speed-up of the View Factor calculation
        - Streams consist of many rays being traced at once to try to maximize cache coherence
    - Particularly beneficial for large vehicle thermal management cases
        - Greatest speed-up shown for cases with large cell counts
    - *Shells are not yet supported by Advanced Ray Tracing*

# cores	Adv RT (s) 2020.1 ViewFactor	Adv RT (s) 2020.2 ViewFactor	VF Speed up
40	1614.9	367.3	**4.40**
80	1097.0	228.9	**4.79**
160	636.1	139.0	**4.58**
320	598.3	136.2	**4.39**
400	545.1	135.2	**4.03**

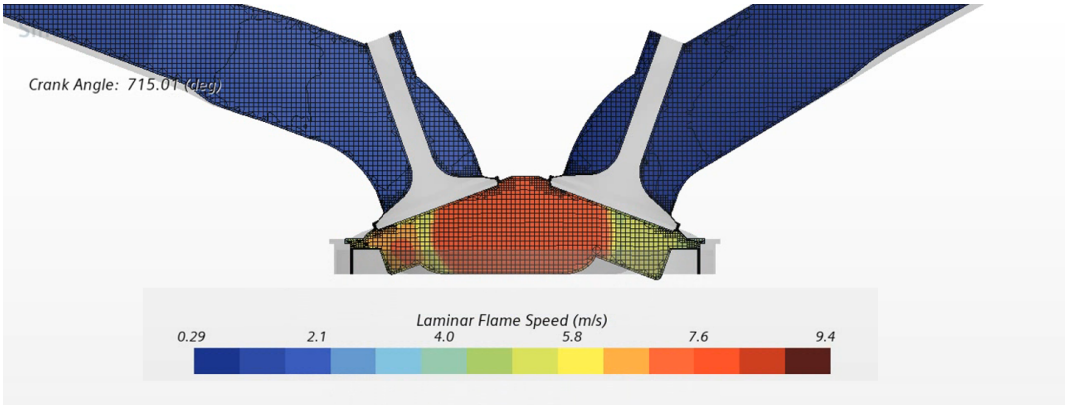
Reacting Flows

- **Model based refinement for Adaptive Mesh Refinement (AMR)**

- Reacting flow flame front model based refinement
  - Provided in addition to standard field function driven refinement
  - Refines cells specifically around the flame front preventing the flame from becoming unresolved by a coarse mesh
  - Preserves the sharp interface of the flame front
- Reduced computational expense
  - Fine mesh is only needed where it is required
  - Can be used alongside adaptive time-step, allowing refinement in space and time
- Improved ease of use
  - Reduces the need for 'guesswork' of where the flame is going to be
  - Start with a coarse mesh for flame propagation studies and let the solver define where the mesh needs to be
- Typical applications include dynamic flame propagation and steady flame positioning

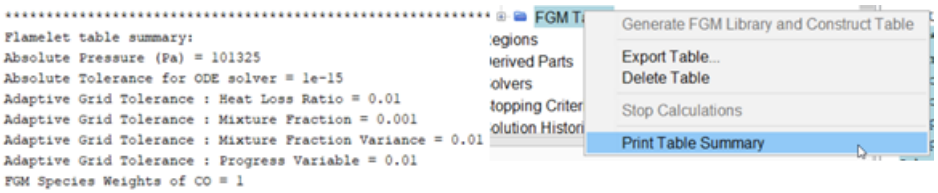


- **Unburnt temperature for Laminar Flame Speed (LFS) correlations**
  - Accurately model complex fuel propagation with the CC-TFC model
    - The unburnt temperature is now available as a field function
    - LFS correlations can now be built using the field function editor
  - Improved ease of use
    - Previously estimates of the unburnt temperature had to be used
    - Now the unburnt temperature used by the CC-TFC model is available.
  - Typical applications are for novel or complex fuels



- **Flamelet table generation summary**
  - Improved ease of use and reduced opportunity for error

        - Use the 'Print summary' option to quickly understand what parameters were used to build the table
    - Reduced complexity
        - Previously expert warning messages that were printed to the console caused concern during the table generation process
        - A verbosity flag has been added so that only expert users can see these warnings that have a very low impact on the simulation



- **Soot modeling using generalized precursor**
    - Accurately model soot formation with method of moments
        - Use multiple soot precursors as source of soot
        - New precursor soot species can be specified: A2, A2R5, A3, A3R5, A4, A4R5, FLTN, P2
    - Improved Ease of Use
        - Wider variety of chemical mechanisms now useable for soot predictions
- **Liquids in Reacting Channel**
    - Accurately model liquids in the tubes of reacting channel approach
        - Constant density is now available for liquids in the 1-D channel

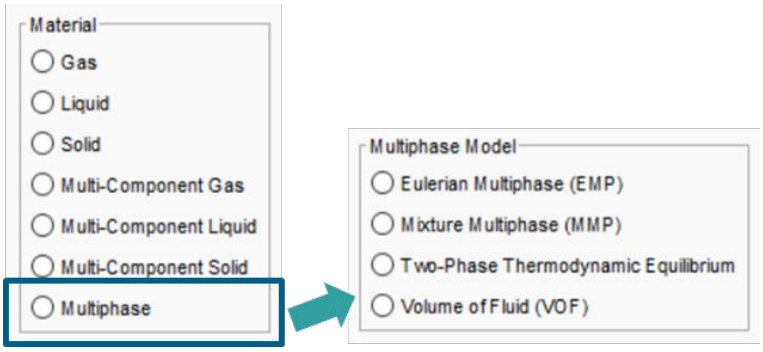
Turbulence

- **Important Note: Removal of the AKN k-epsilon turbulence model**
    - The previously deprecated AKN k-epsilon turbulence model has now been removed
    - The model has been superseded by models such as Lag Elliptic Blending and Standard k-epsilon Low-Re

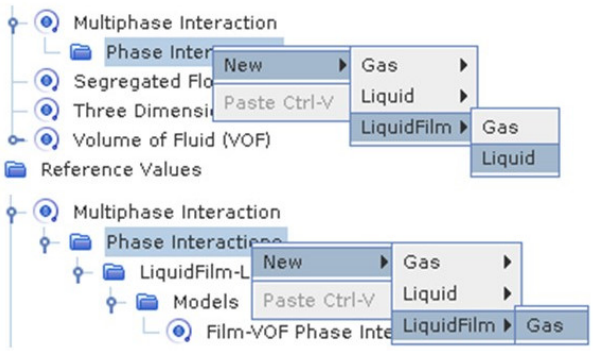
Multiphase Flow

General User Experience Improvements for Multiphase

- **Clearer labeling of multiphase models**
    - Reduced set-up time and user error
    - Consistent terminology used
    - Eulerian family of multiphase models are now accessed as *Multiphase* under material with the following multiphase model choice:
        - Eulerian Multiphase (EMP)
        - Mixture Multiphase (MMP)
        - Two-Phase Thermodynamic Equilibrium
        - Volume of Fluid (VOF)



- **Easier to set-up phase interactions**
  - Reduced set-up time and user error
  - New workflow
    - Under new phase interaction, simply select the primary phase associated with any multiphase model
    - Possible partner phases across all multiphase models are listed for selection
    - Once a pair of phases is chosen, appropriate phase interaction set up automatically without the need to chose type



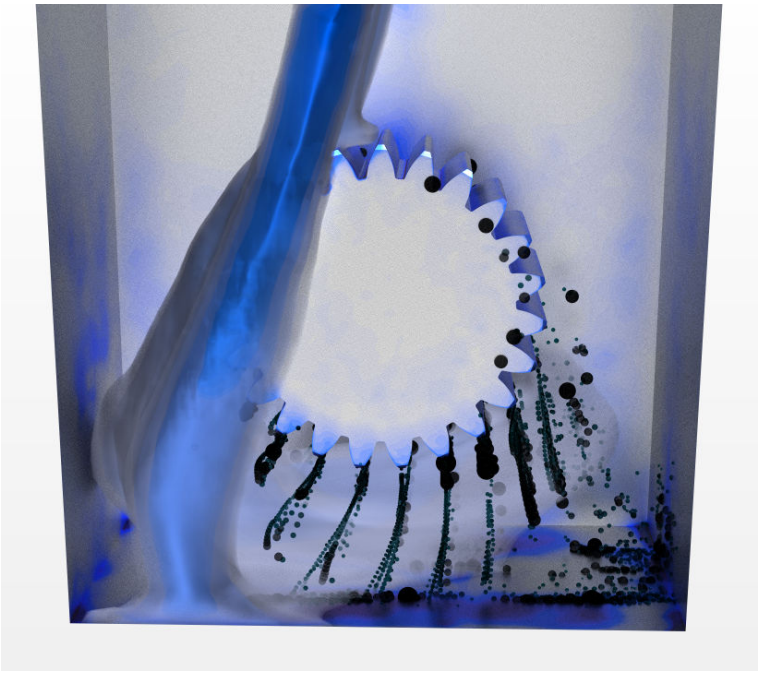
    - For subsequent phase interaction set-up this pair of phases is no longer shown simplifying selection
      - Allows simple set-up of all relevant phase interactions and ability to review any possible pairs not yet set-up

Volume of Fluid (VOF)

- **Hybrid VOF-Film (resolved Film) transition**
  - Improved accuracy of hybrid VOF-Film simulations
    - Option to equalize velocity between Film and VOF phase at transition
    - Reduces disturbances to flowfield due to transition
  - Benefits cases where Film layer is thick compared to first cell at transition
    - Occurs when a zonal approach is taken alongside a low y+ mesh instead of using cell volume fraction

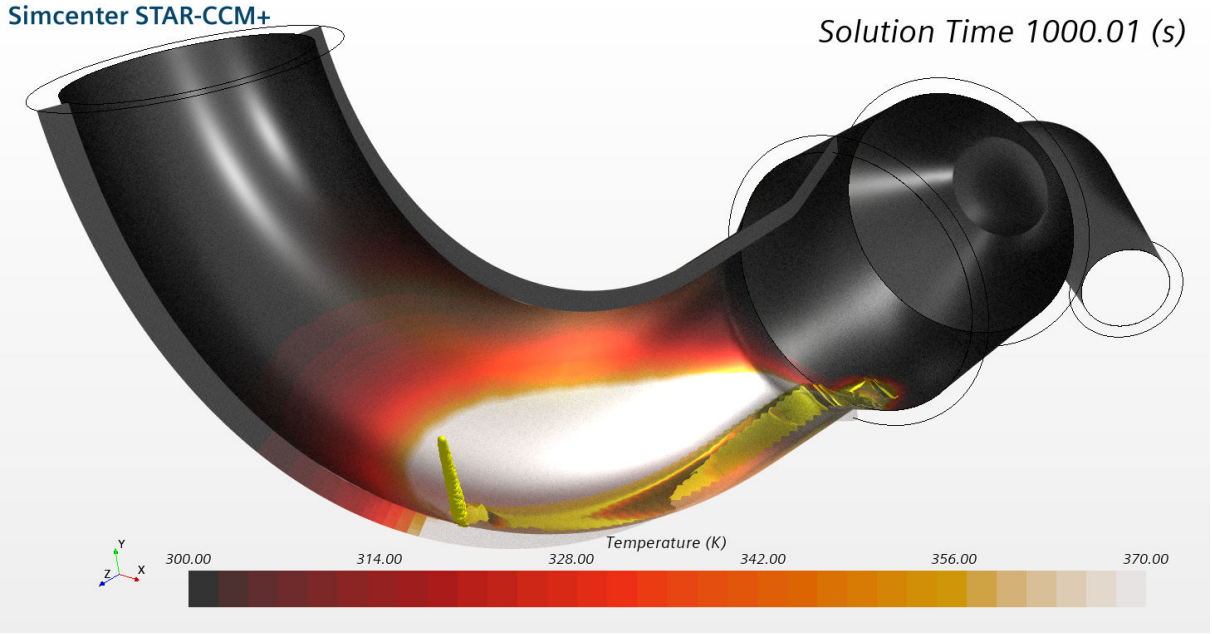
Mixture Multiphase (MMP)

- **Mixture Multiphase impingement into Fluid Film**
  - Reduced computational expense for mixtures with film
    - Allows Mixture Multiphase (MMP) to be used with Fluid Film in place of Eulerian Multiphase (EMP)
  - Allows modeling of applications with fluid films on surfaces including annular flows
  - Brings MMP into the hybrid multiphase family
    - Allows mixtures to impinge into Fluid Film phases
    - Can also be used alongside Lagrangian (LMP) phases
    - Allows modeling strategy of MMP phases for fine sprays/mists and LMP phases for larger ballistic droplets



Fluid Film

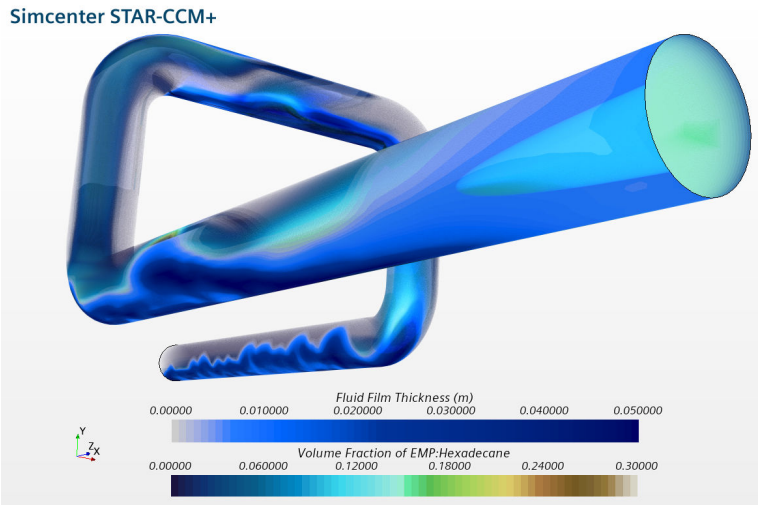
- **Compatibility of Fluid Film with Explicit Mapped Contact Interface**
  - Reduced run time for Conjugate Heat Transfer (CHT) problems with Fluid Film
    - Allows multi-timescale workflow for cases with a fluid film on the wall between fluid and solid
      - Small timescale for flow and film
      - Large timescale for solid
  - Allows simulations with Fluid Film to work with finite element solid energy



- **Solidification and melting with Liquid-Solid-Gas multi-component Fluid Film**
  - Improved ease of use when using Fluid Film Melting-Solidification model
    - Track solidified components in Fluid Film as a solid species in multi-component Liquid-Solid-Gas mixture
    - Previously used 'Relative Solid Volume Fraction' scalar (maintained for compatibility)
  - Consistent approach to other multiphase models' treatment of solid species

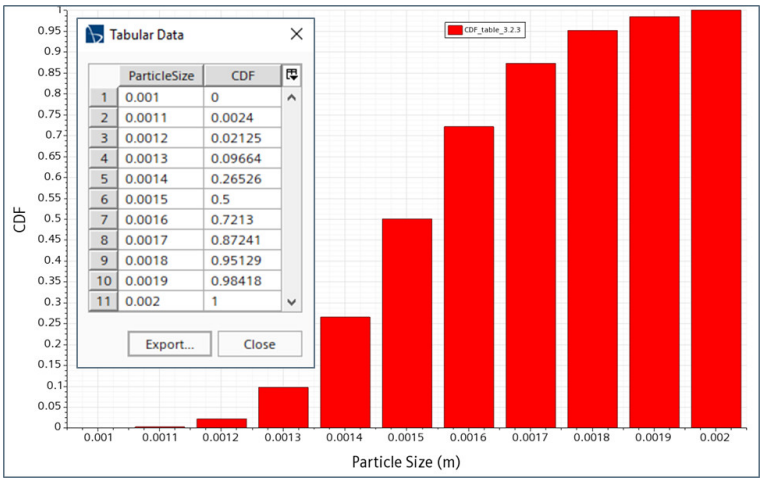
Eulerian Multiphase (EMP)

- **Fluid Film surface tension with EMP**
  - Improved fidelity of multiphase simulations
    - Model annular flows of thin Fluid Film with EMP
    - Surface tension can play a significant role
      - Particularly for hydrophilic fluid-wall interactions where otherwise wetting could be underestimated
    - Such flows are difficult to capture with resolved EMP



- Reduced computational cost
  - No need to resolve film at wall with EMP
  - Enables the use of coarser mesh

- **Fixed bins for A-MUSIG boundary conditions and initialization D4607**
  - Improved ease of use without loss of functionality
    - Allows size distribution specification in pre-defined bins for boundary conditions and initialization
      - A-MUSIG solver continues to solve on adaptive groups, new user defined bins are for the purpose of easier data input
    - Complements existing capability for post-processing



    - Allows easier set-up for comparison of results with other sources of data (experiments/other software)
    - Useful for working with populations of 'standard' sizes
  - Applications include bubble columns and evaporators in refrigeration/air conditioning

- **A-MUSIG surface and volume moment reports D4963, D5049**
  - Improved insight into distribution of dispersed phases
    - Report the mean moments of the A-MUSIG distribution that describe its shape
    - Moments represent the concentration of particles, the average particle diameter, surface area and volume fraction
    - Moment reports are available for boundary and part surfaces and regions
    - Moments can be reported based on
      - Number density weighting
      - Volume fraction weighting

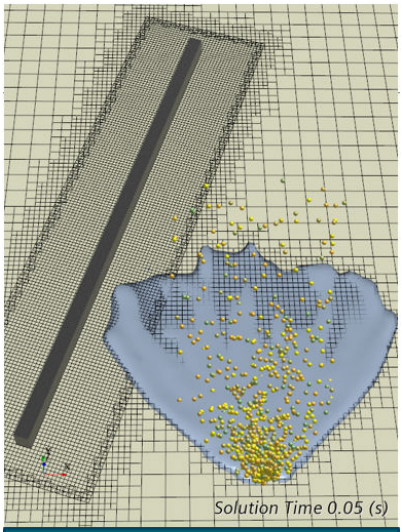
- **Multiple Regime Model - blending function**
  - Improved stability for multiple regime simulations
    - Blending function between regimes can now be controlled via a range of options
  - The following methods are now available:
    - Standard (Default)
      - The previous method plus additional parameter to control width of transition zone
    - Gradient corrected standard
      - Leads to smoother field of blending weight function
    - User specified
      - Blending weighting functions can be set by field function

- **Wall Lubrication Force Model**
  - Improved accuracy for bubbly flow applications
    - Allows more accurate prediction of wall lubrication layers, a critical phenomenon in bubbly flow where bubbles gather and slide along the wall to form a layer of vapor
  - New option added for Wall Lubrication Force

    - *Force* option (Lubchenko model) added as option alongside existing *Coefficient* based models (Antal, field function)
    - Shows improved accuracy over existing methods
- **Available Volume Field Function for EMP**
  - *Available Volume* field function that accounts for presence of blockage due to the presence of Fluid Film phases made available for EMP
    - Previously available for single phase
    - Complements existing *Effective Volume* which is phasic

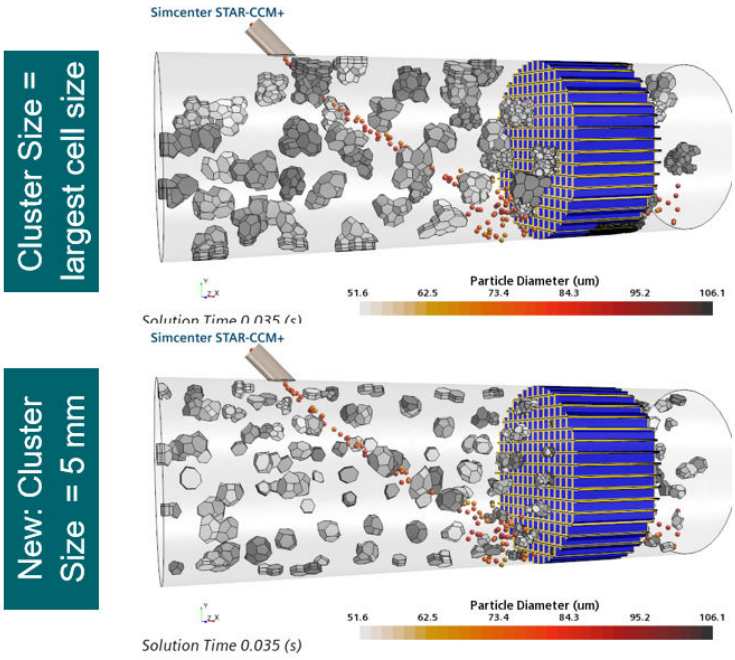
Lagrangian Multiphase (LMP)

- **Compatibility of Lagrangian multiphase with Adaptive Mesh refinement (AMR)**
  - Reduced computational cost in simulations including Lagrangian phases (LMP)
    - Allows AMR to be used for continuous flow field when LMP present (e.g. VOF free surface refinement)
    - Provides cell count reduction for cases where LMP droplets coexist with:
      - Model based refinement for VOF, overset, and reacting flows; AND/OR
      - User defined refinement based on field functions
  - Possible to refine the mesh based on Lagrangian fields via parcel data mapper and field functions

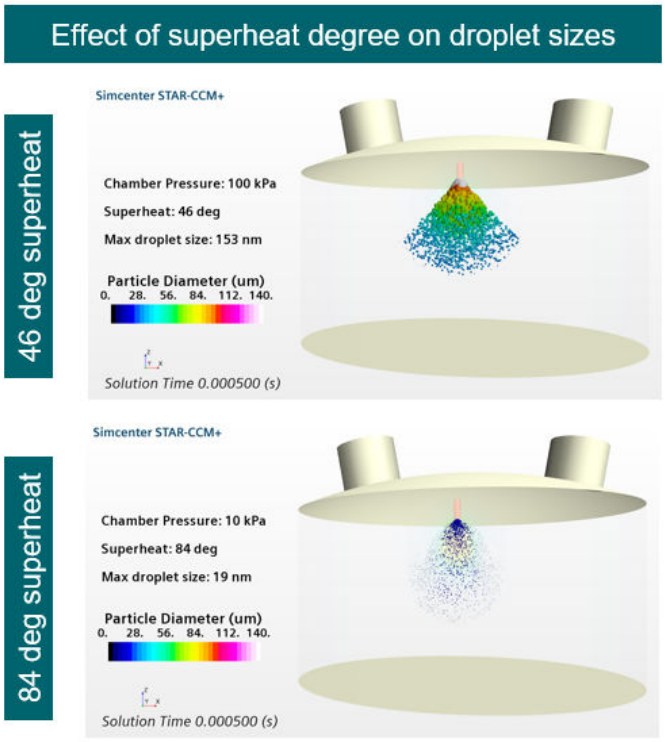


Lagrangin droplets hitting windshield. AMR applied to VOF surface

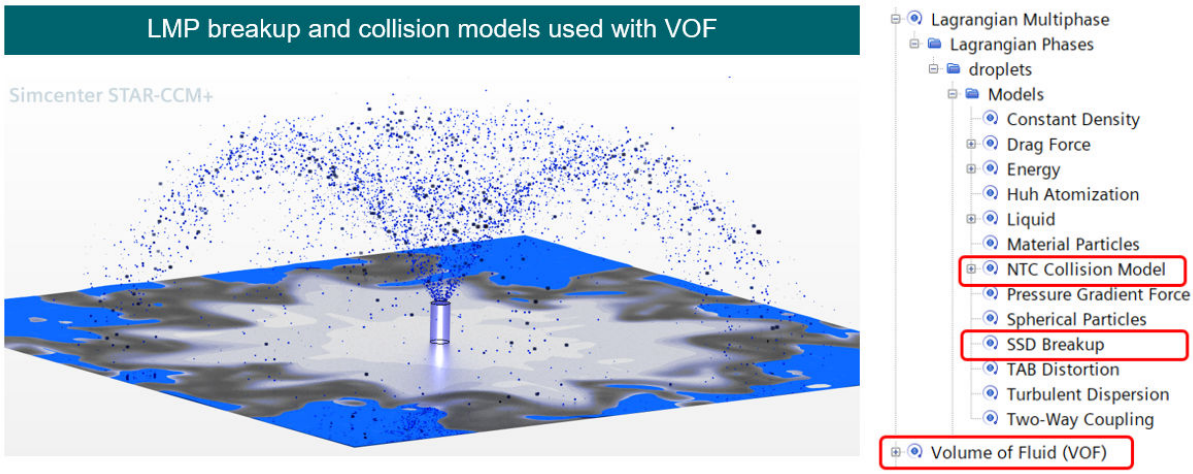
- **Improved control over the size of cell clusters D4354**
  - Improve convergence and accuracy for 2-way coupling model and reduce mesh dependency
  - Cell clustering is used to spread coupling effects of LMP on the flow solution over a cluster of cells
    - Previously minimum cluster size set by maximum cell size
  - New methods allow small clusters in near field when large cells exist elsewhere. Clusters defined by
    - Absolute size
    - Relative to geometric mean
    - Relative to largest cell (previous method)



- **Flash boiling modeling D4035**
  - More accurate modeling of fuel sprays
  - Flash boiling causes a fast transition from liquid to vapor
    - Can occur in internal combustion engines
    - Highly non-equilibrium and complex physics
  - Includes effects within nozzle
    - Control via Nozzle Injector parameters
    - Uses zero-dimensional cavitation and nucleation models to provide nozzle exit conditions
      - Nozzle Injector injects both LMP droplets and continuous phase for vapor
  - In-chamber flash boiling effects
    - Droplet Flash-Boiling model set in physics continuum
    - Accounts for
      - Enhanced vaporization due to superheating
      - Thermal breakup due to bubble growth



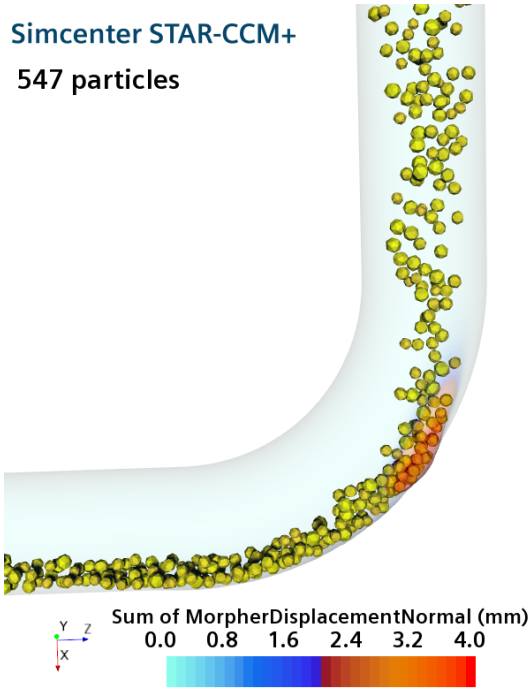
- **Every N Iterations option for Lagrangian Solver Update Frequency D4503**
  - Reduced time to solution
    - Avoids solving Lagrangian phase unnecessarily
    - Increased flexibility controlling update frequency
    - Allows solution every N flow iterations
      - N must be smaller than maximum number of iterations
    - Can improve the simulation time and maintain the stability for simulations with 2-way coupling
  - Lagrangian update frequency options
    - Recommended
    - Once per Time-Step
    - Every N Iterations (new)
- **Compatibility of collision and breakup models with VOF D4010, D5246**
  - Improved realism in hybrid multiphase simulations
    - Allow Lagrangian droplet collisions and break-up to be modeled in simulations also including
      - VOF or Hybrid VOF-film (resolved fluid film)
  - Applications include
    - Vehicle water management
    - Spray dryers
    - Filtration units
    - Wet scrubbers
    - Fuel and other sprays



- **Limit for surface vapor mass fraction in evaporation model**
  - Allow tuning of balance between accuracy and robustness when simulating evaporating droplets at high temperatures
  - New parameter *YsUpperLimit* limits the value of the surface vapor mass fraction
    - The default value is 0.99999
  - Facilitates users migrating from Simcenter STAR-CD to Simcenter STAR-CCM+Simcenter STAR-CCM+
    - Setting *YsUpperLimit* to 0.99 allows better reproduction of Simcenter STAR-CD results
- **Parcel Intersection Face Normal field function**
  - Improved computational cost and accuracy when particle-wall contact physics depends on local surface normal
  - Useful for setting complex dependencies for the coefficients of restitution and boundary stuck mode probability
- **Output spray cone angle for Huh atomization model**
  - Enables a workflow for tuning various model parameters to match experimental spray cone angle
  - Introduces new Output Level Control sub-node in Injector tree
    - Available only when Huh atomization model is selected
    - Provides Verbose option to output Half Cone Angle value in output window

Discrete Element Method (DEM)

- **DEM compatibility with mesh morphing D3217**
  - Increased realism for cases where particles causes boundary erosion or deformation
    - Improved accuracy for boundary erosion and wear
    - Ability to model deformable boundaries in FSI simulations with DEM
  - Applications include
    - Erosion in pipelines
    - Particles on chain, belt drive, incline conveyor
      - Structural analysis of silos for granular materials



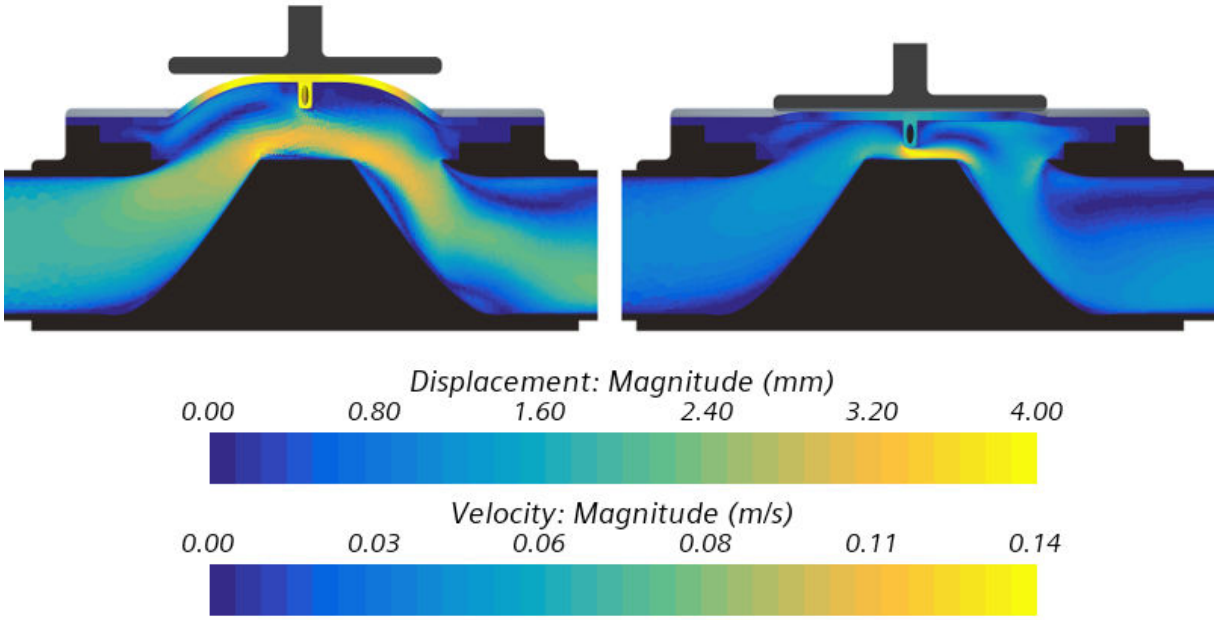
Computational Rheology

- **High Weissenberg number flow support D4919**
  - Allows modeling of more highly viscoelastic problems
    - Such problems traditionally unstable as elasticity dominates
  - Square root conformal option significantly increases critical Weissenberg number at which simulation becomes unstable
    - Enables Simcenter STAR-CCM+ to run problems and flow rates that other codes cannot
- **Multi-layer Film Casting D4912**
  - Allows wider range of film casting applications to be modeled
  - Film casting solver now allows multiple layers to be simulated
    - Each layer may have independent material properties/laws
  - Applications include the production of food packaging, medical blister packs and electronic displays
- **Open boundary condition for traction at Freestream boundary**
  - Accurately predict extrudate geometry for viscoelastic materials
    - More physical boundary conditions for extrusion cases
  - Open boundary provided as new sub-option for traction at Freestream boundary
    - Neutral boundary
    - Calculates traction based on interior values such that open boundary leads to no change from domain values
  - Available when Free Surface and Viscoelastic models are both selected

Computational Solid Mechanics

- **Frictionless contact - rigid plane obstacle D3602**
  - Model frictionless contact with an infinite rigid plane

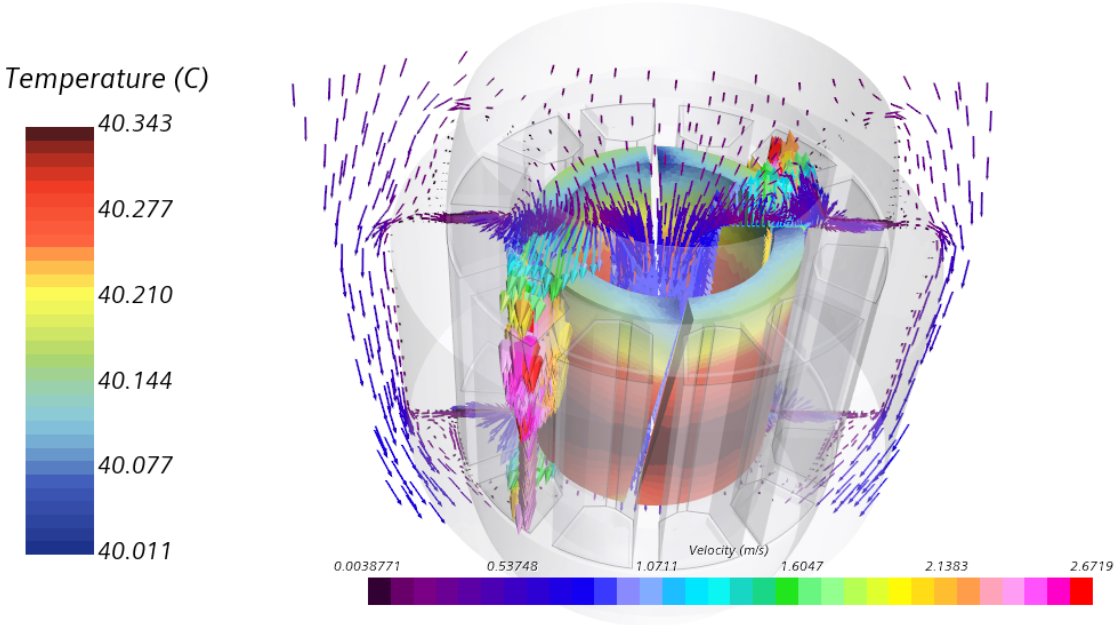
- Solve Fluid-Structure Interaction (FSI) applications with opening and closing flow paths such as valves and seals
- Use in combination with the hyperelastic material model to study rubber seals or gaskets being squeezed against flat surfaces
- The rigid plane specification supports moving Cartesian coordinates systems
  - To model the squeezing of a structure simply specify the plane in a Cartesian coordinate system managed by a translation motion
- The contact implementation is based on a penalty formulation
- Refer to the user guide for help on how to chose the penalty parameter



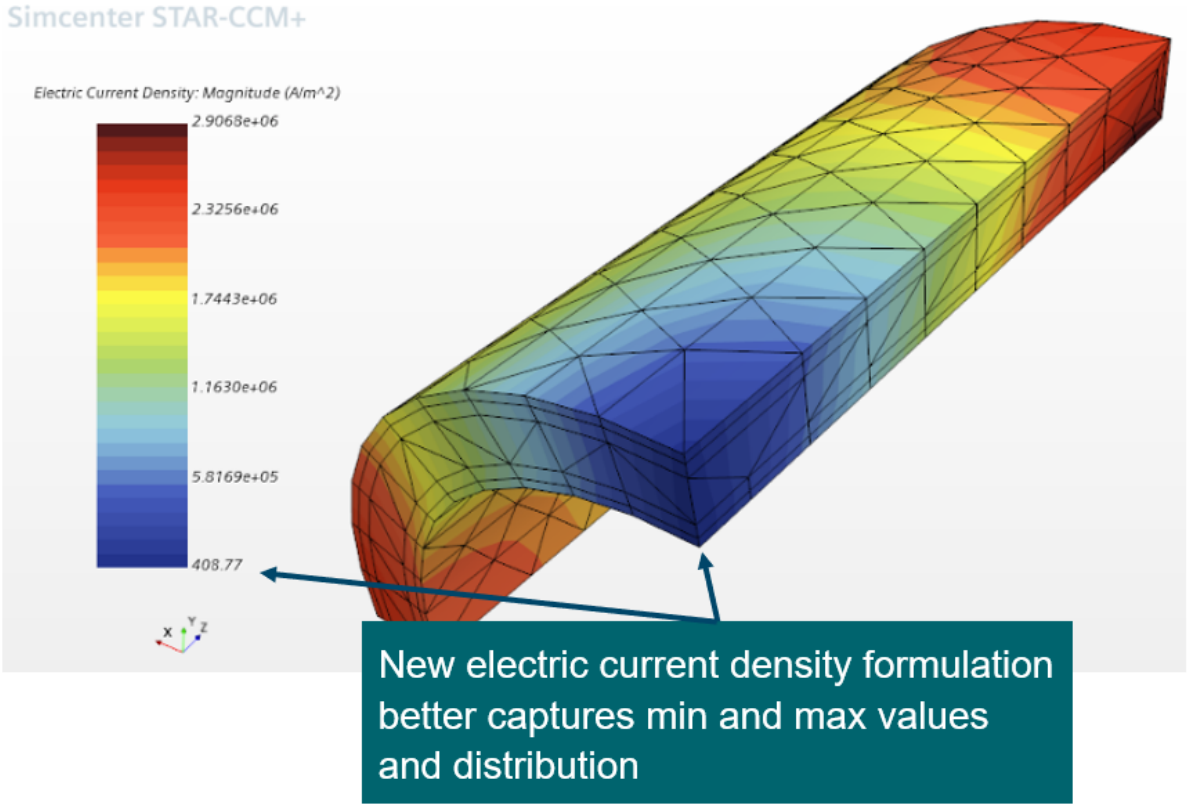
Electromagnetics and Electrochemistry

Electromagnetics

- **Temperature sensitivity of permanent magnets**
  - Simplifies setup of permanent magnets with temperature-dependent properties
    - Introduction of Table (T) option in Permanent Magnet model for the following two properties:
      - Remanence Flux Density (flux density at zero excitation, B(H=0))
      - Magnetic Permeability (slope of the B-H curve at zero excitation, μ(H=0))
    - New Table (T) option added also to Material Database for user-defined materials
  - New option available
    - In both 2D (Transverse Magnetic Potential) and 3D setups
    - When an energy model is selected (including Specified Temperature)
  - Useful for simulation of electric machines
  - Note that the Permanent Magnet model remains a linear model

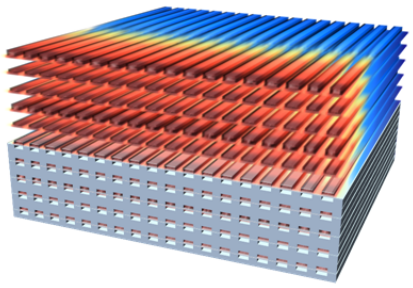


- **Local point variable Electric Current Density**
  - Improves accuracy of Electric Current Density distribution
    - When computed via the FE Magnetic Vector Potential model
    - When eddy currents are included
  - New field function is now
    - Natively defined on vertices and captures intra-cell variations
    - Lends itself to higher order visualization
  - Improves accuracy of Ohmic Heating distribution if this is constructed using the local point variable Electric Current Density field function
    - The new definition allows for a reduction of the mesh count for the same level of solution accuracy
- **Conformal interfaces for Finite Elements**
  - Enhanced robustness for Finite Element workflows through conformal face match at interface
  - See corresponding section in Mesh
- **Hypre LA solver for Finite Volume Electrodynamic Potential**
  - Reduction of turn-around time and more robust convergence for cases with electrical conductivity jumps
  - See corresponding section in Electrochemistry



Electrochemistry

- **Hypre LA Solver for Finite Volume Electrodynamic Potential**
  - Reduced Run-time of 2-3x for Fuel Cell Stack simulations
    - An alternative AMG solver (Hypre LA) is available for the electrodynamic potential solver
    - This solver gives significant speed up and scalability improvements
  - Improved ease of use and convergence
    - Only the number of cycles needs to be set



# cores	Linear Solver		Speed up
	AMG **2020.1**	Hypre LA **2020.2**	
16	739.5	360	**2.05**
32	371.5	143	**2.60**
48	302.5	117.8	**2.57**
64	260	92	**2.83**
80	198.1	66.9	**2.96**
96	156.7	60.4	**2.59**

- **Highly Convective Flows with Electrochemical Species**
  - Improved ease of use and run-time
    - Turbulent and highly convective flows can now be modeled

        - Gradient limiting is now enabled
    - Typical applications include etching analysis where the flow is highly turbulent
- **Surface reactions with Electrochemical reactions**
    - Improved physics resolution
        - Surface reactions are now compatible with electrochemical reactions
        - A surface can have both an electrochemical mechanism and a surface mechanism associated with it
    - Typical applications include Solid Oxide Fuel Cells where in a two step process methane is reformed (surface reaction) and the resulting hydrogen is then hydrolysed in an electrochemical reaction.

Aeroacoustics

- **Important Note: Planned removal of Convective effects for FW-H**
    - Convective FW-H has been deprecated starting in Simcenter STAR-CCM+ 2020.2 and is planned to be removed in version 2021.2.
    - Please contact your Simcenter customer support representative for further information.

Harmonic Balance

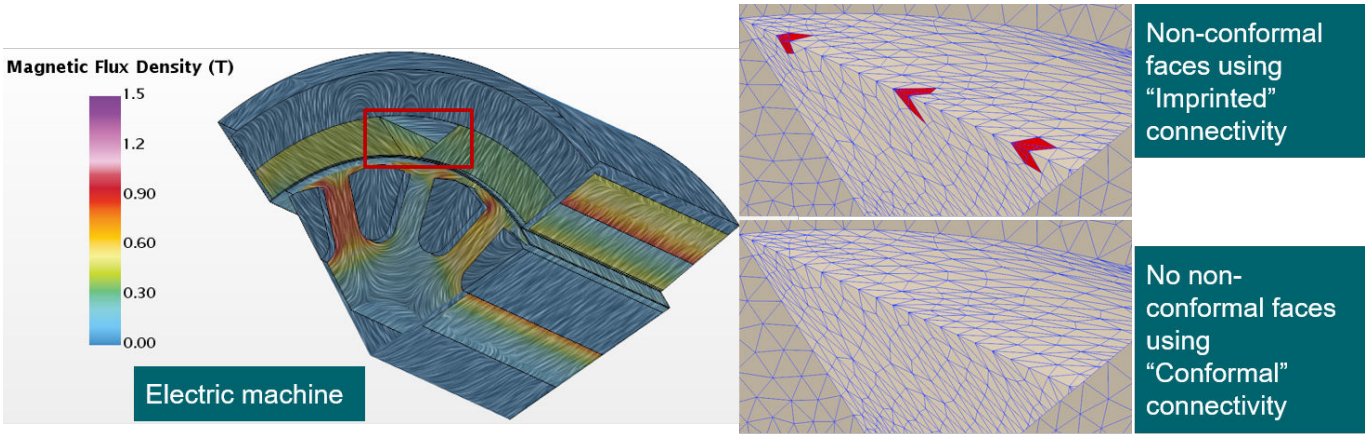
- **Improved Harmonic Balance visualization workflow**
    - Simplified workflow when moving from steady simulation to unsteady simulation with Harmonic Balance
        - Most commonly used field functions will no longer require changes in the scene when moving from steady simulation to HB
        - Time-averaged solution automatically displays in existing scenes
        - Consistent naming of field functions between steady and harmonic balance simulation

Motion, Mesh Adaption, and Mapping

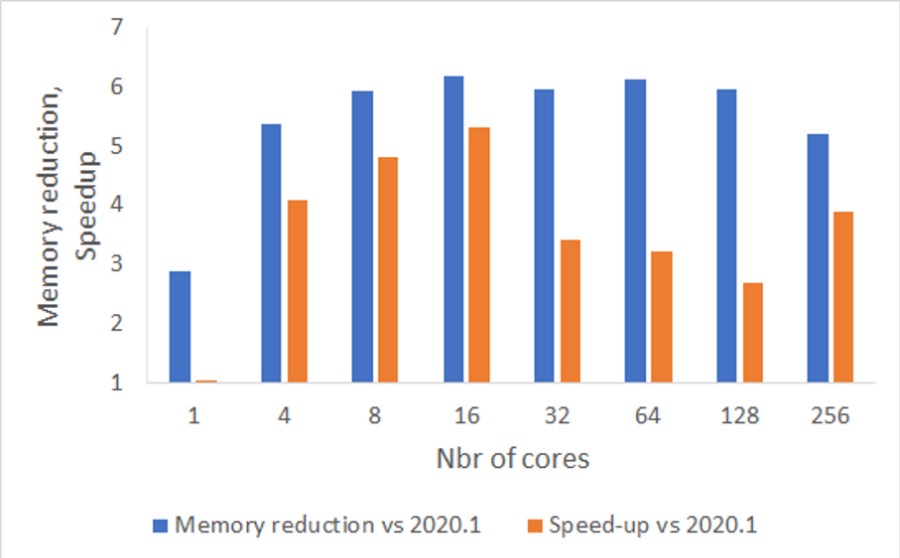
- **Improved small gap handling for overset AMR D3459**
    - More easily refine small gaps through model-driven overset AMR
        - Easily model gear teeth pair intrusion
        - Uniform gap refinement is a pre-requisite for Prism layer shrinkage model
            - Previously user defined refinement criteria needed
            - New option "Uniform Gap Refinement" ensures refinement with no negative volume cells and no hanging nodes in prism mesh
                * Refinement based on "Gap zone width"
- **Model based Adaptive Mesh Refinement for reacting flows**
    - Reacting flow flame front model based refinement
        - Refines cells specifically around the flame front preventing the flame from becoming unresolved by a coarse mesh
        - Preserves the sharp interface of the flame front
    - Typical applications include dynamic flame propagation and steady flame positioning
    - For more information refer to the section on CFD - Reacting Flows
- **Compatibility of Lagrangian multiphase with Adaptive Mesh Refinement**
    - Reduced computational cost in simulations including Lagrangian phases (LMP)

- For more information refer to the section on Multiphase Flows - Lagrangian Multiphase

- **Conformal Interfaces for Finite Element solver**
  - Enhanced robustness for finite element workflows through conformal face match at interface
    - Previously “Imprinted” connectivity type could produce hanging nodes, non-conformal facets
    - Now conformality guaranteed through new "Conformal" connectivity
      - Automatically chosen for contact interface type and FE physics models
  - Improves ease of use by removing dependence on user specified tolerance



- **Automatic deactivation of rigid prism layers in small gaps**
  - Enhanced morpher robustness by controlling "rigid prism layer" behavior in small gaps
    - Beneficial in situations where prism layer structure is critical such as heat transfer in valves
    - Previously rigid prism layers could create negative volume cells when gap decreased
    - Now method dynamically detects small gap and toggles off rigid prism layer
      - Results in maintained prism layer thickness on all wall boundaries, except in narrow gaps
- **Reduced memory and faster volume data mapping**
  - Reduced memory footprint of data mapper
    - Applies to all volume data mappers
    - Provides benefit in scenarios where data mapping is executed once or multiple times
      - Single instance volume data mapping such as solution interpolation
      - Repeated volume data mapping in remeshing scenarios, e.g. in-cylinder combustion, marine multi-mesh sequencing
    - Better data partitioning to localize the interpolation and reduce halo cells
    - Up to 6x reduction in memory on higher core counts for mapping solution from 20 M cells to 15 M cells.
  - Faster volume data mapping
    - Up to 5x speedup for mapping solution from 20 M cells to 15 M cells.



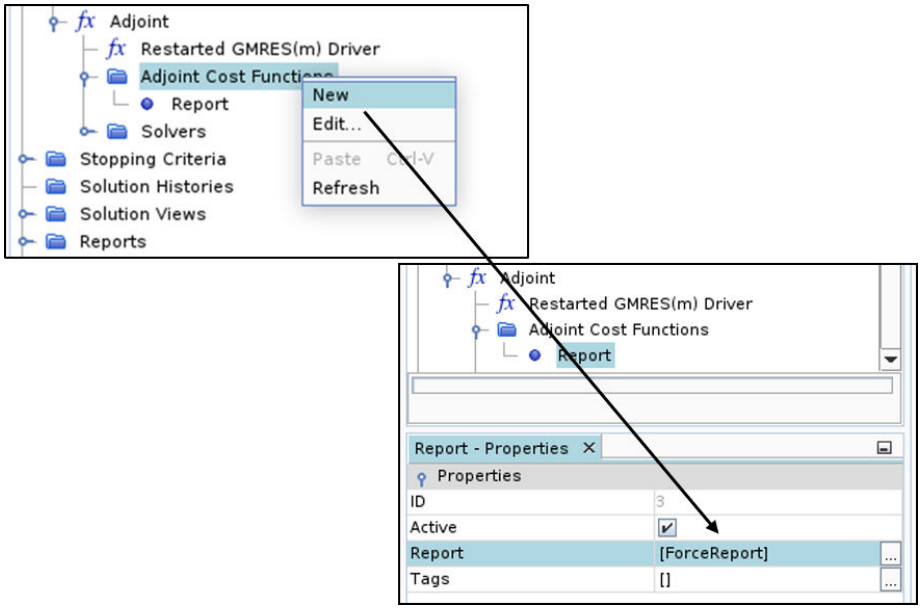
Mapping of a race car from 20M to 15M cells

- **Blade element method for high advance ratios**
  - Better net lift and torque prediction for rotors at high forward speeds
    - Inflow model now accounts for reverse flow region
    - Suitable for simulation of retreating side stalling behavior for aerospace propellers and helicopter rotors
    - Supports both steady and unsteady BEM methods
- **Closed-loops of DFBI bodies**
  - Previously, modeling closed loops of articulated multi-body systems in DFBI was not possible
    - This limitation has now been removed
  - Example: Subsea template hung by rope, excavator bucket
- **Enhanced mass conservation across overset interfaces using coupled flow solver**
  - Mass conservation across overset interfaces now available for both coupled and segregated flow solvers
  - Can be used for both closed and open systems

Design Exploration

Adjoint

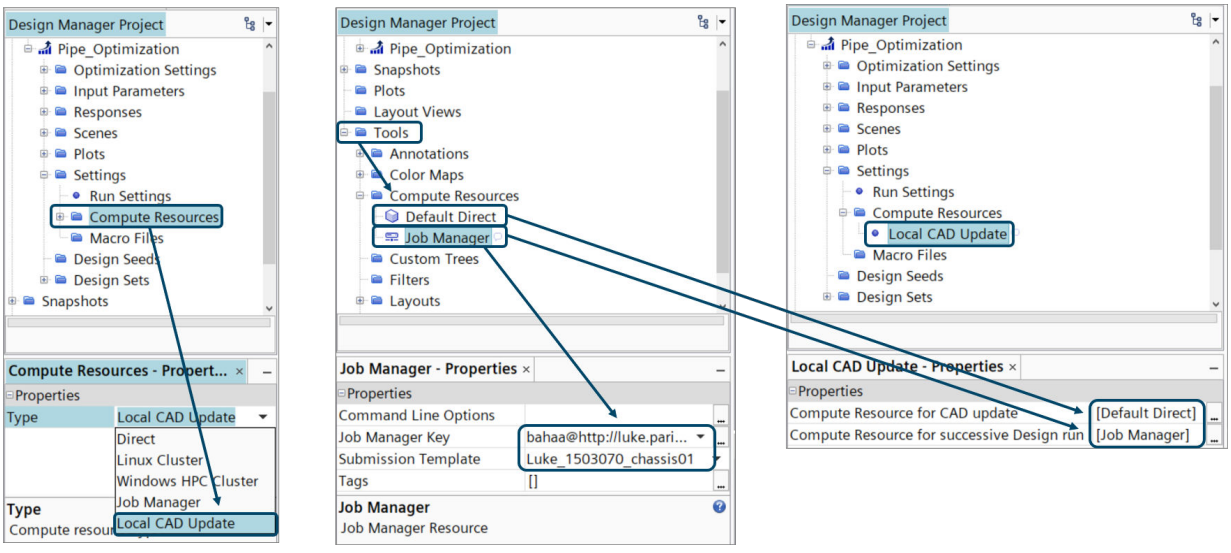
- **Reports for adjoint cost functions**
  - Simplifies optimization workflow by reducing the need for duplicate setup of cost functions
    - Ability to create a cost function directly from a report
      - Select cost function from already existing report
  - Consistent workflow with Design Manager that uses report for cost functions
  - Only reports of differentiated functions can be selected as cost functions



- **Adjoint MRF compatibility for relative reference frame**
  - Expanding application coverage by including MRF definition based on another reference frame
  - Beneficial for vehicle cornering simulations

Design Manager

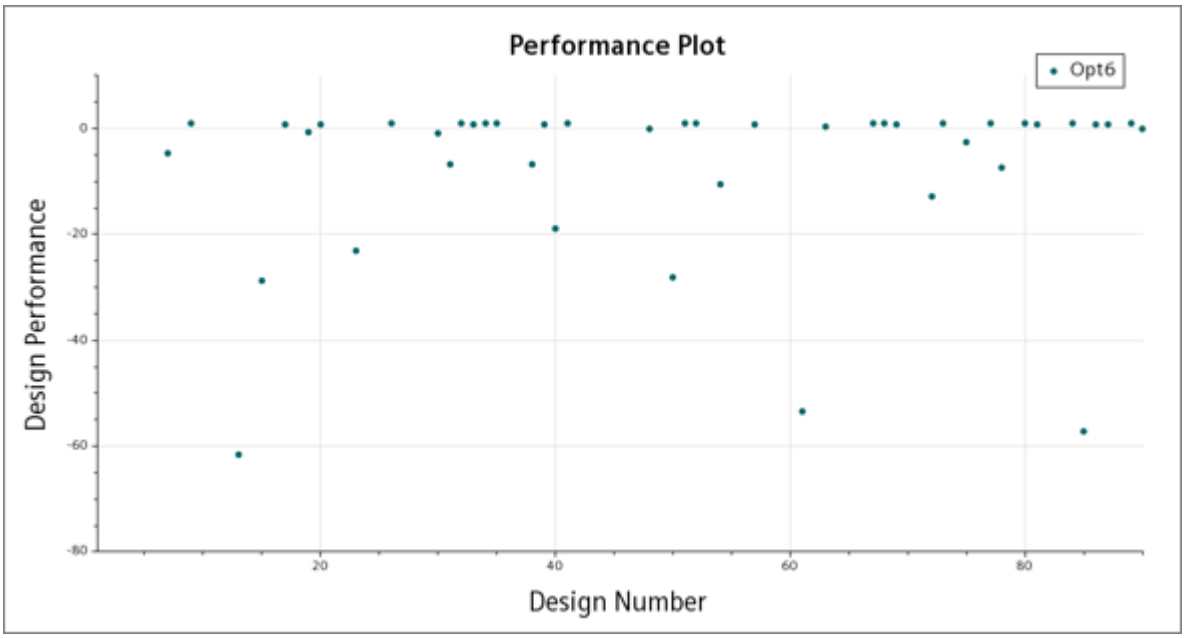
- **Local CAD update with CAD Clients**
  - Tighter integration of design exploration with your industrial native CAD process
    - Easily and robustly explore designs using native CAD tools
    - New cross platform communication process fully integrated in Simcenter STAR-CCM+
    - CAD update requested and performed locally on Windows using your preferred CAD tool
  - Facilitate deployment with an automated workflow
    - Automated transfer of .sim files containing new CAD models to Linux systems for meshing and solving
    - Use Job Manager for operations orchestration and file transfers



- **Improved visibility of Design Details**

- Identify runtime information for each design easily and intuitively
  - Quickly find additional runtime details such as
    - Execution type
    - Compute resource used
    - Start and end dates and times
  - Scope of support covers
    - Initial design runs
    - Design rerun, appending new information to previous run
    - Multiple resource usage (Local CAD update)

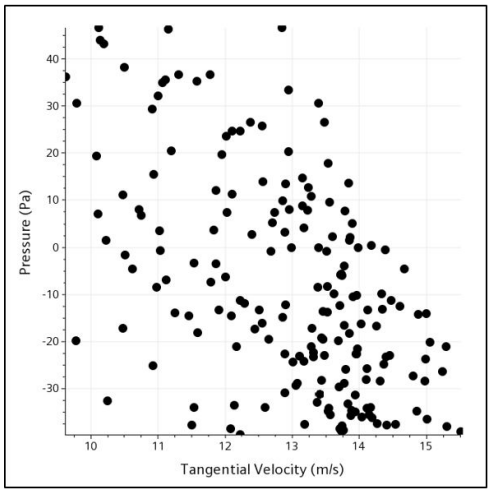
- **Performance Plot D5016**
  - Performance now accessible in any plot type



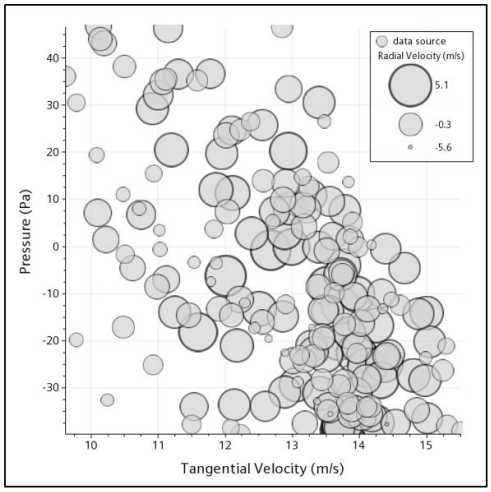
- **Automatic abort of study when baseline design fails**
  - Saves time for studies with objectives using the Baseline Normalization

Data Analysis

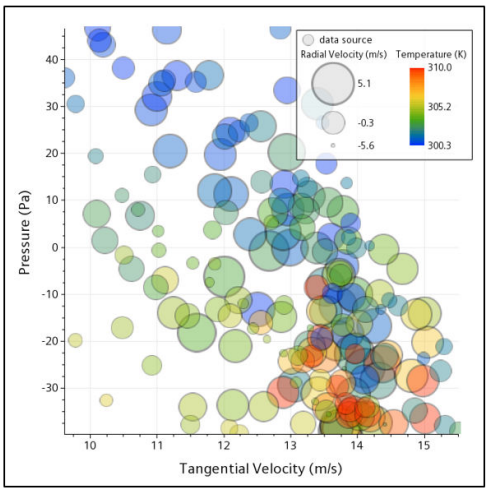
- **Bubble Plots D3442, D5054**
  - Use bubble plots to add layers of information to standard XY plots
    - Use bubble size and color to understand additional functional dependencies



Relationship between Pressure versus Tangential Velocity

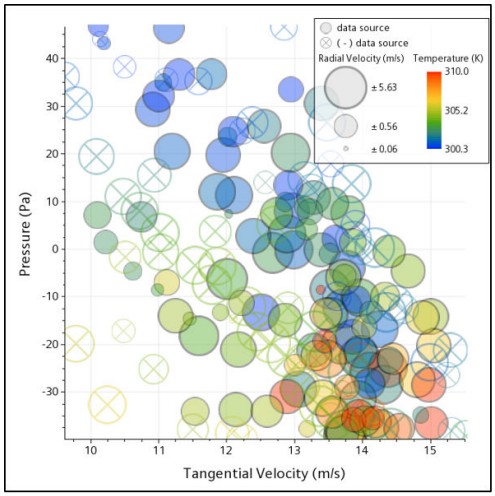


Bubble **size** adds an information layer (Radial Velocity)

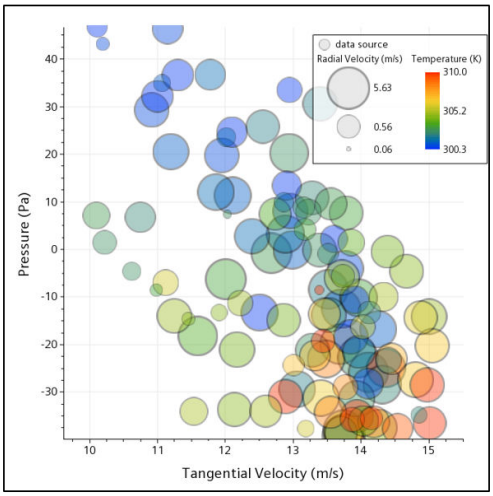


Bubble **color** adds another information layer (Temperature)

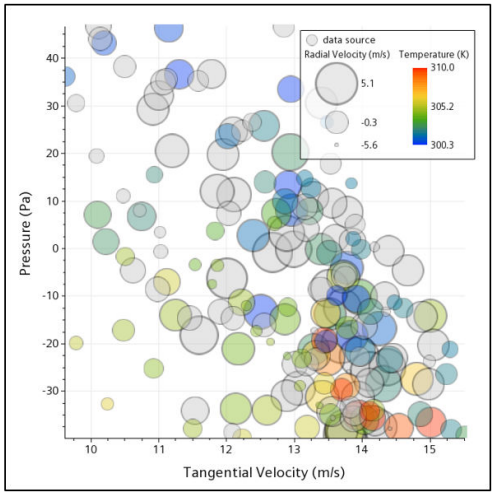
- Customize XY plots with controls for
  - General bubble size and appearance
  - Size scaling based on any Field Function
  - Color scaling based on any Field Function
  - Legend display and placement
- Special support permits display of negative values for log and square root scaling
- Add additional layers of information with full support for Data Focus



Negative data values need special handling if log or square root size scaling is used

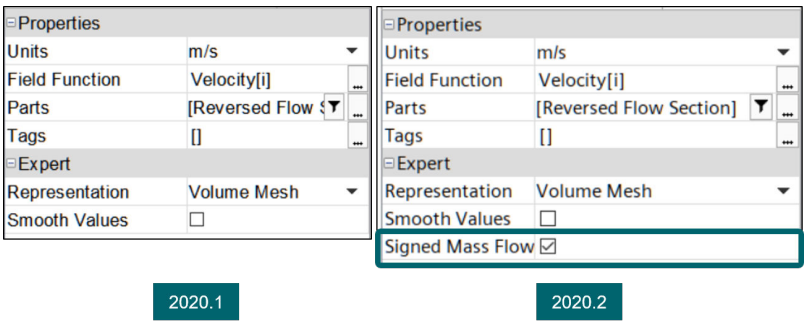


Data with negative symbol sizing can be hidden to improve plot appearance

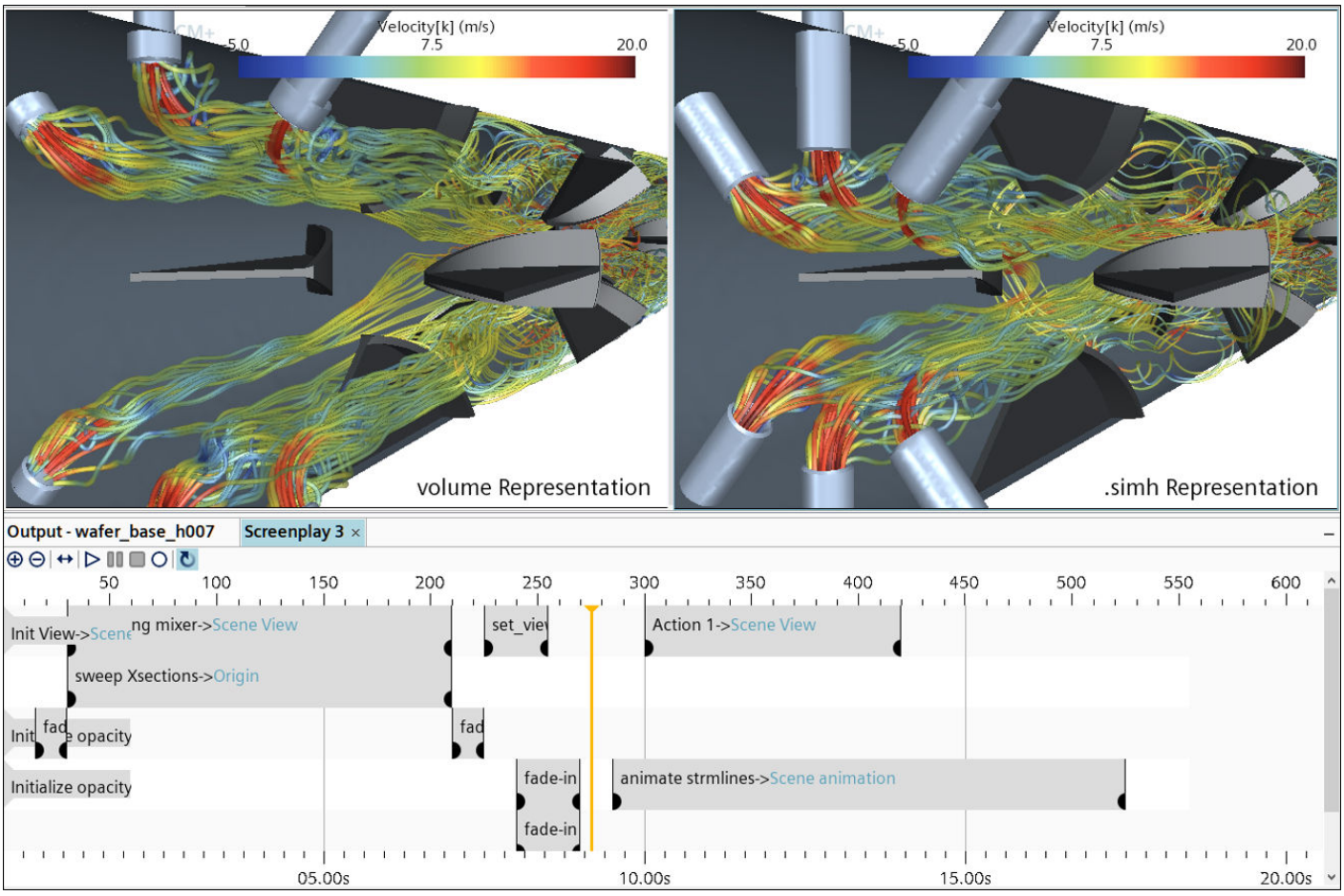


Data Focus is supported in Bubble Plots

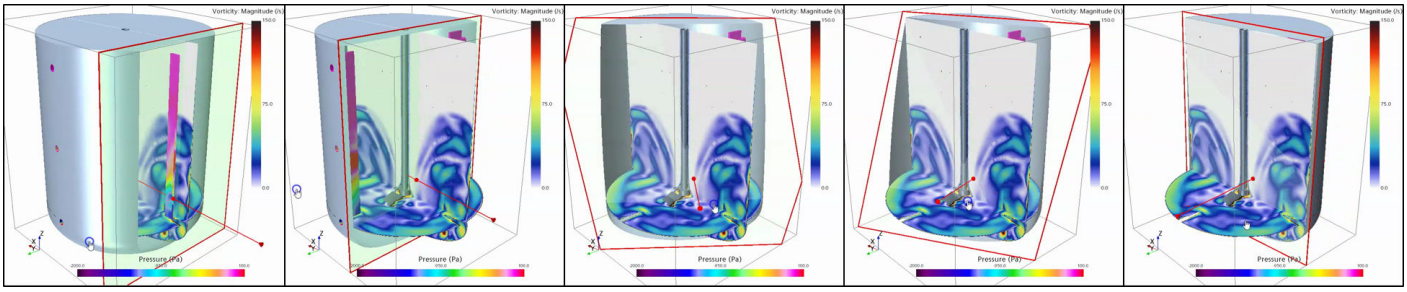
- **Signed (+/-) Mass-Flow Average Reports D5100**
  - Quantify the extent of reversed flow within your flow domain
    - New option lets you return a signed mass flow rate
    - Default behavior returns the absolute mass flow rate



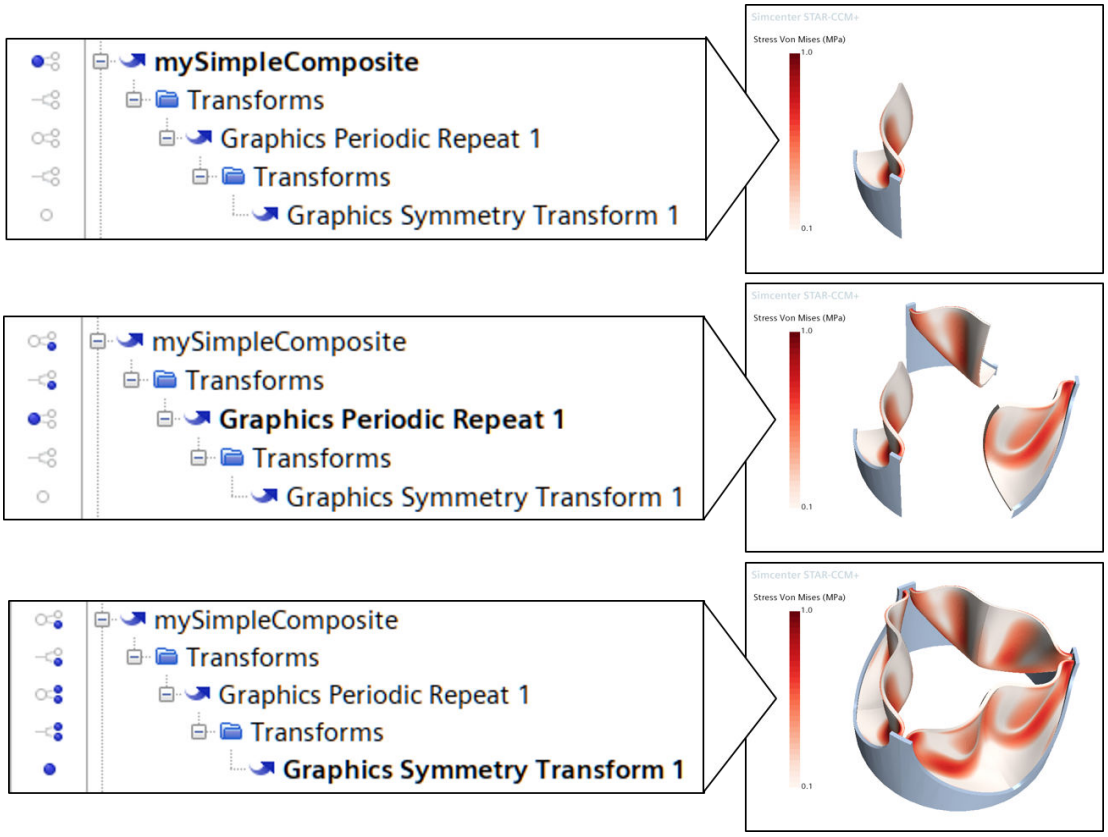
- **Layout View hardcopy support for Screenplay animations**
  - Create highly effective animations for a broad range of stakeholders, leveraging dashboard-style Layouts
  - Use your existing data analysis workflows, combining Layouts with Screenplay
    - Export of the full layout view is automatic
      - Resolution settings for writing an animation apply to the Layout width/height
  - Important note:
    - It is possible to populate Layout Views with content from different simulations but...
    - Screenplay can only be used to animate properties for the active .sim file



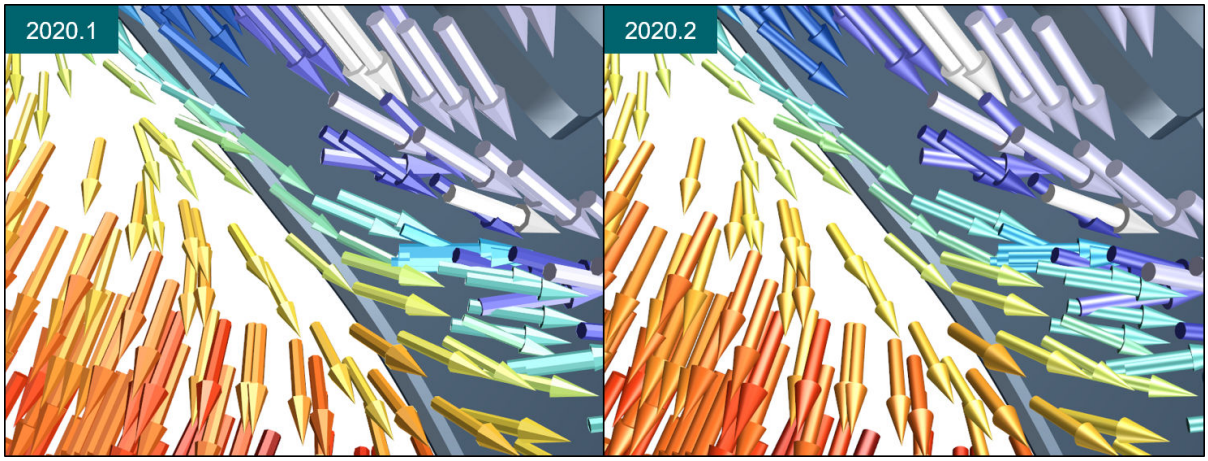
- **Interactive Clip Plane manipulation D2251, D4606, D5234**
  - Explore complex datasets quicker and more intuitively
  - Modify the location and orientation of any clip plane on-the-fly



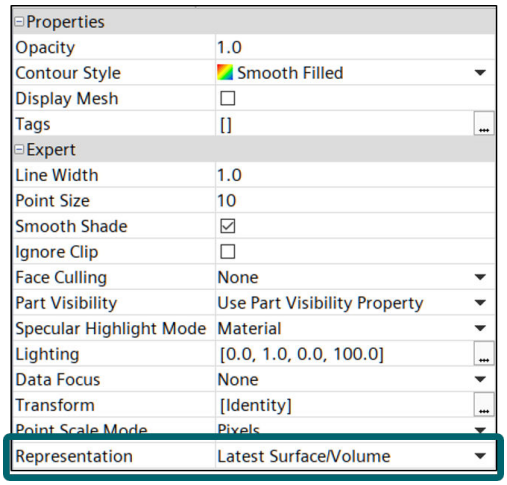
- **Composite Transform support D5344**
  - Streamline your workflow for presentation and animation of your results
    - Composite transforms overcome the previous limitation of having just one transform per displayer
    - A new Superposing transform lets you combine multiple transforms in a logical, hierarchical order



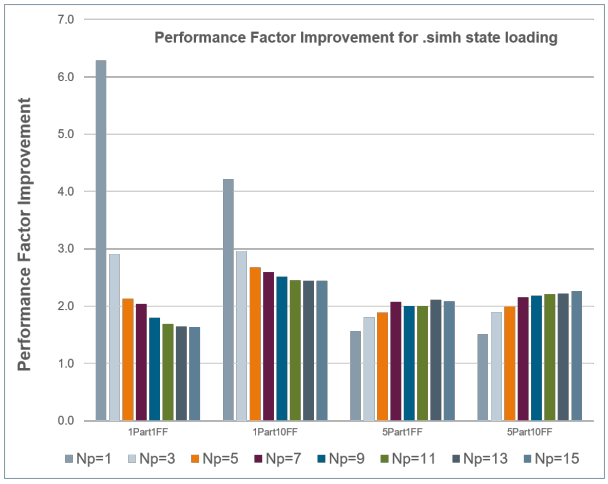
- **Improved appearance for vectors in scenes**
  - Vector appearance is improved for better visual comprehension of results
    - The "3D Head and Tail" glyph Vector Style is now the default
    - Vectors displayed this way will use less memory and animations will play more smoothly



- **Latest Surface/Volume is new default Representation for Scenes D5262**
  - Avoid the frustration of being unexpectedly confronted with empty scenes
    - The display of content in scenes depends on the choice of Representation
    - The new default makes it more likely that your scene will have relevant information displayed at any point in the meshing operation pipeline



- **Performance improvement of ~2X for Solution History loading**
  - Navigate between Solution History (.simh) states faster
  - Performance improvements realized through framework optimizations
  - The chart below shows factor improvements for different stored part and Field Function counts, for different processor counts



- **Hardware Headset updates for Simcenter STAR-CCM+ Virtual Reality**
  - **Certified** (fully tested in-house)
    - HP Windows Mixed Reality
    - HTC Vive
    - Oculus Rift S
  - **Supported** (known to work)
    - Oculus Rift
    - HTC Vive Pro
    - Varjo VR-2
  - **Unsupported** (and expected to work)
    - All Windows Mixed Reality Devices (using standard controllers)

Application Specific Tools

Simcenter STAR-CCM+ In-cylinder Solution

- **RNG *k-ϵ* Turbulence Model**
  - Renormalization Group version of the *k-ϵ* model has been implemented for in-cylinder simulations
  - The model is available from the Simcenter STAR-CCM+ In-cylinder solution Model Selection panel as an alternative RANS (Reynolds-Averaged Navier-Stokes) turbulence model
- **LES for In-cylinder Simulations**
  - Through Large Eddy Simulations, detailed investigations of flow structure and flow fluctuations can be carried out in order to correlate cycle-to-cycle variations with variations in engine performance parameters
  - LES can now be selected as turbulence model from the Simcenter STAR-CCM+ In-cylinder solution Model Selection panel
  - The LES turbulence model has been verified for cold flow simulations
- **Support for Tables with Data Outside 0-720 degCA**

- Any engine cycle convention can now be used in tables describing valve lift profiles, boundary conditions and initial conditions
- Manual shifting of tables with cyclic data to 0-720 degCA is no longer required

- **Huh Atomization Model Setup**
  - Huh atomization can be activated in combination with the Reitz-Diwakar and KHRT break-up models from within the Simcenter STAR-CCM+ In-cylinder solution for single-pulse injections
  - Mean injection velocity is automatically calculated, and nozzle data can be specified for the whole injector or individually per nozzle hole
  - Support for multi-pulse injection will be included in a future release
- **Auto-Ignition/Knock with TKI Model**
  - The Tabulated Kinetics for Ignition model is activated by selecting “Knock” in the Model Selection panel
  - The TKI model is compatible with the ECFM combustion models, and relies on TKI tables containing auto-ignition data
  - A set of basic tables is available through Support Center under Simcenter STAR-CCM+ > Downloads > Major Releases > 2020.2 > [platform] > Related Files and Documentation > In-Cylinder
- **NOx and CO emissions post-processing**
  - NOx and CO emissions are grouped together in a separate folder allowing for a quick overview of emissions
  - Emissions data are retrieved at a specific reporting time (by default exhaust valve opening) and reports and plots are created for mole and mass fractions and specific emissions in g/kWh
- **Basic Support for 2-stroke Cycle and More Engine Configurations**
  - Previous limits on number of intake and exhaust valves have been relaxed
  - The number of intake and exhaust valves is automatically calculated
  - Zero-valve geometries are supported
  - The number of strokes (2 or 4) is specified when creating engine parts
  - Manual setup in the Simcenter STAR-CCM+ Simulation Tree is required for a complete 2-stroke simulation setup
  - Full support for 2-stroke simulations from within Simcenter STAR-CCM+ In-cylinder solution will be provided in a future release

Electronics Cooling

- **PCB library QuickPart**
  - Improves setup time with storing/recalling PCB QuickParts into libraries
    - Supports both simple and detailed rectangular, circular, and custom PCB types

User Guide

- **New Tutorials**
  - Foundation Tutorials

    A new section has been added for basic post-processing tutorials. These short tutorials are based on material that was previously contained within the Introductory tutorial.
    - Post-Processing: Examining Velocity Vectors
    - Post-Processing: Plotting Data on a Derived Part
    - Post-Processing: Creating Streamlines

- Geometry
  - 3D-CAD: Cyclone Separator
- Reacting Flow
  - Flamelet Generated Manifold: Perfectly Premixed Combustion with Adaptive Meshing
  - Eddy Break-Up: Coal Combustion
- Solid Stress
  - Contact with Rigid Plane: Diaphragm Valve
- Coupling with CAE Codes
  - FMU Co-Simulation: Temperature Controller
- Analysis Methods
  - Field Histories: Pressure Time Derivative

- **Modified Tutorials**
  - Introductory Tutorial – Revised to reduce the length; some post-processing sections removed and presented as foundation tutorials instead
  - All multiphase tutorials were updated to use the new method for creating phase interactions
  - Simcenter Amesim Co-Simulation: 1D Coupling – Updated to couple with Simcenter Amesim 2019.2
  - GT-SUITE Co-Simulation: 1D Coupling – Updated to couple with GT-SUITE 2019
  - Adaptive Mesh Refinement: Hypersonic Flow – Now uses a dome-shaped mesh for reduced cell count; also the *Range* parameter on the **Adaption Request** has been changed to [0.5, 1.0]
  - FSI and 6-DOF Motion: Stress Analysis on Boat Propeller – Modified in order to reduce the overall runtime
  - DEM Particles in a Conveyor – Now includes use of the plane widget when defining the location of the clip plane
  - Harmonic Balance: Single Stage Periodic Flow – Post-processing sections now use new HB field function names and the HB Solution View
  - Gasoline Engine: Motored – Removed any setup associated with the valve lash
  - Moving Reference Frames: Rotating Fan – New geometry and mesh settings
  - Rigid Body Motion: Rotating Fan – Updated due to new mesh from the MRF rotating fan tutorial
  - DES and FW-H On-The-Fly: Noise from a Cylinder (Unsteady Analysis) – *Maximum Physical Time* for the solution reduced to 0.0533 s (instead of 0.12 s previously)
- **Retired Tutorials**
  - Flamelet Generated Manifold: Perfectly Premixed Propane – Replaced with new version that utilizes Adaptive Mesh Refinement

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