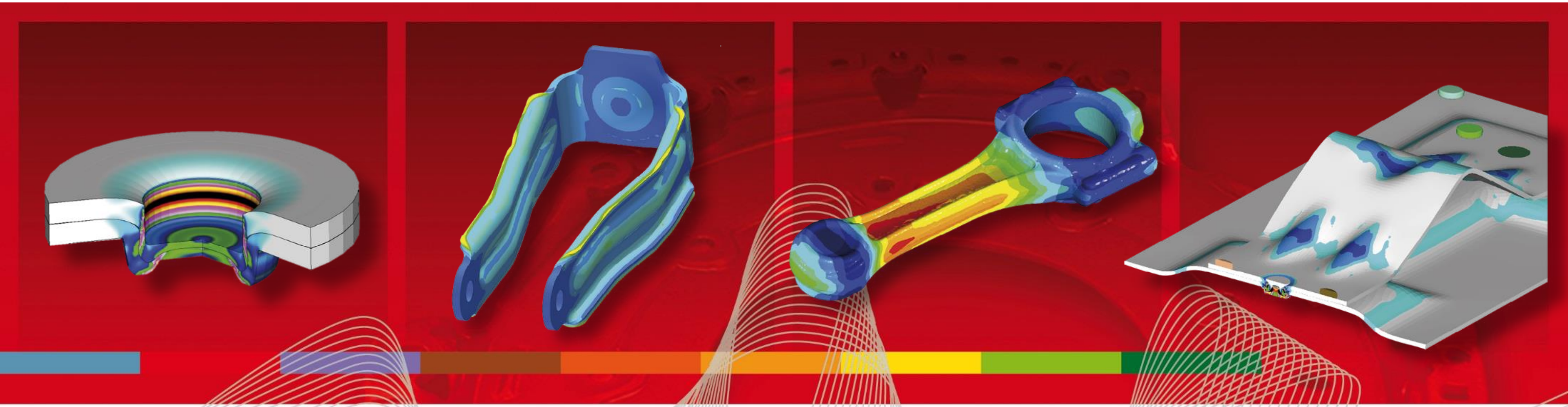
Tutorial

Simufact Forming

Introduction to Simufact Forming 2025.1



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Patents
U.S. Patent No. 10,740,910

Contact
https://hexagon.com/support-success/manufacturing-intelligence/design-engineering-support

Table of contents

Simufact Forming basics tutorial

- This tutorial is intended for first time users of Simufact Forming. It will explain the basic concepts of the software and show you its capabilities as well as demonstrate the typical workflows.
- The topics covered in this tutorial are:

Throughout this tutorial a lot of helpful tips and tricks will be shown in this sidebar. The categories are:

Note: helpful information for starters

Tip: hints and background information

Important: essential information

Warning: risk of data loss or malfunctions

Caution: possible sources of errors

Infosheet

Tutorial chapter

Demo example

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Simulation basics

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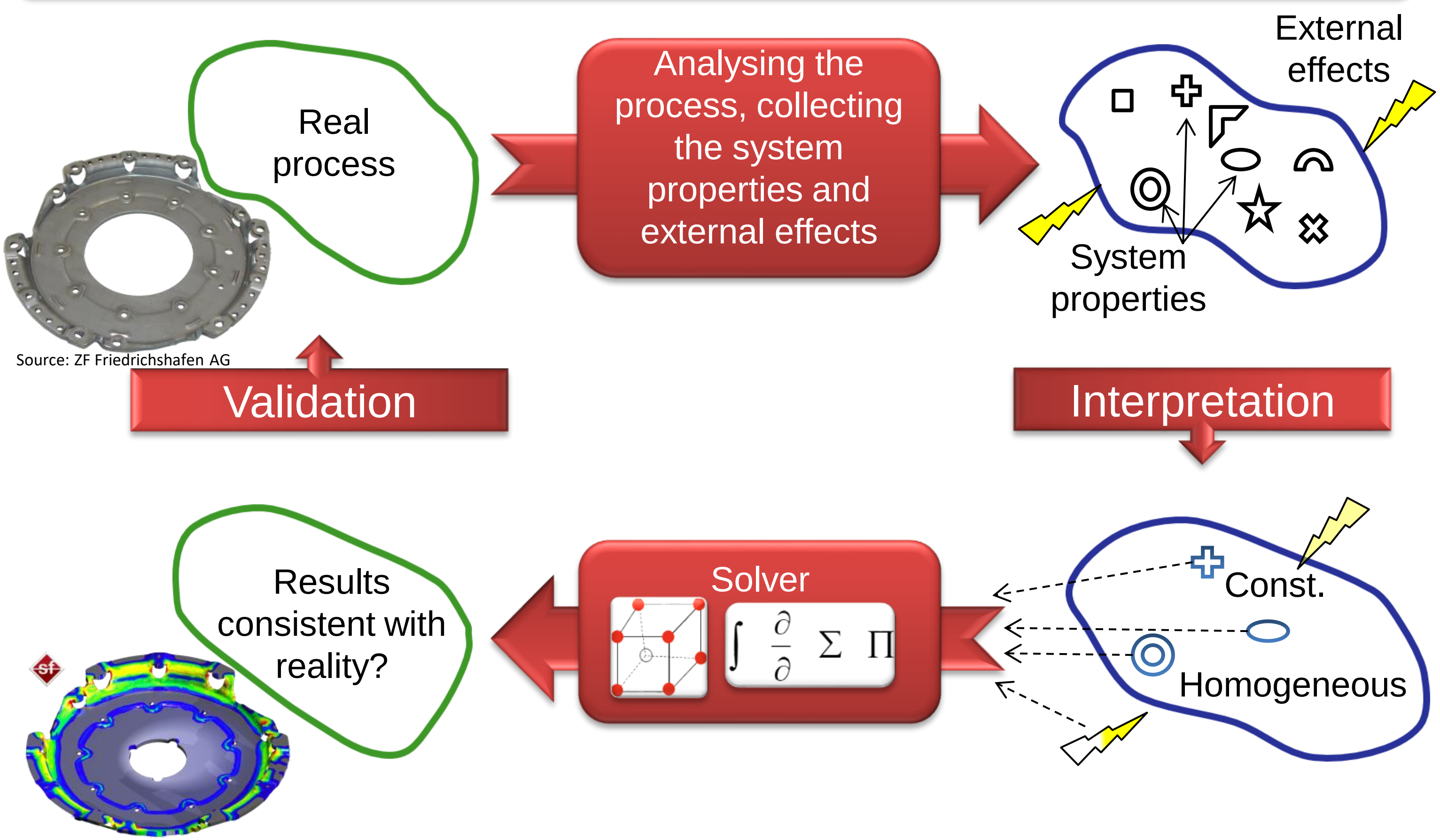
Simulation basics

What is manufacturing simulation?

"Simulation reproduces a system with its dynamic processes, within an experimental model, to gain knowledge, that is transferable to reality."



Simulation …

- …is an aid for process and tool design.
- …shows what is possible and what is not.
- …supports the forming expert but cannot replace him.
- …enables a deeper process understanding.
- …saves time and costs for experiments on the machine.

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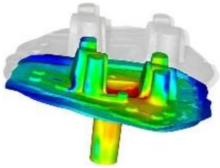
Simulation basics

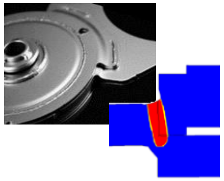
Simufact product lines

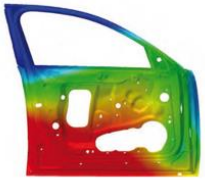
Simulating Manu**fact**uring - The Manufacturing Division of MSC Software

simufact forming
Forming Simulation

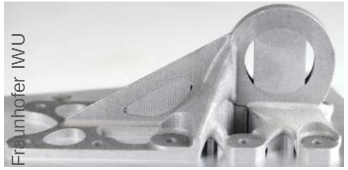


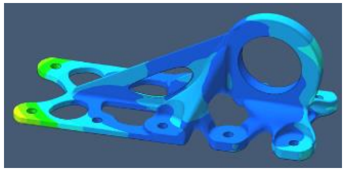
simufact welding
Welding Simulation





simufact additive
Additive Manufacturing Simulation





Supporting the optimization of metal-based manufacturing processes

Simufact offers over 25 years of experience in the field of simulating manufacturing processes. More than 100 experts attend to over 1000 satisfied customers worldwide.

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Simulation basics

Simufact Forming applications

METAL FORMING

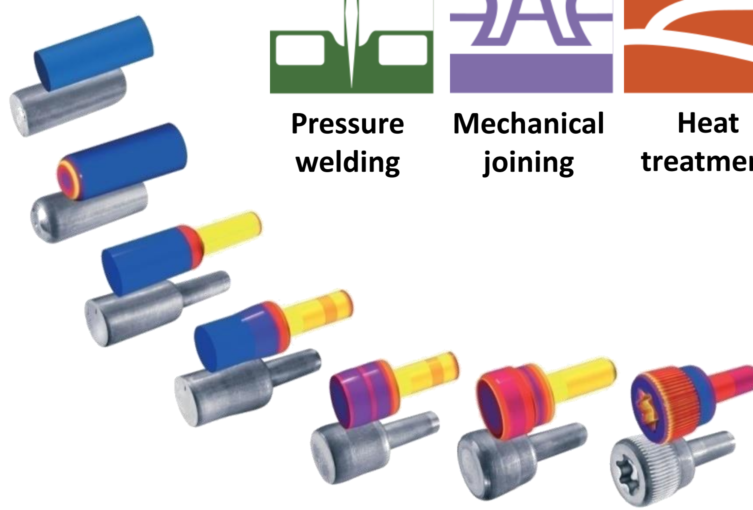
All metal forming applications, independent from temperature, material, machine, and its kinematics.

Classical forming applications:

Cold forming | Hot forging | Sheet metal forming | Rolling | Ring rolling | Open die forging

Additional complementary process types:

Pressure welding | Mechanical joining | Heat treatment | General



You can simulate nearly every possible metal forming process with Simufact Forming. From simple upsetting tests to complex open die forging kinematics.

Simufact Forming is being constantly updated. New versions will likely cover new areas of application!

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Simulation basics

Structure of Simufact Forming

simufact forming
Forming Simulation

Pre processor
(modeling)

- CAD import
- Element selection
- Material definition
- Initial conditions
- Boundary conditions
- Force application
- Kinematic

Solver
(calculating)

- Assembly of $\underline{\underline{K}}$
- Solving of $\underline{u} = \underline{\underline{K}}^{-1}\underline{F}$
- Strain
- Stress
- Force
- Total equivalent plastic strain
- …

Post processor
(Result validation and interpretation)

- Result display
- Deformed structure
- Stress distribution
- Temperature distribution

These are the three main modules that are necessary for every simulation. Simufact Forming combines all of them into one program.

Graphical User Interfaces allow a user-friendly model setup (pre processing) and analysis evaluation (post processing).

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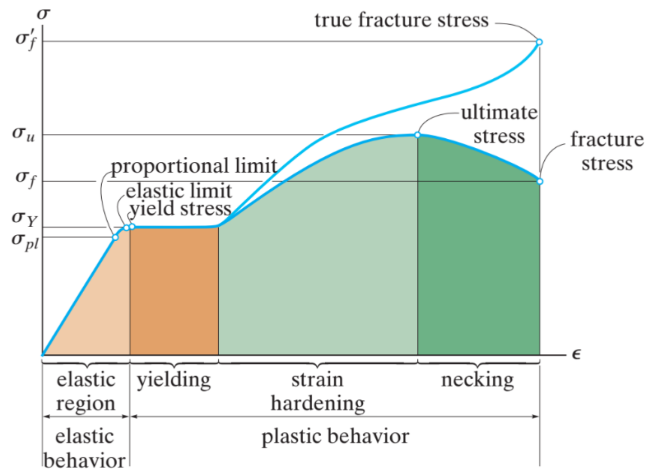
Simulation basics

The core of manufacturing simulation: The material

- The key item of every forming process is the workpiece.
- Its inherent properties (mechanical, thermal, electrical,…) are defined by the associated material data.
- Especially the mechanical material properties can be quite complex and are a source of non-linearity which results in significant computational efforts.
- Simufact Forming comes with its own extensive material library, Simufact Material. Nearly all included materials use elastic-plastic material models.
  → respects elastic deformation
  → respects strain rate dependencies
  → respects plastic deformation (including hardening and softening)



Conventional and true stress-strain diagrams for ductile material (steel)
Source: R.C.Hibbler-Mechanics of Materials

Simufact Material currently contains over 700 of the most commonly used materials!

Users can add new materials and expand the library with their own data. For more detailed information about this please see the Simufact Material manual!

For even more advanced applications special models to predict grain size evolutions and phase transformations are available.

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Introducing Simufact Forming

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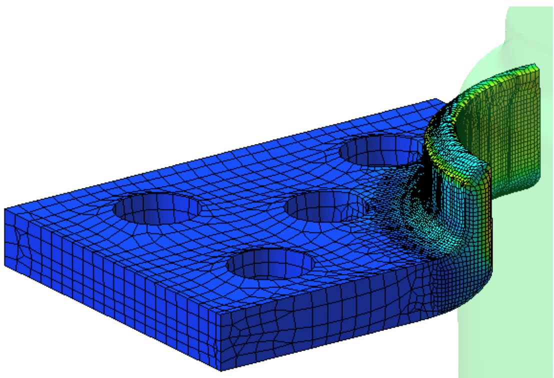
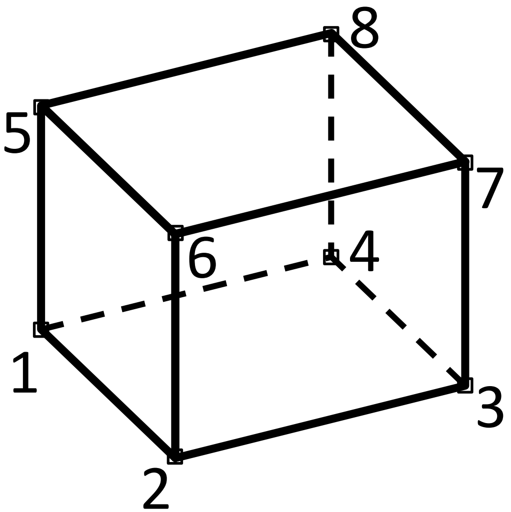
Introducing Simufact Forming

Solver technology: Finite Elements (FE)

- The Finite Element Method divides the part geometry into a finite number of elements (discretization).
- Simufact forming provides quad elements for 2D simulations and tetrahedron or hexahedron elements for 3D simulations.
- Hexahedron elements are always the first choice if accurate results are required.
- The finite element method is based on the implicit MSC.Marc solver. This non-linear finite element solver is highly productive, multifunctional and offers effective parallelization options.
- The FE solver is the standard solver for most forming simulations.





Hexahedron elements deliver the best result quality with respect to stresses, strains and damage.

Simufact Forming comes with multiple meshers to create finite element meshes for your workpiece without the need for third party meshing programs.

During the forming process the finite elements get distorted. Simufact Forming can perform automatic remeshings for an optimal result quality.

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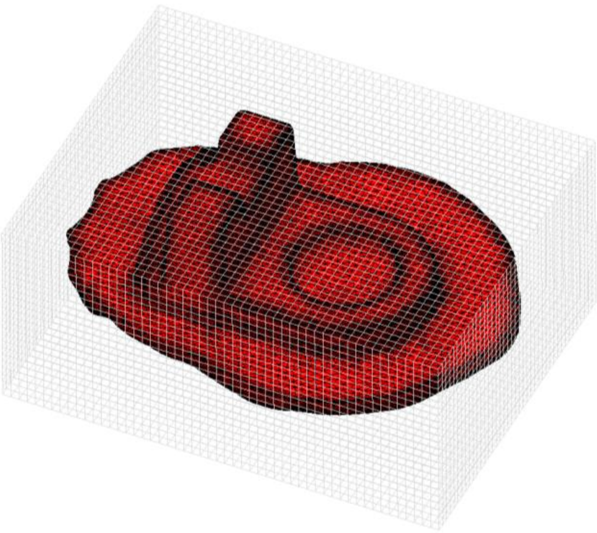
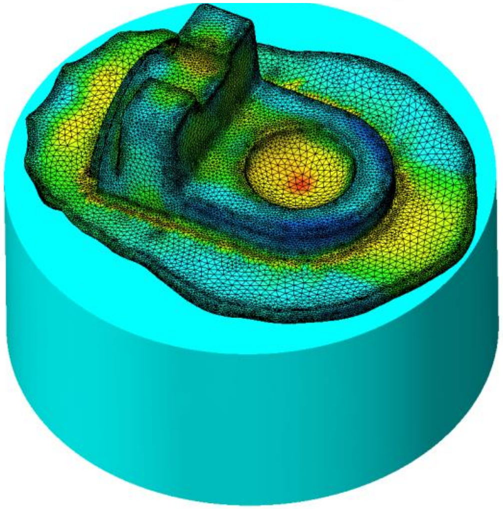
Introducing Simufact Forming

Solver technology: Finite Volumes (FV)

- The FV solver is based on the explicit MSC.Dytran solver and originates from the computational fluid dynamics (CFD) simulation.
- Its strong suit is predicting material flow.
- The FV solver in Simufact Forming is specifically designed for hot forging applications. It is not recommended for other process types.
- The characteristics of hot forging processes fit the ***requirements*** of the FV solver:
  - High temperatures → low flow stresses, easy material flow
  - High strain rates → dynamic material movement, short process times
  - Constrained material movement through forging dies → only little free movement
- Classical applications are hot closed die forging operations or hot extrusion processes.
- FV simulations can show small details such as folds and flash formings, because a fine surface discretization is not as costly as an equally fine finite element mesh would be.





Only the surface of the workpiece is discretized via a surface trias mesh and the material moves through a stationary grid of FV elements.

For suitable processes the FV solver is around 4 – 10 times faster than the FE solver with comparable result qualities.

The FV solver is very stable in self contact situations such as fold formations.

Do NOT use the FV solver for processes that do not meet the requirements for FV simulations!

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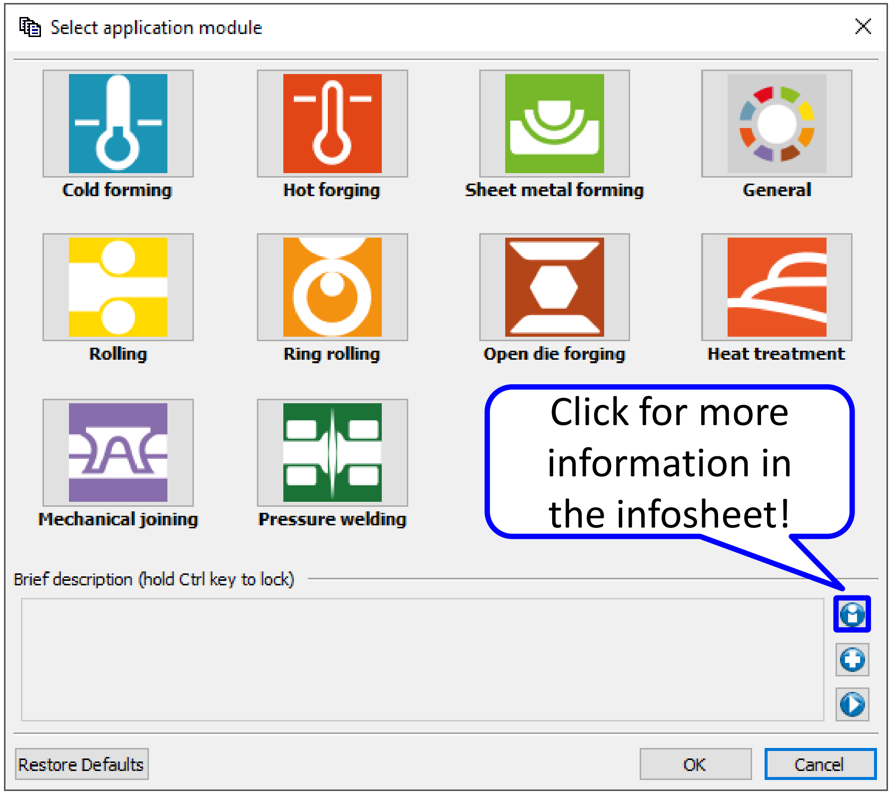
Application modules and process types

- Simufact Forming offers many application modules tailored to the needs of various forming processes.
- Every application module contains individual default settings for solver, mesher and different process types (e.g. upsetting, extrusion, heating, etc.).
- This helps the user to achieve good simulation results without having to delve into the more advanced settings.
- Some application modules contain exclusive machine kinematics (e.g. ring rolling, open die forging).



Choosing an application module is the first step you will do when creating a new process simulation.

The brief description will help you choose a suitable application module for your simulation.

Watch out for the infosheet icon. Many dialogs offer detailed information at the click of this button.

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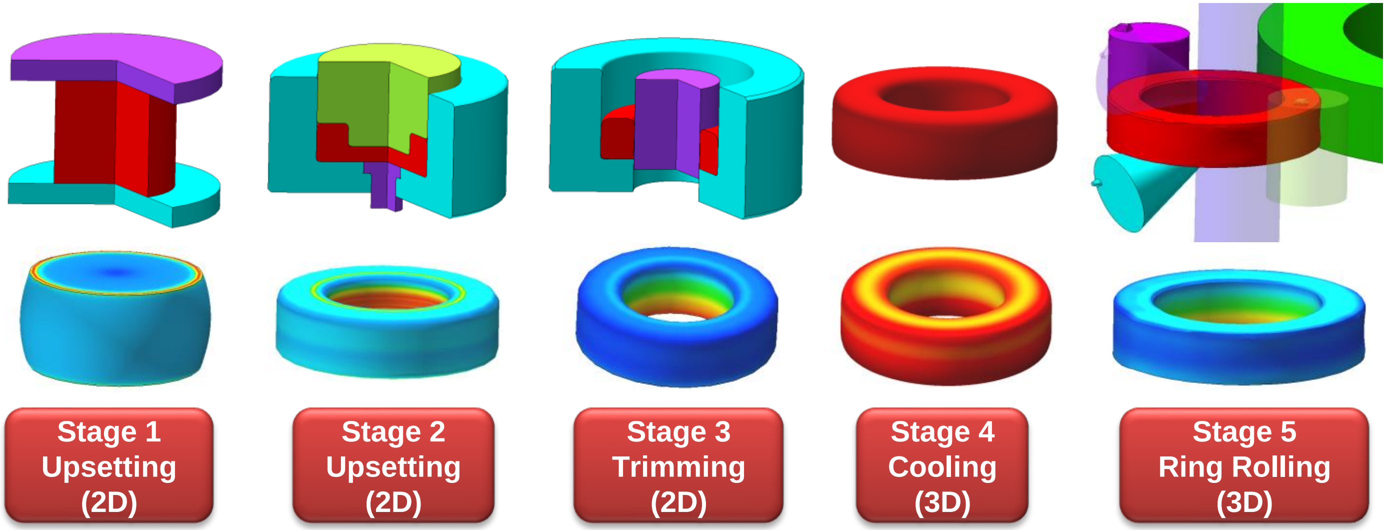
Simulation type: 2D or 3D simulation, process chain

- Full 3D calculation is meant for complex workpiece geometries. Symmetry planes (segments) or the cyclic symmetry option can save valuable computation time.
- 2D axisymmetric simulations can often be used for upsetting or extrusion processes.
- 2D planar simulations are suitable for many rolling operations.
- Simufact Forming fully supports result transfers from 2D to 3D simulations. You can set up the preforming operations of a multi stage process as 2D simulations and expand into 3D around the rotation axis as soon as it is required by the shape of the workpiece. This expansion is also possible for 3D symmetrical processes.
- This enables a quick and easy setup of whole process chains!



2D simulations are strongly recommended when the simplification is acceptable!

2D simulations in Simufact Forming are set up with 3D geometries which will be cut at a later stage. So there is no need to generate special 2D geometries inside your CAD system!

2D simulations can save a lot of computation time as the element count is typically lower.

The shown ring rolling process chain can be found in the Demos&Examples explorer!

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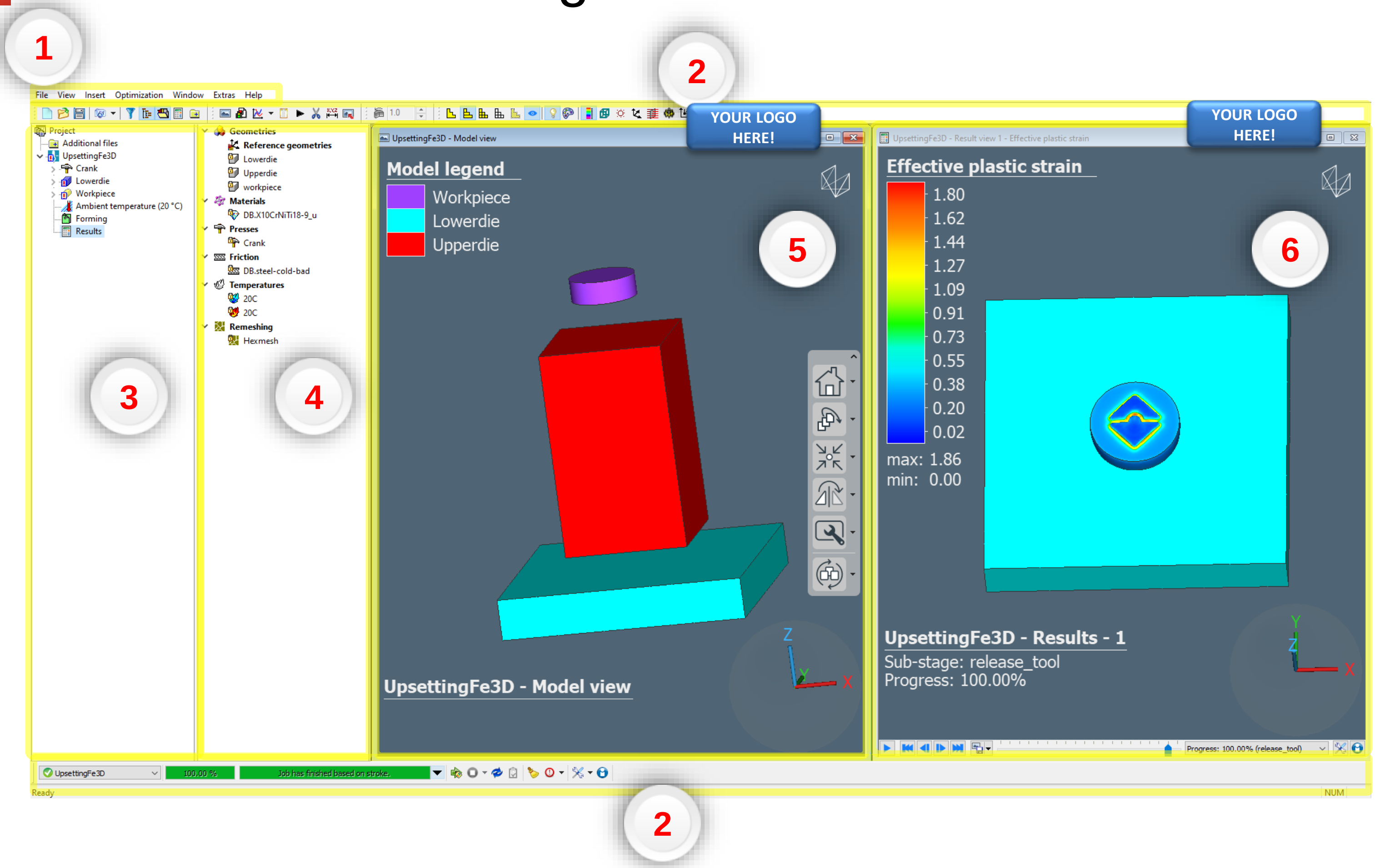
The Simufact Forming GUI:



1: Menu bar	2: Toolbars	3: Process tree
4: Object catalog	5: Model view	6: Result view

Getting used to the Forming vocabulary will help with future learning!

The GUI is designed to be modular. You can hide/display or rearrange most elements!

Hovering your mouse pointer over a button in the toolbars will display a short hint about its functionality!

You can add the logo of you company! See Extras > Options > Settings > Graphics.

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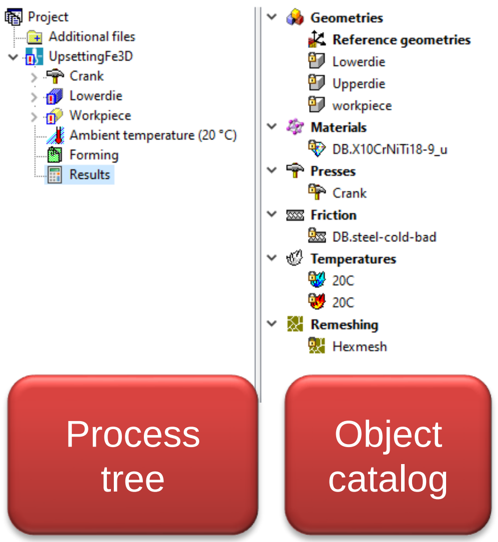
Process tree and object catalog:



- Simufact Forming is based around working with *objects*.
- *Objects* can be almost anything from geometries to materials, to physical properties or mesh information.
- The *object catalog* collects and contains every *object* that you have used in your *project*.
- To create a simulation you fill the *process tree* with *objects*.
- Use drag and drop to move *objects* from the *object catalog* to a *component* in the *process tree*.
- The same *object* can be simultaneously used in multiple *processes*.
- A *component* acts like a container that can contain multiple *objects*.
- The *process tree* contains additional items that are neither component nor object like the ambient temperature and the forming control.

Note the difference between an object and a component!

The press object is an exception as it is directly assigned to the process and can contain components.

Expand or collapse the contents of a process or single components with the + and – buttons!

You can use filter functions for both process tree and object catalog to keep big projects clearly.

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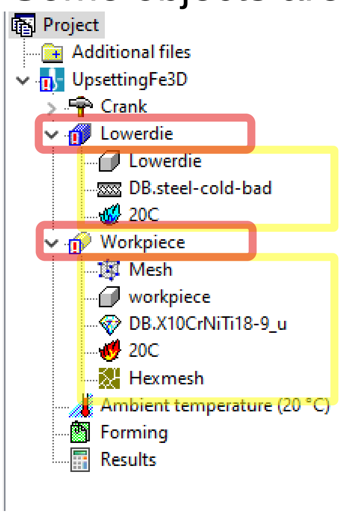
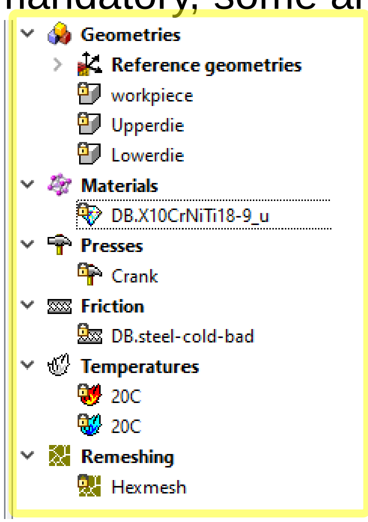
Components and Objects:

- Typical components in a Simufact Forming simulation are the dies and the workpiece.
- You can add numerous dies to a process but only a single workpiece can be present (note the 💡).
- There are different types of dies e.g.:
  - Rigid dies without heat conduction
  - Rigid dies with heat conduction
  - Deformable dies
- Objects are assigned to components.
- Every object contains specific information that is used to define the component.
- Some objects are mandatory, some are optional or situational.





component

object

Rigid dies without heat conduction still respect heat transfer <u>between</u> bodies. Only the distribution of heat inside the die is idealized and stays constant.

💡 The icon of the die component changes depending on the selected type!

💡 A deformable die can act as a second workpiece!

⚠ Not every object can be assigned to multiple components (e.g. geometries)!

⚠ Dies need at least a geometry, a friction and a temperature object!

⚠ The workpiece needs at least a mesh, a geometry, a material and a temperature object!

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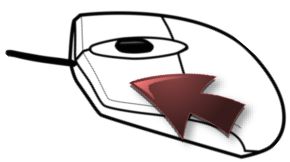
View manipulation and interacting with Simufact Forming:

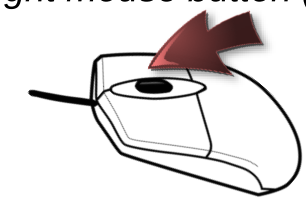
- **Mouse controls:**

Left mouse button (LMB)



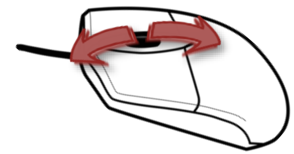
Single click = ***select***
Hold = ***pan view / drag***

Right mouse button (RMB)



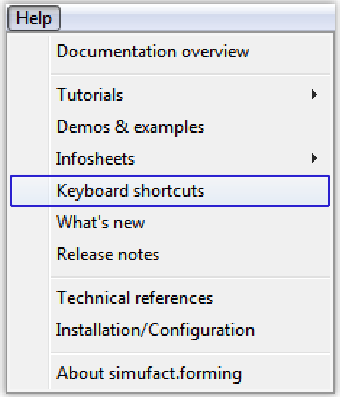
Single click = ***context menu***
Hold = ***rotate view***

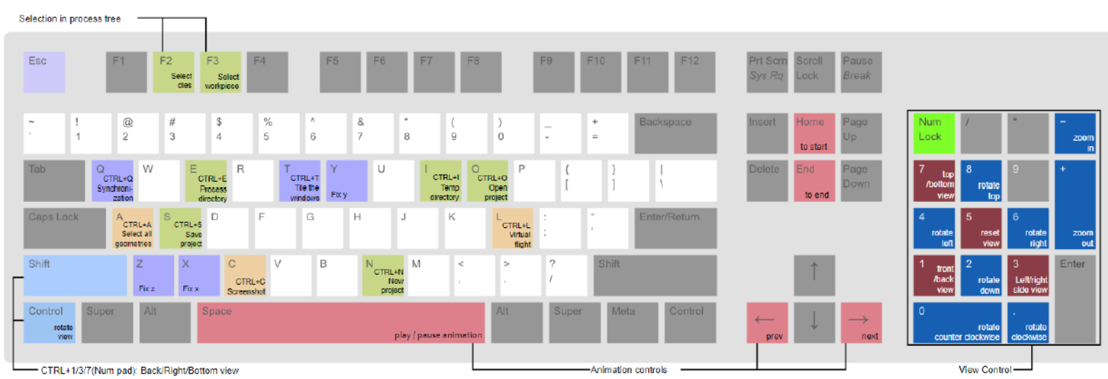
Middle mouse button (MMB)



Scroll wheel = ***zoom in / out***
Hold + drag = ***zoom box***
Double click = ***reset zoom***

- **Keyboard controls:**
  - ➢ Please refer to the infosheet for all available keyboard shortcuts:





If your system is set up for a left handed mouse, Simufact Forming will adapt accordingly!

In addition to a regular mouse, the use of 3DConnexion space navigators is supported as well!

© 3DConnexion

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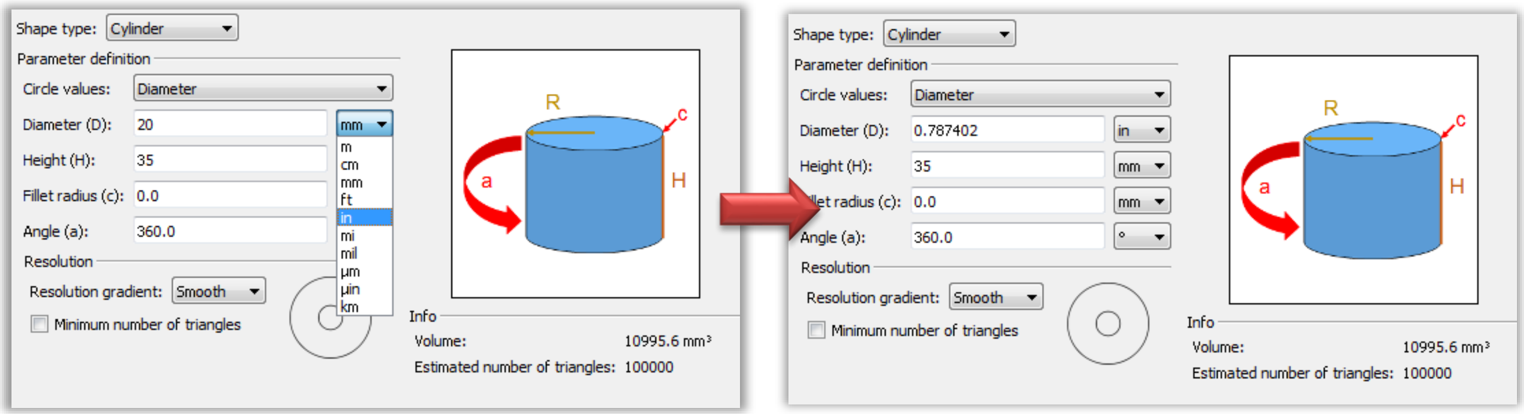
Unit systems in Simufact Forming:

- Unit definitions in Simufact Forming are completely flexible.
- You can select and work with the units for your in- and output values that you desire.
- Simufact Forming maintains a consistent unit system in the background so that you don't have to convert it manually.
- The GUI can do live unit conversions for you.
- You can adapt the default units for all values to your liking.



Flexible GUI driven unit conversion makes working on projects with international colleagues much easier!

You can change the default unit settings via the menu bar under **Extras > Options > Units**.

Hold the *Ctrl* key on your keyboard while selecting a different unit to the suppress automatic conversion.

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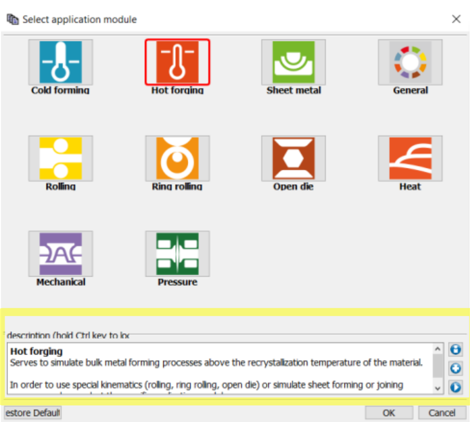
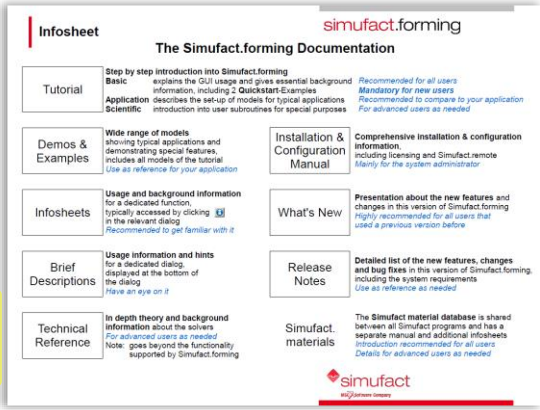
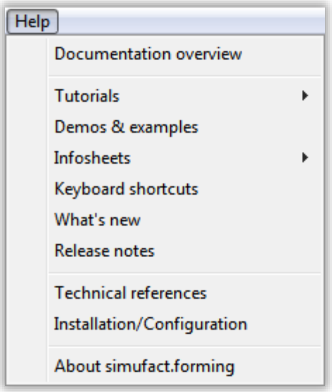
Simufact Forming help and documentation system:

- Simufact Forming aims to provide you with the required information where you need it.
- Keep an eye out for brief descriptions, linked infosheets, tutorial chapters or demo models!
- Simufact maintains a vast array of example processes which are available for every user.
- For many of these demos detailed descriptions and step-by-step model setups are provided in the application tutorial.
- These demos & examples will help you set up similar processes with ease.





Every piece of information available about Simufact Forming is accessible via the Help menu:



Infosheets are spread throughout the Simufact Forming GUI and provide valuable information!

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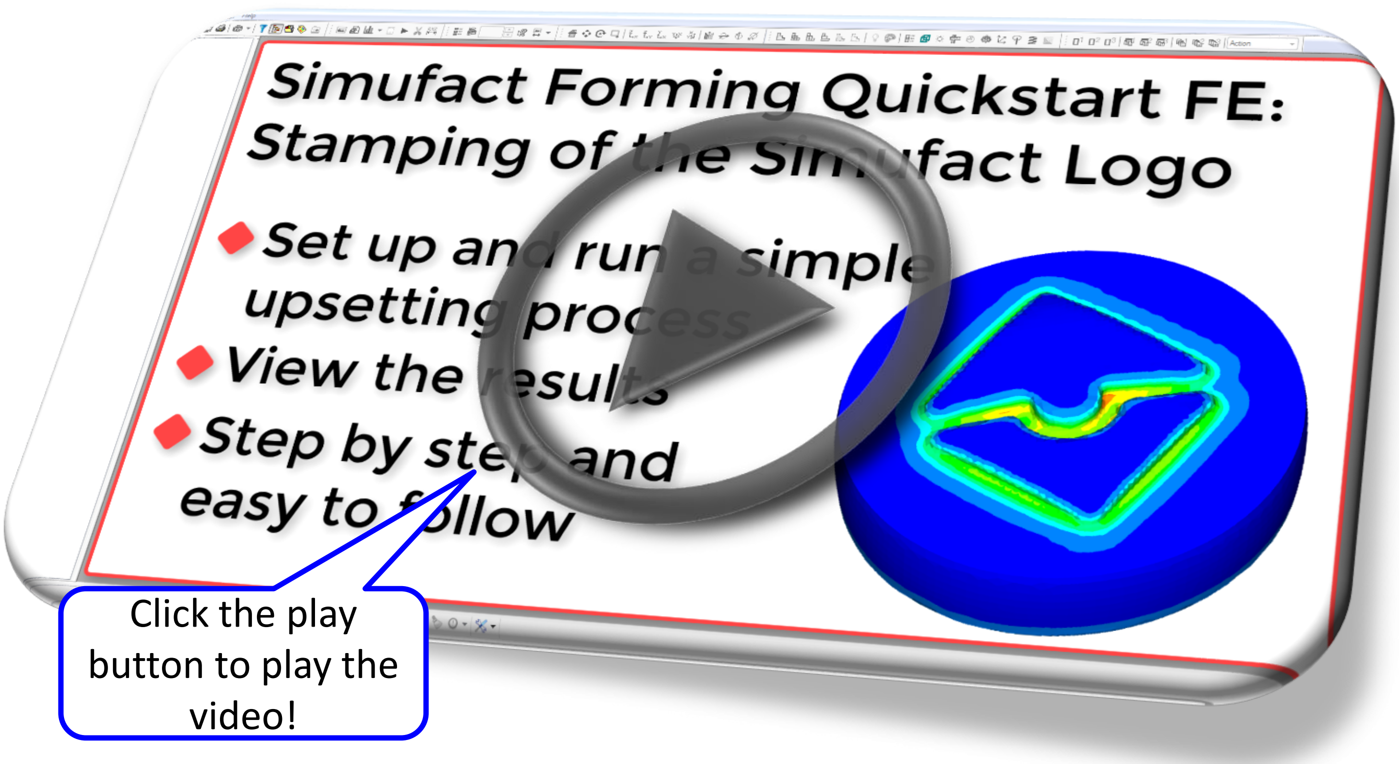
Introducing Simufact Forming

Setting up your first simulation with Simufact Forming

- We have created a video tutorial where the complete set up of a simple upsetting process is shown and explained step by step.
- If you are a first time user of our software you should take the time and follow the video instructions to set up this model by yourself to get acquainted with the look and feel of Simufact Forming.



There will be more detailed video tutorials like this one in future versions of Simufact Forming!

The completely set up model is available in the Demos&Examples browser under Tutorial > Cold forming > Upsetting of a cylinder.

You can find similarly detailed step by step descriptions in the application tutorial or directly linked in the Demos&Examples browser for every model in the tutorial category.

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Preprocessing

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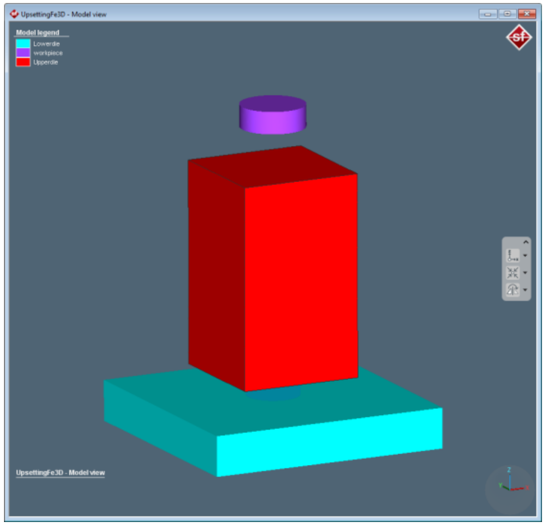
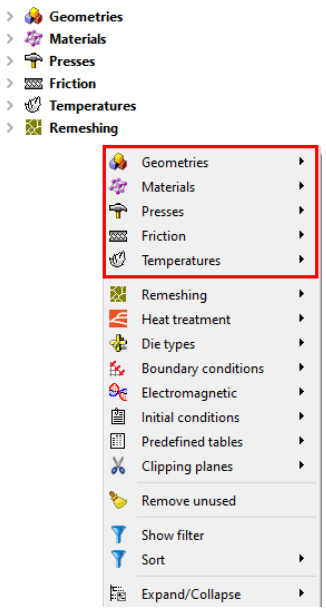
Preprocessing

What is preprocessing?

- During preprocessing you set up the model of your process so that it contains all the information that is needed for a successful simulation.
- For a basic forming model, the main steps are:
  - Select a suitable **application module** and process type.
  - Import (and position) **geometries**.
  - Choose the desired **material**.
  - Define a **press** (machine motion).
  - Specify **friction** properties.
  - Specify **heat** properties.
  - Create a workpiece **mesh**.
  - Possibly adapt some simulation **settings**.
  - Start the simulation!

- Except the first, all these preprocessing concepts of Simufact Forming will be described in this chapter. Application modules and process types have been covered previously.





During preprocessing, the model view is automatically updated when you assign new geometry objects to the workpiece or die components!

When adding objects to the object catalog, for standard forming processes, you can go through the first 5 entries of the context menu and you should have all the objects you need!

You can create process templates to increase your efficiency when working repeatedly with similar processes!

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Preprocessing

Difference between analytical and discrete geometries

- Analytical description
  - Description via mathematical functions (e.g. NURBS splines or faces)
  - Ideal geometry depiction
  - File formats: IGS, STEP, CATPart, etc.

- Discrete description
  - Description via discrete surface facets
  - Approximation of curved facets → discretization error
  - File format: STL, BDF, arc, ply, etc.

Internally, Simufact Forming only uses discrete geometry descriptions!

Analytical geometries must be discretized!

A discrete description is always an approximation to the real geometry!

Discretization can be done during the export of the CAD system or during the import into Simufact Forming.

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Preprocessing

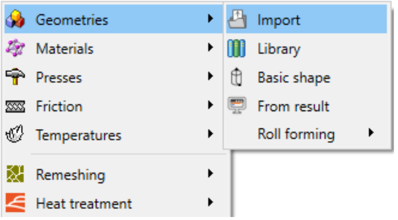
Importing analytical geometries: CAD import

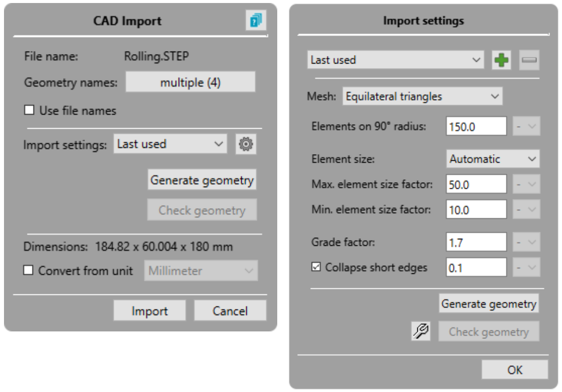
- Open the CAD import dialog via **Geometries > Import**.
- The geometry name of a single body or assembly part can be set to the file name or edited in the dialog.
- The context menu lists various import settings for applications like 2D Simulation, Hot Forging, and Die Load, etc.
- Using the gear icon, you can adjust several parameters, including:
  - Mesh

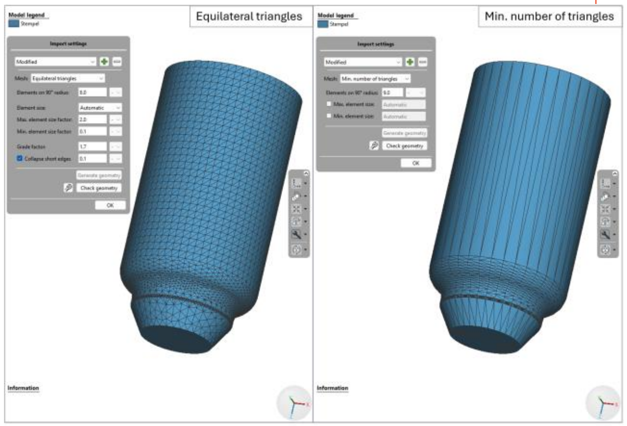
    Equilateral triangles: discretizes the surface with homogenous distributed triangles, ensuring a nearly uniform distribution

    Min. number of triangles: discretizes the surface using narrow, elongated triangles.
  - Elements on 90° radius

    Controls the number of facets used to discretize a 90° radius. Increasing this value improves discretization accuracy and quality
- Custom settings can be saved as presets by clicking the plus button







In an assembly, click "Multiple" and then double-click each component to rename them individually.

For more details, refer to infosheet **CADImport_en.pdf**.

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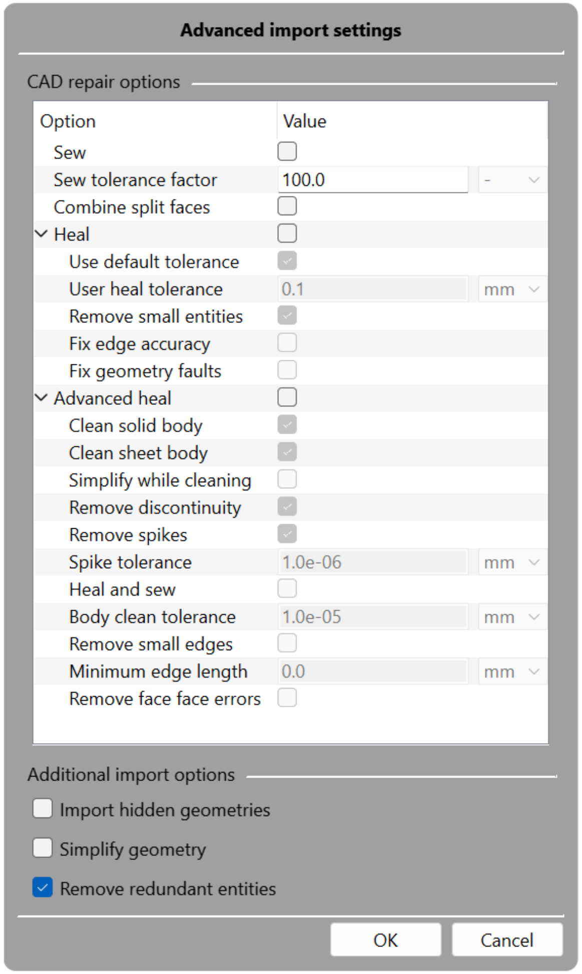
Preprocessing

Importing analytical geometries: CAD import

- Select Check Geometry to identify mesh defects. Defects marked in red color should be addressed by modifying import settings or using geometry repair options before importing.
- Click the wrench icon to repair the geometry and access advanced repair settings to fix mesh defects.



The changes in geometry repair are saved for import settings. After changing the geometry needs to be regenerated.

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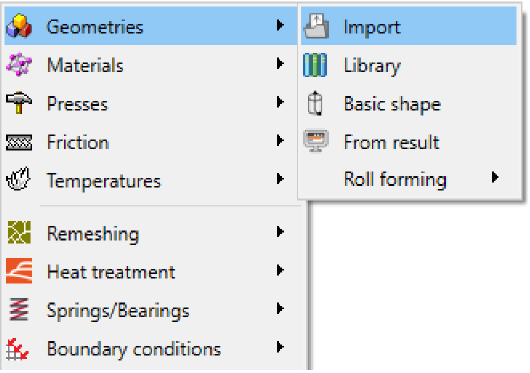
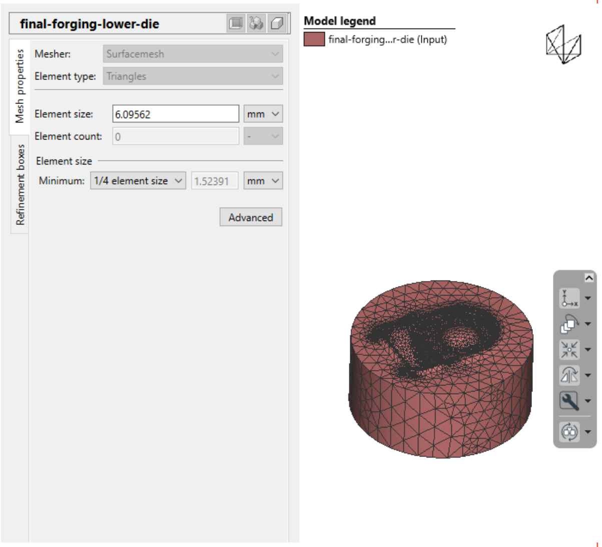
Preprocessing

Importing and remeshing discrete geometries

- Files with discrete surfaces and volume meshes, like BDF and STL, can be imported directly through **Geometries > Import**.
  - If the BDF file contains a volume mesh, it will be imported as a volume-meshed body.
- STL files typically only include surface facet coordinates. Make sure to select the correct units (default = mm).
- To import FE geometries with results from UNV, the UNV import dialog will open. For more details, refer to the **UNVImport_en.pdf** infosheet.
- If the imported surface are unsatisfactory, they can be remeshed by right-clicking the geometry object and selecting Modify **Geometry > Surface Remesh.**
- Note that remeshing does not improve the actual geometry representation.





Depending on your CAD system the names of the parts might or might not be saved in the STL file. If it is not, the default name will be generated from the file name.

This is also true for complete assemblies saved in one STL file.

When using the Surface remesh option you can set a high element size and a smaller minimum size (<1/5th) in the advanced parameters. This way you can achieve an increased spreading from small to big facets to reduce the total number.

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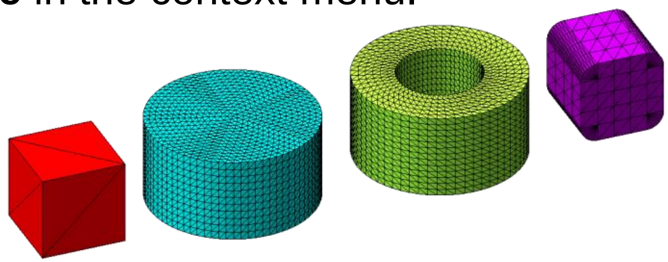
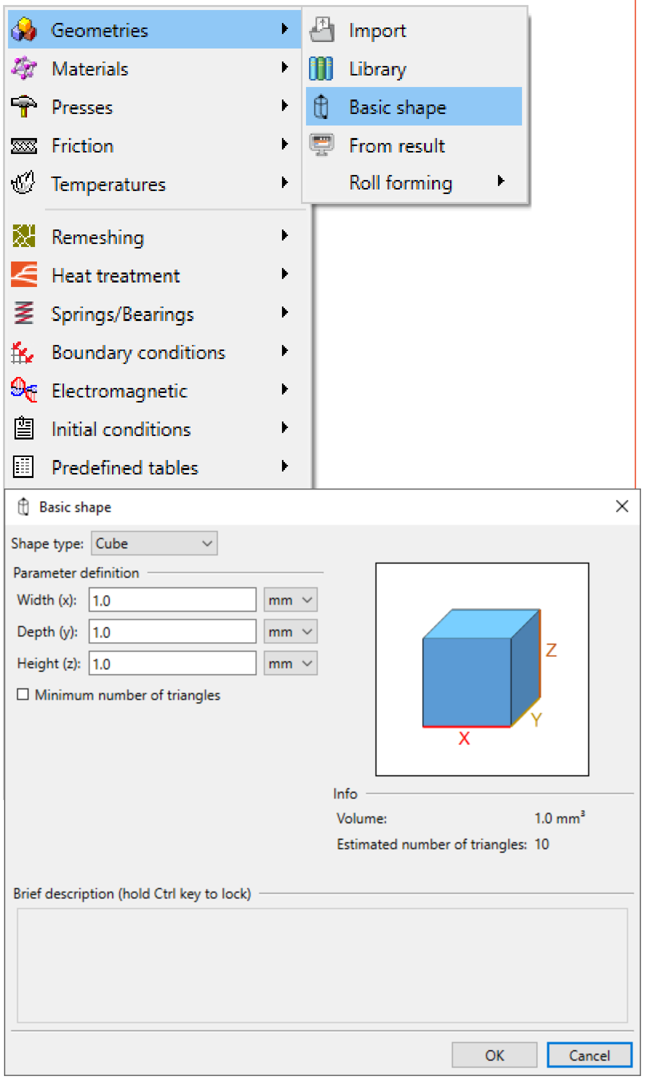
Preprocessing

Creating simple geometries: Basic shapes

- Typically, workpiece and especially tool geometries are created in the user's CAD system of choice and then imported to Simufact Forming.
- However, it is possible to create simple geometries directly in Simufact Forming without having to use any CAD software.
- The available shapes are:
  - Cube
  - Cylinder or section of desired angle
  - Hollow cylinder or section of desired angle
  - Rounded cube
- You can add these shapes to the object catalog by selecting **Geometries > Basic shape** in the context menu.





Basic shape geometries are often used as workpiece geometries. You can easily create blocks, billets, pipes or sheets of different sizes.

Basic shape dimensions can be edited. Edit function can be found in Modify geometry submenu. Basic shape edit creates a copy.

Cubic autoshapes tend to have very few but very big surface facets. If you want them to have a finer surface mesh you can use the **Modify geometry > Surface remesh** option on the object.

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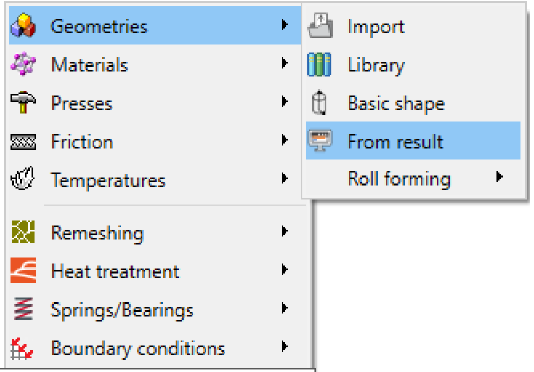
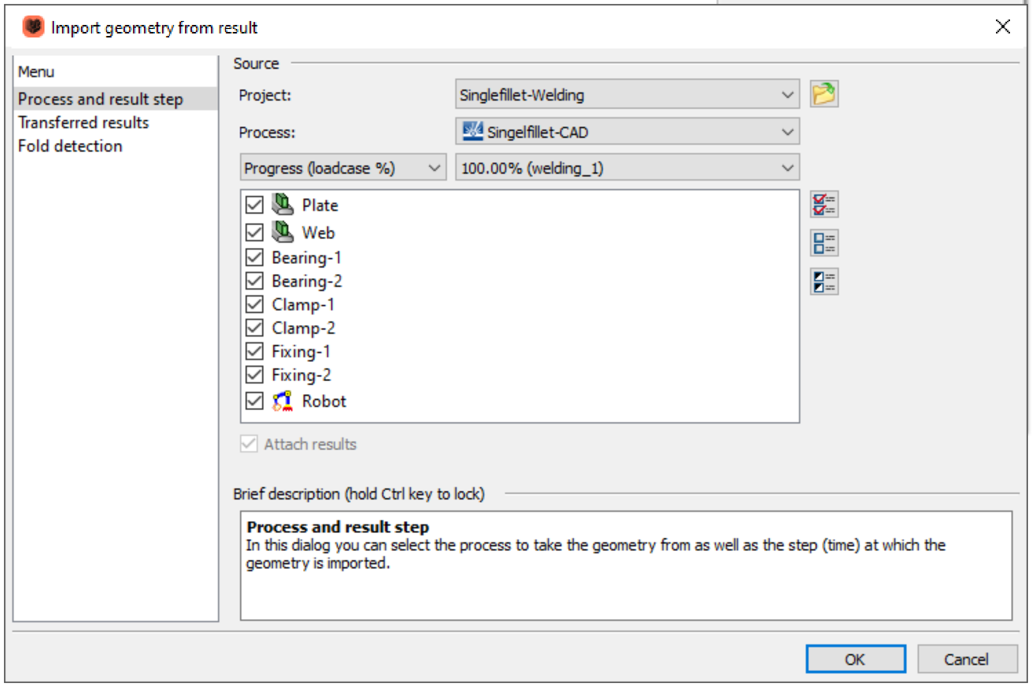
Preprocessing

Importing geometries from results

- Geometries can also be imported with results and with a mesh from a specific time step of a selected other process.
  - This “other” process can also be part of other Simufact Forming projects.





For the result transfer between Simufact appli-cations, the UNV format is used.

In the infosheet ‘TransferWeldingForming’ an example is shown, where geometries from a Welding simulation are imported to start a simulation in Forming.

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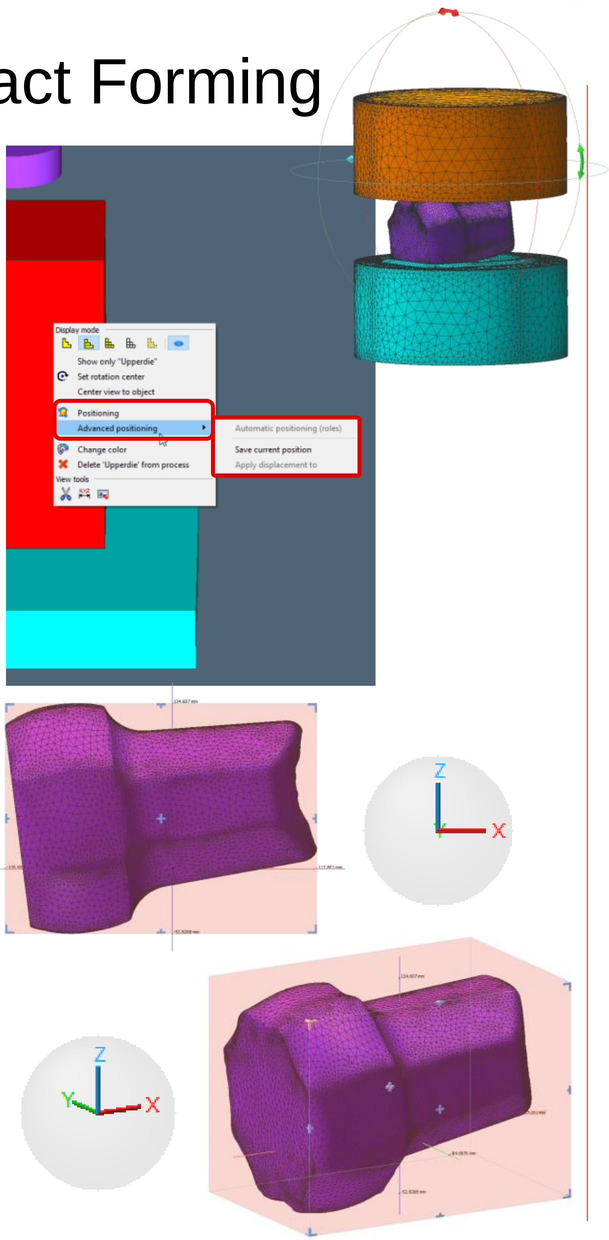
Preprocessing

Positioning components in Simufact Forming

- Typically, the tool positioning should be done in the CAD system. However, Simufact Forming offers some positioning operations in the model set up.
- There are three different concepts available:
  - Manual positioning (Drag arrows directly)
  - Direct positioning (Move by x mm, Rotate by y degrees)
  - Positioning via bounding box (Align to other bodies)
  - Contact positioning (Positioner)
- Every model component is surrounded by its so-called bounding box.
- The edges of this box are parallel to the global coordinate directions and its dimensions are determined by the maximum dimensions of the component in the corresponding direction.
- You can easily align bodies relative to each other by positioning them according to the min, max or center dimensions of their bounding boxes.
- You can also align it/move it to special locations such as the origin or defined points.



You can access the positioning menu from the context menu of the desired component in the model view or in the process tree.

The bounding box does not rotate with a component. It is always aligned parallel to the global axes!

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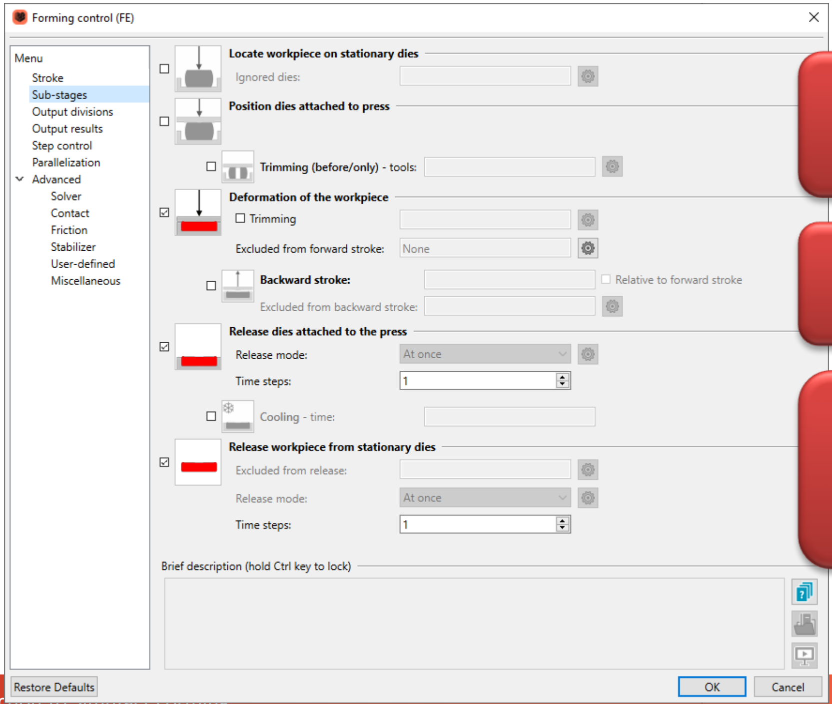
Preprocessing

Utilizing the automatic positioning feature

- Simufact Forming offers the so-called sub-stages.
- They can be used to automatically position components.
- For example you can draw your tools at their bottom dead center (BDC) and the sub-stages will automatically position the workpiece in the tool and open the tool accordingly.
- This can only be used if the main forming direction is the z-direction.
- For more information about this please see the infosheet or watch the Quickstart FE Video Tutorial.
- Sub-stages are especially useful in combination with the stage control. See the “Advanced” chapter of this tutorial for more information.



Substages 1 and 2: Positioning tools

Substage 3: Forming

Substages 4 and 5: Removing tools (allow elastic spring back)

If sub-stage 2 is active and you are using the tool positions at their BDC you can define a stroke of 0 mm to enable an automatic calculation. It is then calculated auto-matically as the distance between BDC of the press controlled die(s) and its position after sub-stage 2.

In FV simulations and some FE processes not all sub-stages are available.

The sub-stages are a powerful tool for a more comfortable model setup.

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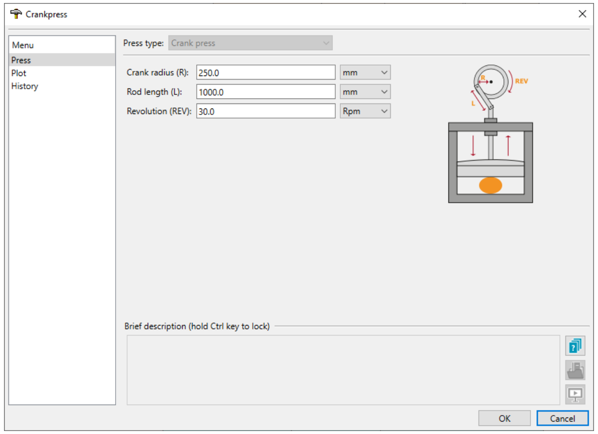
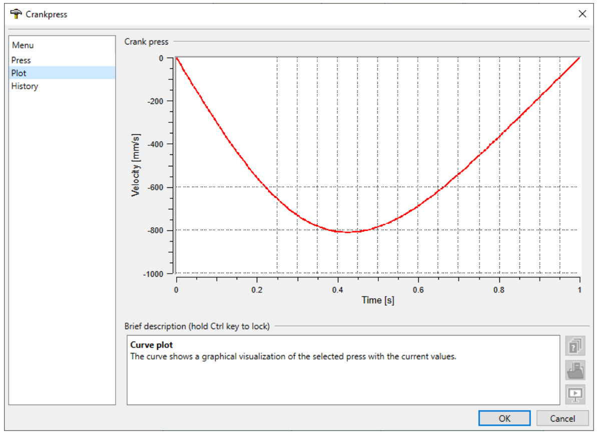
Preprocessing

Forming machines and tool movements: Presses

- Simufact Forming aims to be a software that keeps close to the actual manufacturing processes.
- Therefore it offers a variety of the most common forming machines to control the tool movements:
  - Crank press, Hammer, Screw press, Hydraulic press and more…
- They are set up with their machine specific parameters (e.g. crank radius, rod length and revolutions per minute for a crank press, max. energy for a hammer,…)
- Presses are added to the object catalog and then assigned to the process. Then the moving tools are assigned to the press.
- Typically the forming direction is the –z-direction.
- Non-standard movements can be achieved by using table presses and / or local coordinate systems.





For each default press you can find additional information in the infosheet linked in the dialog!

In the press dialog you can view the plot to see the movement the press will do with the current settings.

All of the standard presses can move tool(s) only in z- or –z-direction. For move-ments in other directions you will have to use the press type **Tabular motion**.

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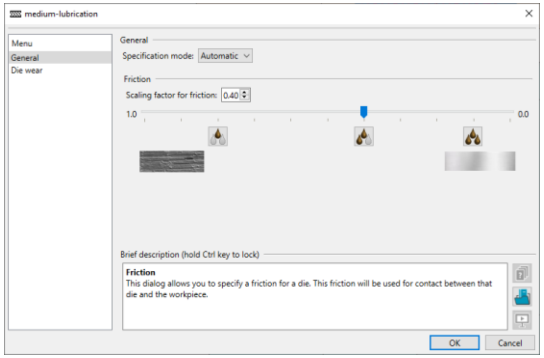
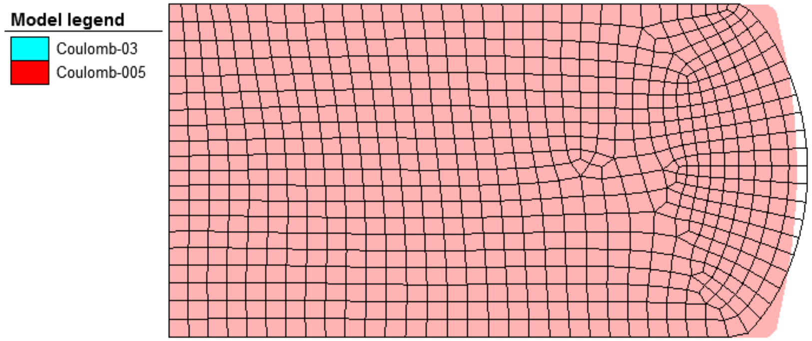
Representation of physical interactions: Friction

- Physical interactions between the components in the model are described mathematically.
- There are three main points where these interactions are defined in Simufact Forming.
- Friction:
  - Friction is an important factor in metal forming processes and can influence material flow and forming forces substantially.
  - The friction definition is covered in Simufact Forming by the friction object which is assigned to a die. They determine the occurring friction stresses.
  - There are multiple friction laws available that the user can choose from. You can set up the parameters manually or use an automatic functionality (only available for general steel materials).





Simufact Forming also comes with a library of friction objects which are mainly based on our experience and are a good place to start your simulation with.

For detailed information about the friction modeling in Simufact Forming please see the respective chapter of the Application tutorial.

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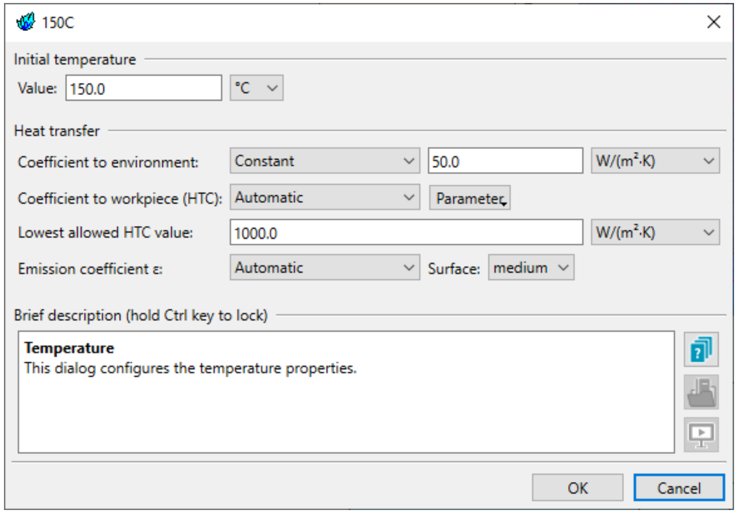
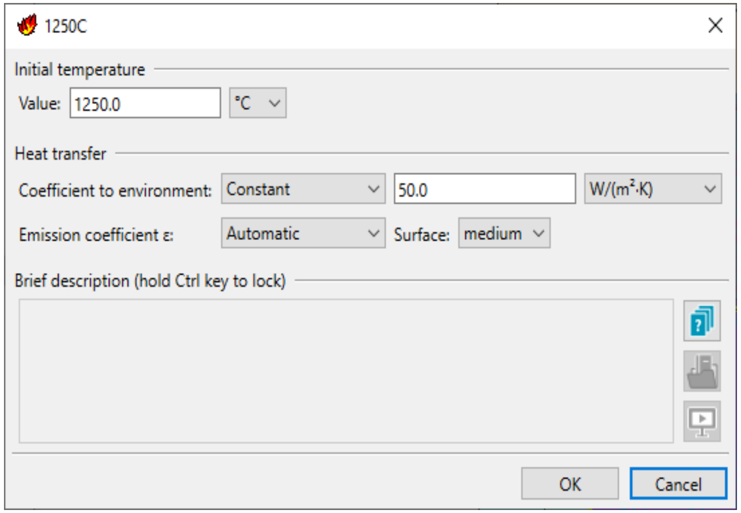
Preprocessing

Physical interactions: Thermal properties

- The thermal properties of a component govern the distribution and transfer of heat between the model components and to the surroundings.
- Each component needs an assigned temperature object to define these interactions.
- Simufact Forming offers default values for all coefficients and automatic calculations for some of them. Alternatively, all of them can be manually defined (as a constant or a temperature-dependent table) by the user.
- During forming processes the forming energy is largely converted into heat. This so-called dissipation factor is a material property and can be modified directly in the material object.





The automatic calculation of the heat transfer coefficient (HTC) from die to workpiece takes the contact pressure between the two components into account.

The default dissipation factor is 90%.

Assigning an initial temperature to a component does not change its dimensions! To go from cold to hot dimensions you can use the Heat up function in the context menu of an object!

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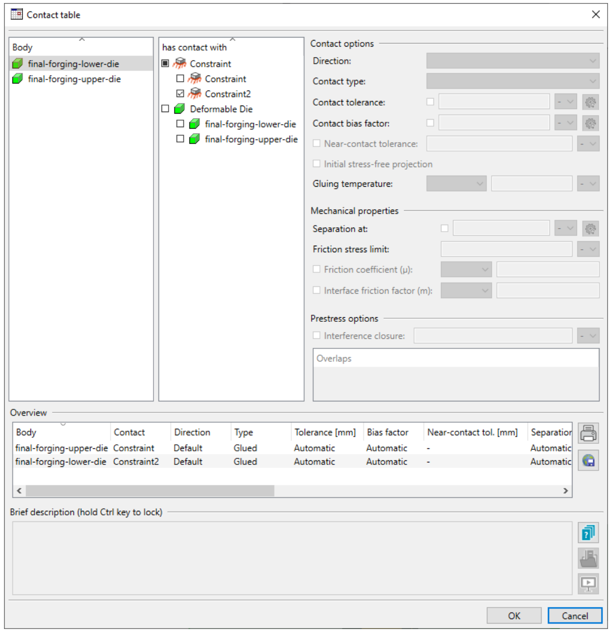
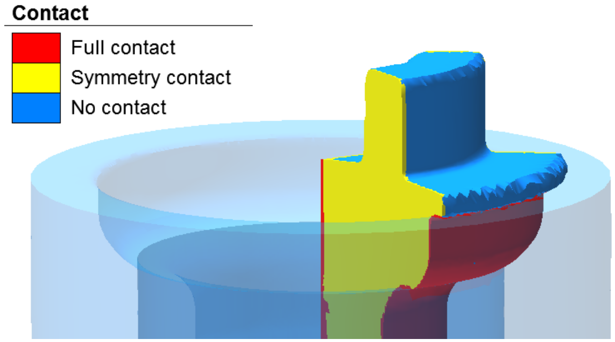
Preprocessing

Contact and contact tables

- There are a few important things to know about contact calculation in Simufact Forming.
- There is no contact between rigid dies! They can penetrate each other without effect.
- If there are only rigid dies and a workpiece in the model, it is assumed by default, that all dies can contact the workpiece.
- If there are multiple deformable bodies in the model, a contact table has to be set up where all possible contact situations between the components have to be defined manually.
- Additionally the contact table can be used to gain access to more advanced contact settings (contact tolerances, glue contact, etc.).





If a component simply vanishes at the start of a simulation it is probably not correctly defined in the contact table!

Contact should typically only be defined in one direction. From the finer meshed body to the coarser meshed body.

For some examples of the use of contact tables please see the more advanced examples in the Application tutorial. E.g. the flanged socket head bolt.

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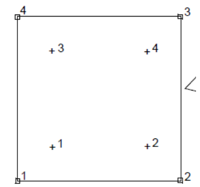
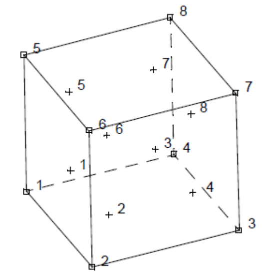
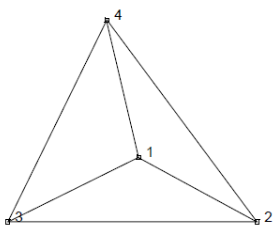
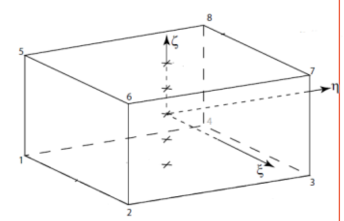
Meshing technologies and areas of application

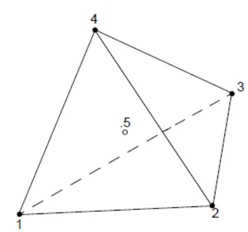
- Every FE simulation needs a FE mesh for the deformable bodies
- Simufact Forming offers multiple element types and different meshing techniques. The available options are:
  - 2D: Quad elements (*Element type 3, 10, 11*)
    - Advancing Front Mesher, Quadtree Mesher
    - Basic 4 Node 2D Element
  - 3D: Hexahedron (*Element type 7*)
    - Hexmesher, Sheetmesher, Ringmesher
    - 8 integration points, highest accuracy, highest cost
    - Recommended for meshing of the workpiece!
  - 3D: Solid-Shell (hexahedron geometry, Element type 185)
    - Sheetmesher
    - Special mathematical formulation for selected sheet metal applications
  - 3D: Tetrahedron (*Element types 134*)
    - Tetmesher
    - Only one integration point, fast calculation
    - Inaccurate depiction of plasticity
    - Only recommended tools in die analysis!
  - 3D: Tetrahedron (*Element type 157*)
    - Tetmesher
    - 4 integration points, more expensive
    - Only recommended if hexmesher fails!
  - 3D: Tetrahedron (*Element type 247*)
    - Tetmesher
    - Additional pressure DOF for each node
    - More accurate than the 134 and faster than 157

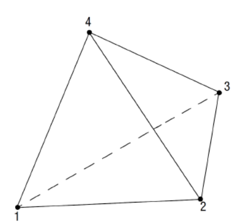












Quad elements are the only option for 2D simulations. You can choose between the two meshers for different meshing strategies.

FV simulations do not work with an FE mesh. Therefore the in this case used surface mesher is not listed here as it technically does not create finite elements but surface facets.

You can find detailed descriptions of the different element types in the Technical reference in Marc Vol. B.

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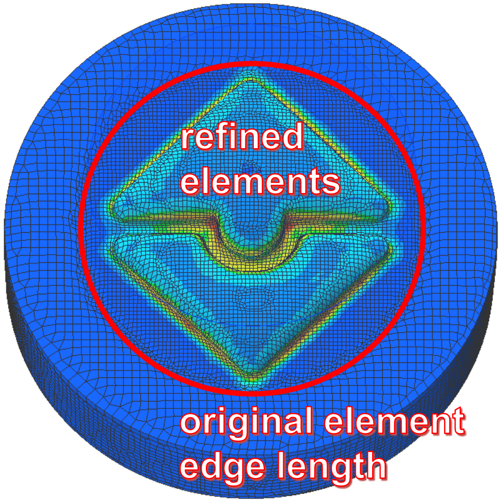
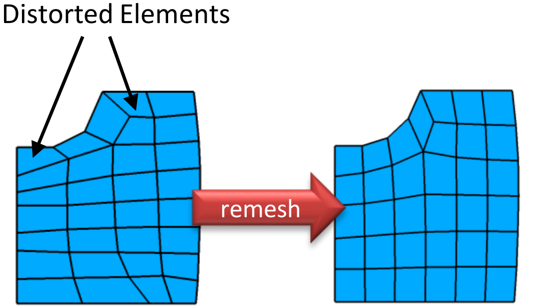
Preprocessing

Refinement and remeshing

- All meshers delivered with Simufact Forming support the use of so-called refinement boxes.
  - Define regions of interest in your model and refine your mesh in that area only.
  - Each refinement level halves the original element edge size.
- During a forming process, the elements get distorted.
- Big distortions have a negative impact on the result quality or can lead to errors during the calculation.
- To ensure best results and stable calculations, Simufact Forming can perform automatic remeshings during the process.
  - You can control when and how a remeshing is performed in the settings of the remesh object .





Deformed geometry with excessively distorted elements

New mesh with same topology and regular elements

Be careful with increasing refinement levels. The number of used elements will rise exponentially!

Using the surface refinement boxes is generally the recommended option. Full refinement is only needed in special cases.

Simufact Forming uses sophisticated algorithms to map the results from the old mesh to the new one to ensure an optimal transfer.

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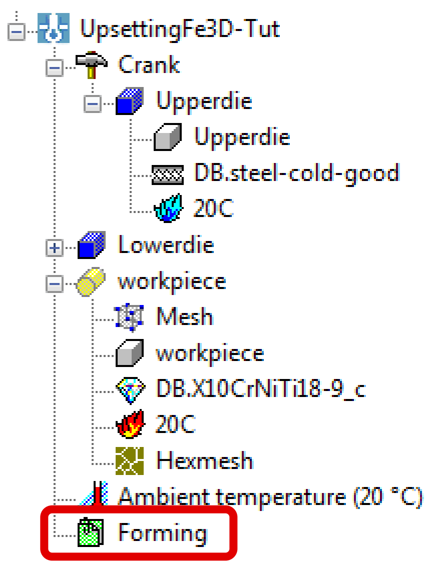
Preprocessing

Defining process and numerical parameters: Forming control

- All of the general simulation settings are combined for each process in the so-called Forming control.
- Here you can define the termination criteria of the simulation (stroke, time, force,…) and activate or deactivate sub-stages (automatic positioning).
- You can also access many numerical parameters if you need to adjust them. The most important are:
  - **Output divisions:** Control how frequent result files are written.
  - **Output results:** Activate special output results that are not activated by default.
  - **Step control:** Control the time step size during the calculation.
  - **Parallelization:** Activate parallelization options to significantly speed up the calculation.
  - **Advanced:** Advanced numerical parameters which should only be touched by experienced users.



Keep in mind that writing results more frequently requires more disk space!

Deviating from the automatic time step control is only necessary for special processes. Setting manual time steps can speed up the simulation but can also compromise the results!

Activating parallelization options is strongly recommended for 3D simulations exceeding 10000 hexahedron elements!

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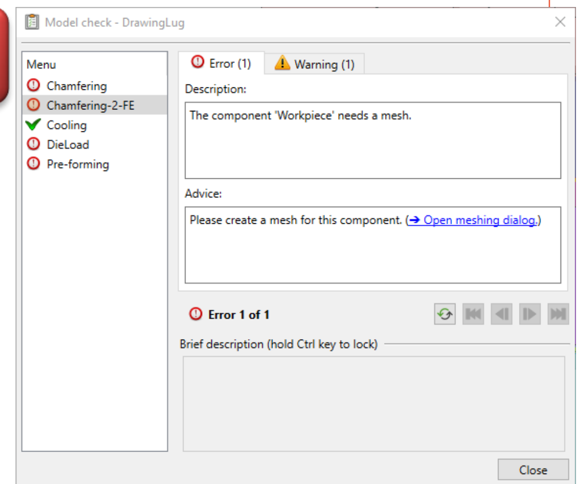
Preprocessing

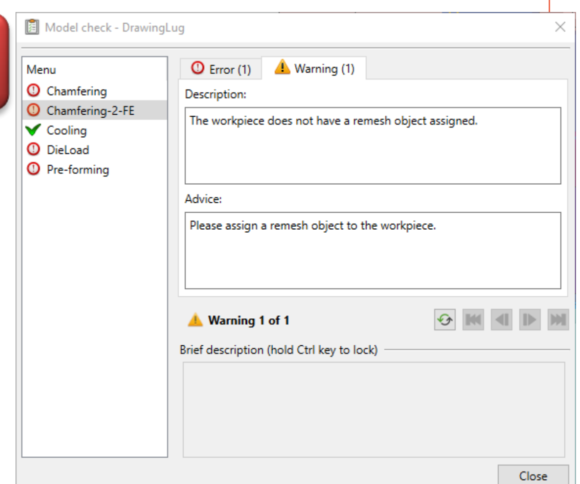
Model check, warnings, errors and advice

- Right before starting a simulation, Simufact Forming runs an automated model check to see if everything is in order.
- If something is amiss, the model check will prompt error or warning messages as well as practical advice on how to proceed.
- If the model contains an error, the simulation cannot be started until the issue is fixed.
- If the model check shows warnings, the simulation can be started anyway. However, you should read the warning messages carefully and decide for yourself if you want to ignore it.

Error



Warning



You can run the model check separately by using the icon in the bottom tool bar.

The model check can‘t catch all errors prior to starting the simulation. However it gets updated with each version of Simufact Forming!

If there are multiple errors or warnings you can go through them with the arrow buttons.

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Calculation

back to p.1

Calculation

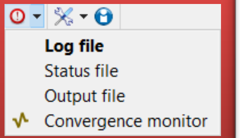
Doing the math

- Nearly all the information that was gathered while setting up the model is written in text form into a so-called .dat file.
- This file is read by the solver program and is the basis for the calculation.
- The solver calculates a result for each increment (defined by the step control).
- During the calculation, the solver writes some informational output for the user:
  - The status file (*.sts) primarily reflects the progress of the simulation. It logs completed increments as well as remesh operations and displays the total wall time after finishing.
  - The output file (*.out) contains detailed solver specific output throughout all stages of the simulation.
  - The log file (.log) contains selected solver specific information as well as information about additional programs that are called during the simulation (e.g. meshers).

Solver
(calculating)

- Assembly of $\underline{\underline{K}}$
- Solving of $\underline{u} = \underline{\underline{K}}^{-1}\underline{F}$ (FE)
- Solving of $\frac{\partial Q}{\partial t} + \nabla F = 0$ (FV)
- Strain
- Stress
- Force
- Total equivalent plastic strain
- …

Access the solver output from the GUI:



The convergence monitor can be used to quickly evaluate the numerical quality of the simulation. It gives a quick overview of the number of cycles that are needed per increment as well as the convergence behavior of the simulation.

Marc comes with multiple matrix solvers. You can select which one to use in the Advanced settings in the Forming control.

For more information on this topic please see the Technical reference in Marc Vol. A.

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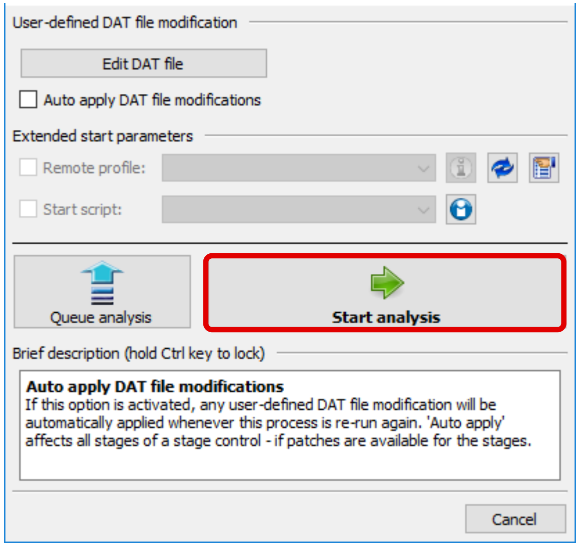
Calculation

Running the solver

- After the solver has been started, you can safely close the Simufact Forming GUI. Solver calculation will not be stopped, because it is executed on another core process.
- Furthermore, Simufact Forming offers the possibility to run the Graphical User Interface (GUI) locally and the solver remotely in the background on a different machine. This enables the usage of powerful central computer resources for the simulations. Especially for long running simulations it can increase the stability to use dedicated computers.



Caution: If the solver runs locally, the machine itself has to be running during the whole duration of the process.

When using the solver remotely, the client machine can be shut down without interrupting the solving process on the remote server.

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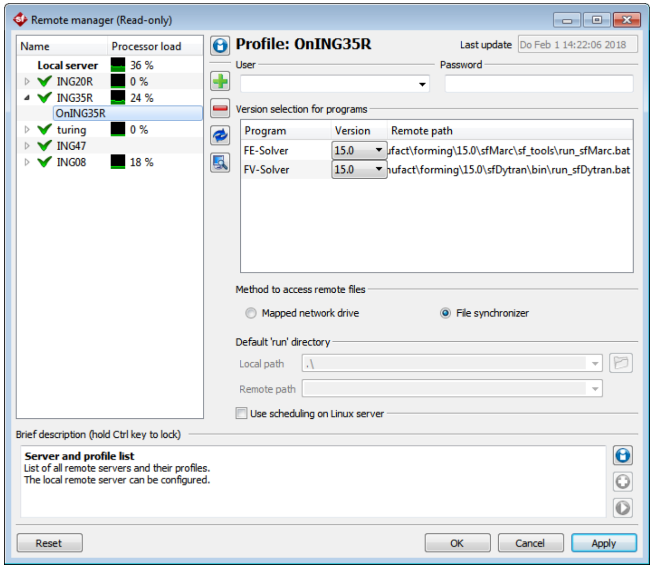
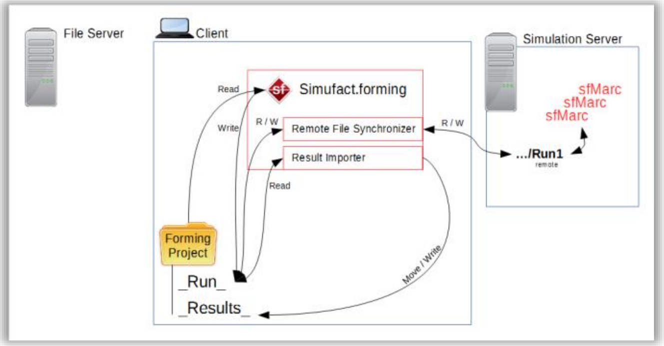
Remote calculations with Simufact Remote

- Simufact Forming comes with an additional software called Simufact Remote which allows for an easy remote simulation management.
- The result files are automatically synchronized between client and server so that no manual copying of files is necessary.
- While the forming GUI only runs in Windows environments, the solver and therefore the calculation can be done on Linux systems as well.
- More information can be found in the **Installation Guide.**





For detailed instructions on how to set up a remote environment please refer to the chapter „Remote“ of the Simufact Forming Installation Guide.

A lot of information can also be found in the infosheet linked directly in the remote manager application.

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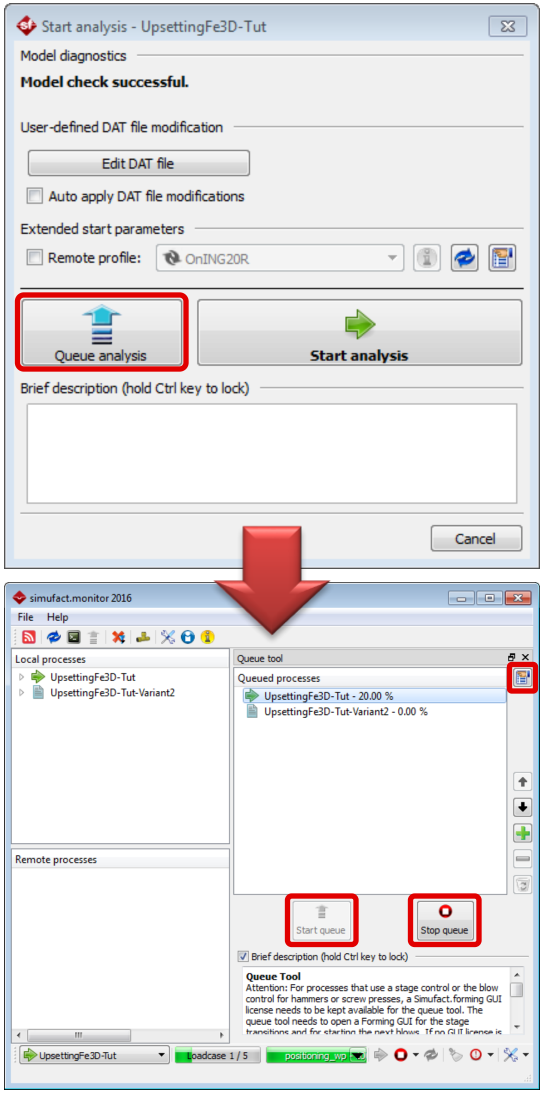
Organizing simulations with Simufact Monitor

- As available licenses and computing capacity are generally limited it is important to keep track of your running simulations.
- Simufact Monitor gives you an overview of the recently performed and currently running simulations on your computer and provides a queue to manage future simulations.
- Keep in mind that the queue feature is currently limited to the local host and is not a replacement for a sophisticated network queuing system.
- You can use Simufact Monitor when you select Queue analysis when starting the simulation from the GUI.



Simufact Monitor can run and start simulations without having to have the project opened in the GUI.

Use the Scheduling settings of the monitor to control how many calculations should be run at the same time.

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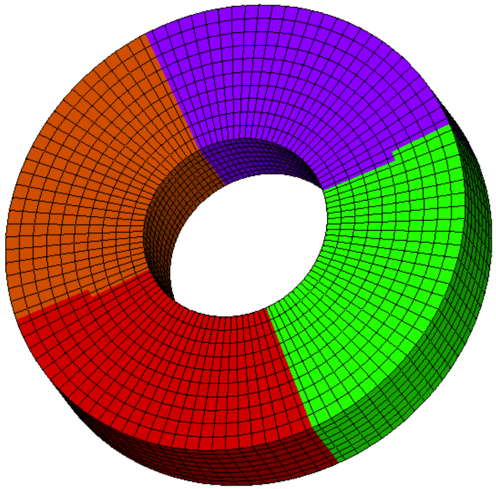
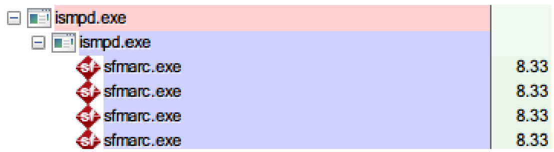
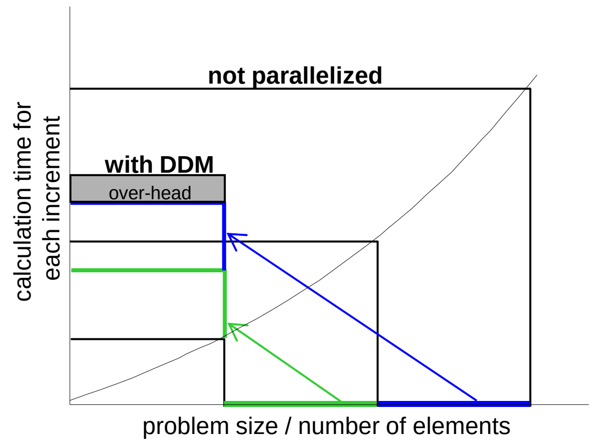
Calculation

Parallelization options in Simufact Forming

- Multi-core processors have been the standard for many years now.
- To make use of more than one core at once you will have to parallelize your simulation between multiple cores.
- Simufact Forming offers two possibilities:
  - **Domain Decomposition Method (DDM):** Divides a model into smaller parts (domains). Each domain is calculated by a separate core. This method gains efficiency the bigger the model gets (the more FE elements it has).
  - **Shared Memory Parallelization (SMP):** Distributes the assembly and solution of the matrix equation systems to multiple cores.
- Parallelization can drastically reduce simulation time and increase your efficiency when working with Simufact Forming!







Models with more than 10000 Hex-elements can benefit massively from parallelization.

Excessively high parallelization settings can actually slow down the simulation as the communication between the used cores may take more time than the actual calculation.

DDM is not yet supported for FV simulations!

Find more detailed information about this topic in the infosheet linked under **Forming control > Parallelization!**

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Postprocessing

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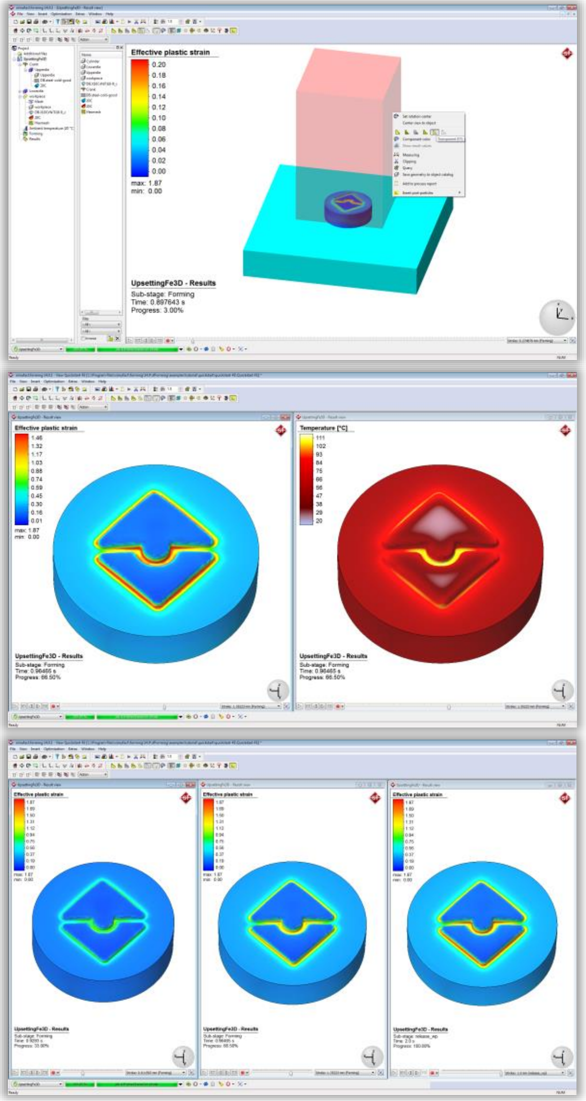
Postprocessing

Visualizing results of the calculation

- Just like the preprocessing earlier, the postprocessing is done in the Simufact Forming GUI.
- Double click the Results icon in the process tree to open the result animation window.
- You can display the simulation results as a function of the simulation progress (time, stroke, increment,…) and view it as an animation.
- There is a wide variety of result values available which you can select directly in the animation window.
- By default, the result values are mapped over the surface of the workpiece and shown as a so-called contour plot. Some result values are also available as vector plot ( ).
- The result view can be modified by the user in many ways (legend settings, background color, size and position of GUI elements).



Use the context menu to change the visualization of components directly in the result view!

You can hide the process tree and object catalog to have more space for your animation window.

You can save the process animation to a video file for presentation purposes!

You can open multiple result windows and automatically synchronize the views to easily compare result values.

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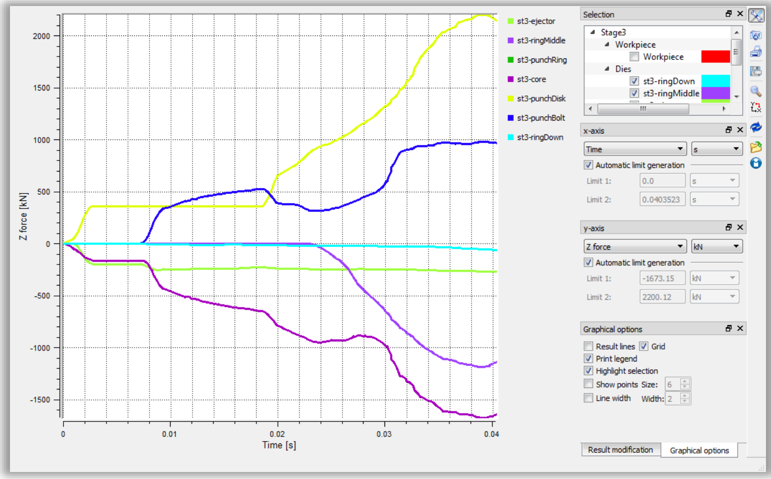
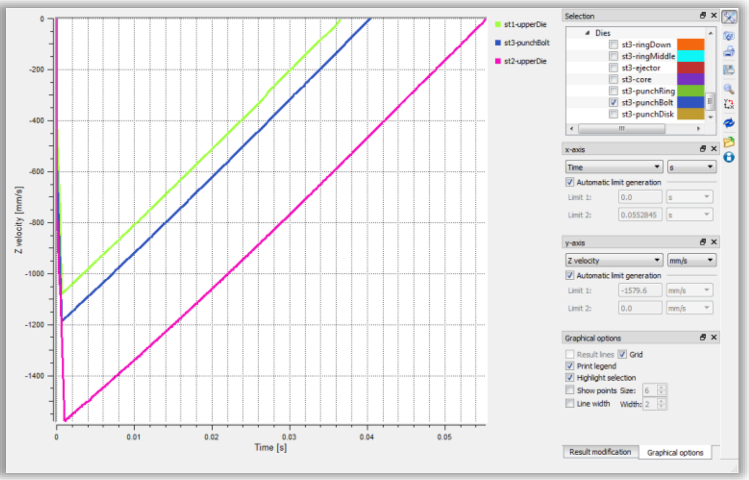
Postprocessing

Evaluating integral process values: the THS-Plot

- The history plot (also called time history (THS) plot) displays integral process values such as forces or energies as a graph.
- Click the icon in the top tool bar to open it. Use the arrow on the right to add the results of multiple processes to a single THS plot!
- You can check the progress of forming forces, die movements and velocities and much more as a function of the simulation progress (time, stroke, increment,…).
- There are many comfort functions to adapt the display of the graphs to your likings.
- From here you can also export these results as a .csv-file to further evaluate the results in a table handling software of your choice.





You can freely change the axes limits and select displayed units.

You can simultaneously view the results of multiple simulations in one THS-plot by clicking the arrow next to the icon in the tool bar and selecting the plot to which the new result should be added!

The THS-plot can sum up, average and adapt curves to symmetry angles for you!

Please find more information in the linked infosheet!

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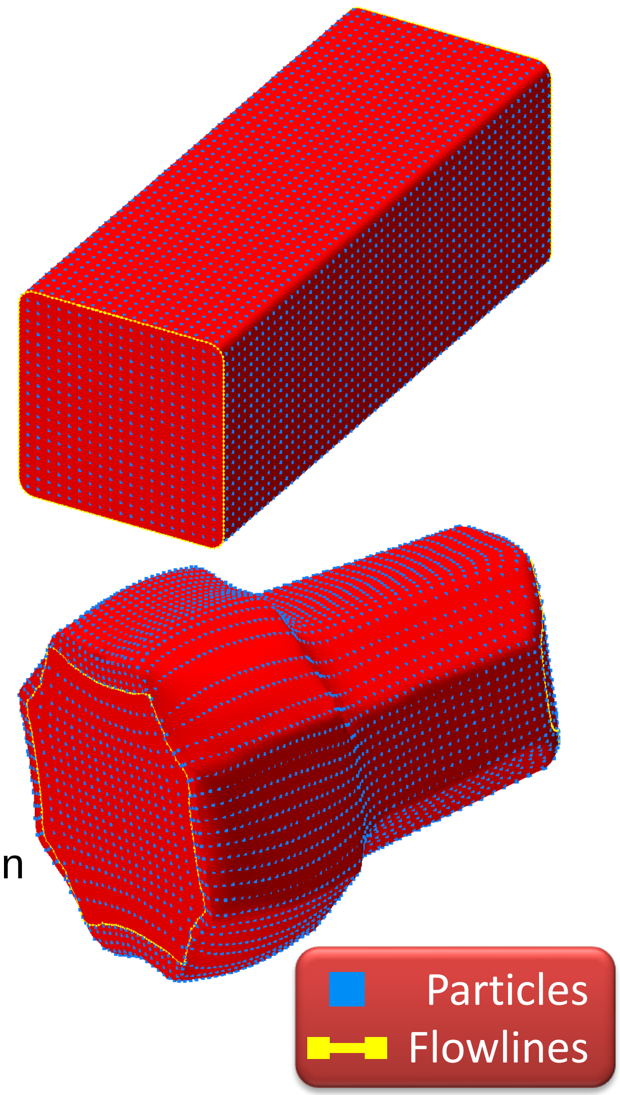
Postprocessing

Utilizing particles, post-particles and flowlines

- Particles and post-particles are points that can be freely defined in the model which follow the material flow and can as such be used as tracking points.
- You can select which result values should be stored for the defined particles.
- Flowlines behave in the same way but can not store any result values besides their own position. They are exclusively used to track material flow over the course of the simulation.
- The position of these points or flowlines is not influenced by the mesh or remeshings!
- Particles and flowlines have to be defined during the preprocessing.
- Post-particles however can be defined when the simulation is already finished!
- Their results can be viewed in the THS plot or exported as a .csv-file.



Excessive numbers of particles or points for flowlines can slow down the GUI as well as the simulation and result in increased result file sizes.

For more information on how to create and use the post-particles please see the infosheet linked in the creation dialog!

For an application example of particles and flowlines please see the example **Tutorial > Hot forging > Drawing lug**!

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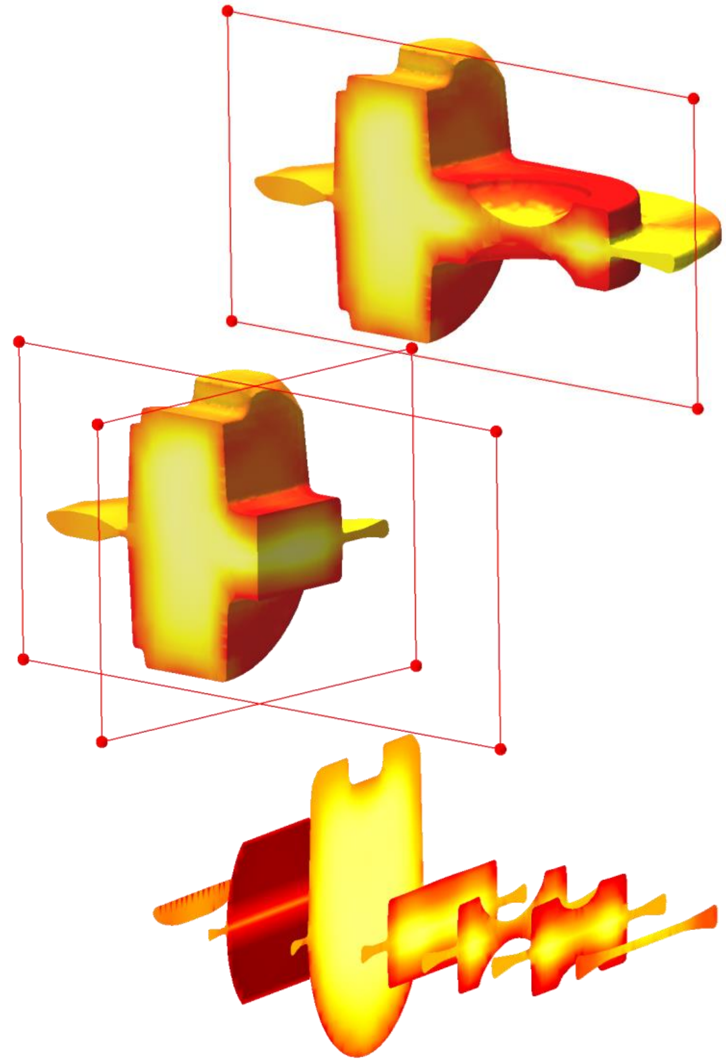
Postprocessing

Taking a look inside: Clipping planes

- Simufact Forming offers an easy creation of various combinations of clipping planes which allow you to take a look at the results inside the workpiece.
- You can add planes normal to any desired direction.
- Their position can be changed comfortably in the view by dragging the planes to the desired position or by entering a specific position in the creation dialog.
- You can save cutting plane positions and contours to the object catalog to reuse or export them.



If you cut components when their mesh is displayed, you see triangular facets in the cut view. This is not the shape of the finite elements but rather new surface facets that are temporarily created to display the cutting plane.

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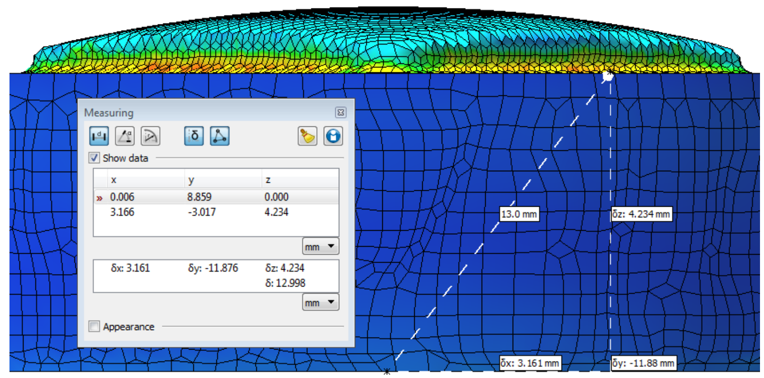
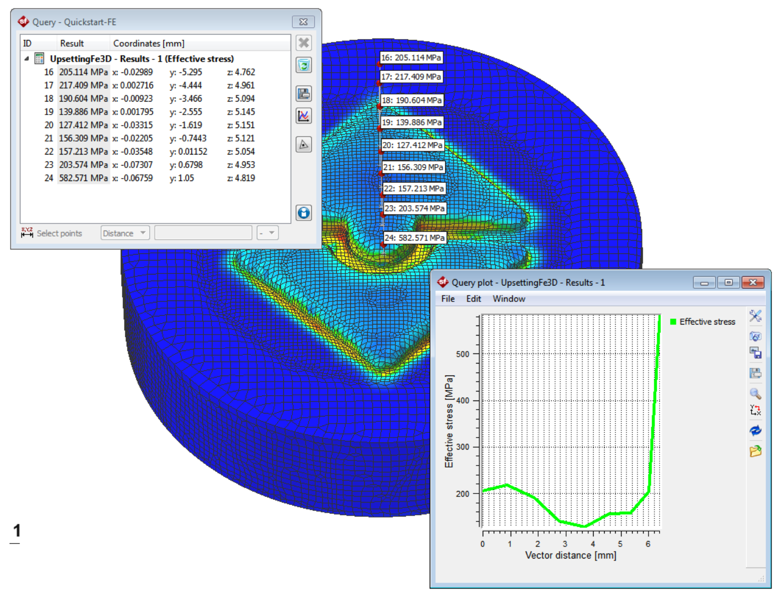
Postprocessing

Tools for measuring and querying

- One of the main goals of the simulation is to predict the exact shape of the formed workpiece.
- To accurately meter model dimensions Simufact Forming provides a Measuring tool.
- This tool can measure distances, angles and radii.
- It can show you the delta values along the global axes, or the center point of a circle.
- You can use the Query tool to display result values for single nodes of the FE mesh.
- You can create lists of result points and create path plots of that list.
- Query points can also be synchronized between multiple result windows.





You can select if the measuring tool should catch nodes or if it can be an arbitrary point on the surface.

You can directly enter coordinates in the measuring tool, and they will be displayed in the view window.

With right-clicking on a query point in the view you can access its display settings.

See also the infosheet linked in the Measuring dialog for a description of all functionalities!

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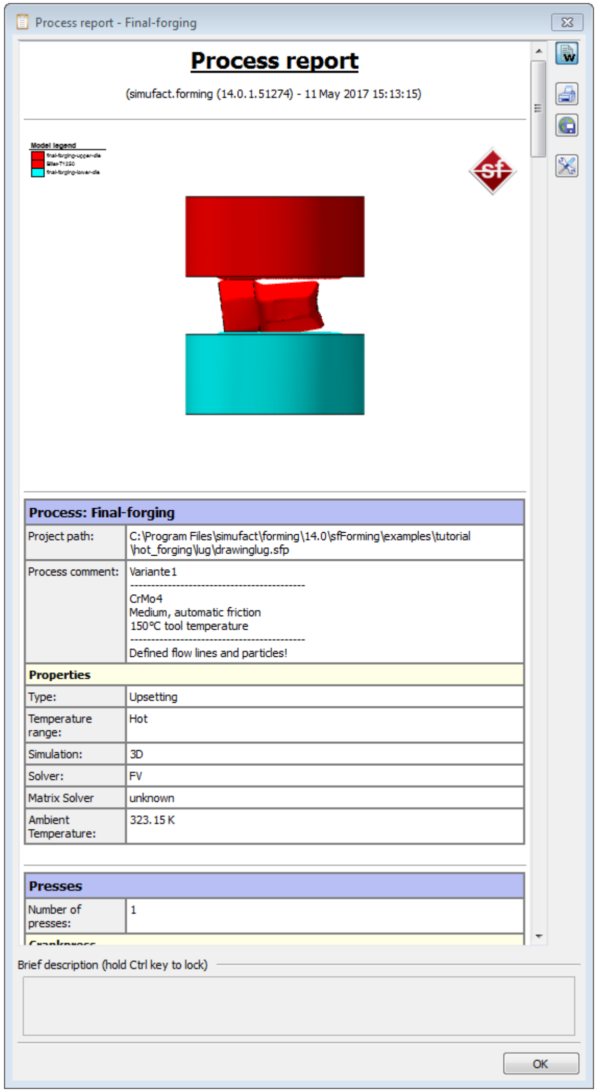
Postprocessing

Documenting your efforts: Process reports

- Documenting your simulation work is a good habit but can be quite exhaustive.
- To support you in your documentation efforts, Simufact Forming offers the so-called Process report.
- This html-style report gathers all of the most important information about the model setup as well as the results of the simulation and creates a tabular overview.
- You can control what information should be written and what should be omitted.
- Furthermore you can add snapshots of the result view to the report and add your own notes to them.
- The comments from the comment box in the process selection dialog will be in the report as well.



To add snapshots to your report just use the context menu in the result view and select Add to process report.

You can edit these snapshots later. You can rearrange them, delete them or edit their description.

You can print the report or save it as an .html file. You can comfortably view them with any web browser!

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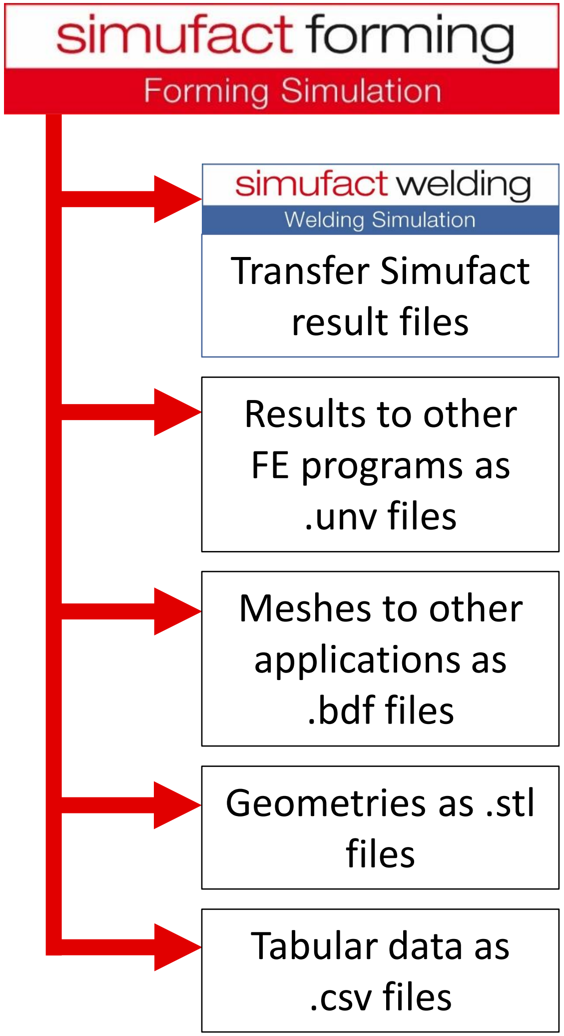
Postprocessing

Exporting results from Simufact Forming

- Simufact Forming offers multiple options to transfer simulation results to different programs for further processing.
- By default, Simufact Forming writes the results in its own proprietary file format. (see Infosheet 'ExtractSimulationResultsFromArc')
- You can import these result files into Simufact Welding to append a welding simulation to your forming simulation.
- If you want to use non-Simufact software, you can use the UNV interface.
- You can export selected results (of FE simulations) as a .unv file which can be read by most FE programs.
- Furthermore, you can export geometries as .stl files, meshes as .bdf files as well as most tabular data as .csv files.
- 2D contours created with the clipping tool can also be exported in the .igs format.



The .unv export is only available for FE results!

FE results with inside coarsening should not be exported as .unv files as the used tying conditions are not exported and the mesh would be corrupt. You can deactivate the inside coarsening in the meshing dialog!

.unv files as well as .bdf files can also be imported to Simufact Forming via the object catalog: **Geometry > Mesh from file**

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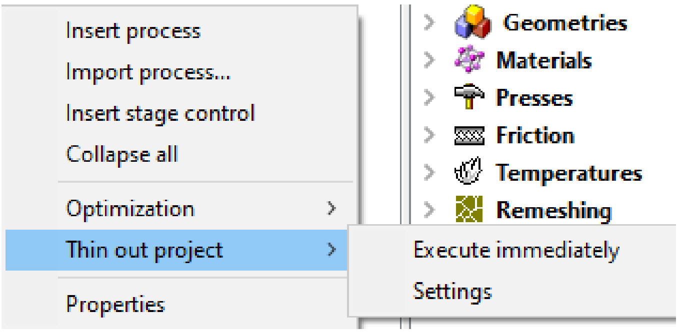
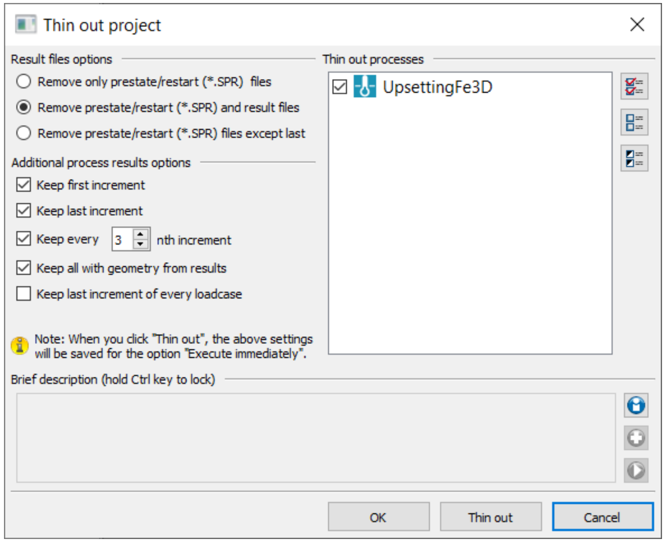
Postprocessing

Result data management

- Storing all results of every completed simulation will require a high amount of disk space.
- The amount of required disk space depends on the number of elements and the output interval frequency and can therefore rise very fast.
- The result data can be managed within Simufact Forming with a right-click on **Project > Thin out project**.
- In the settings dialog, the user can define which data should be kept and decide how *.spr files should be treated.
- Please be aware, that any removed result can’t be restored without rerunning the simulation!





Thin out settings are saved for the user.

If the settings are already defined, the user can thin out immediately.

The additional process result options are applied and any spr/result file which does not match the defined options will be removed.

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Advanced modeling techniques

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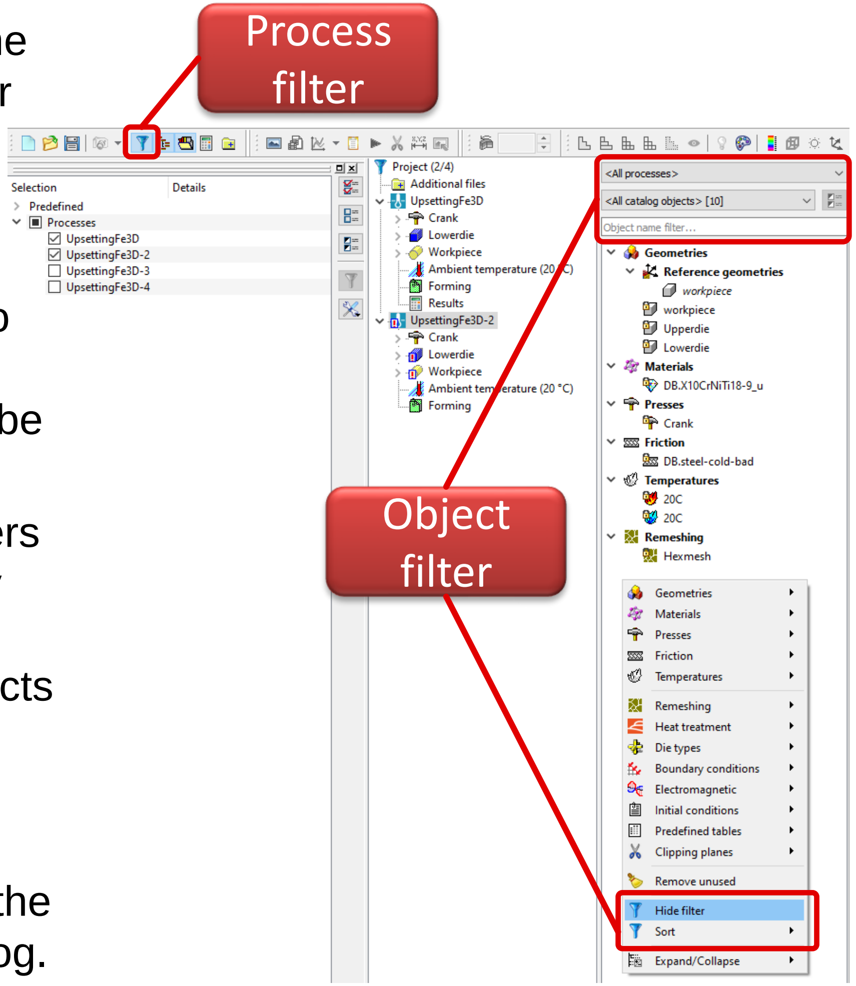
Advanced modeling techniques

Keeping an overview in big projects

- Simufact Forming provides some comfort functions to keep bigger projects nice and tidy.
- The key are the different filter functions.
- You can use the process filter to hide processes that clutter the project but are not yet ready to be deleted.
- Furthermore, you can apply filters to the catalog to hide/show only certain objects. E.g. show only press objects or show only objects assigned to a certain process.
- To quickly clean up a cluttered object catalog you can use the Remove unused command via the context menu entry of the catalog. This removes all objects which are not assigned to any process.



Note the change in the project icon at the top of the process tree when a filter is active. It shows how many processes are visible.

You can sort the items in the object catalog either by their name, their modification date or in reverse by clicking on the Sort entry in the object catalog context menu.

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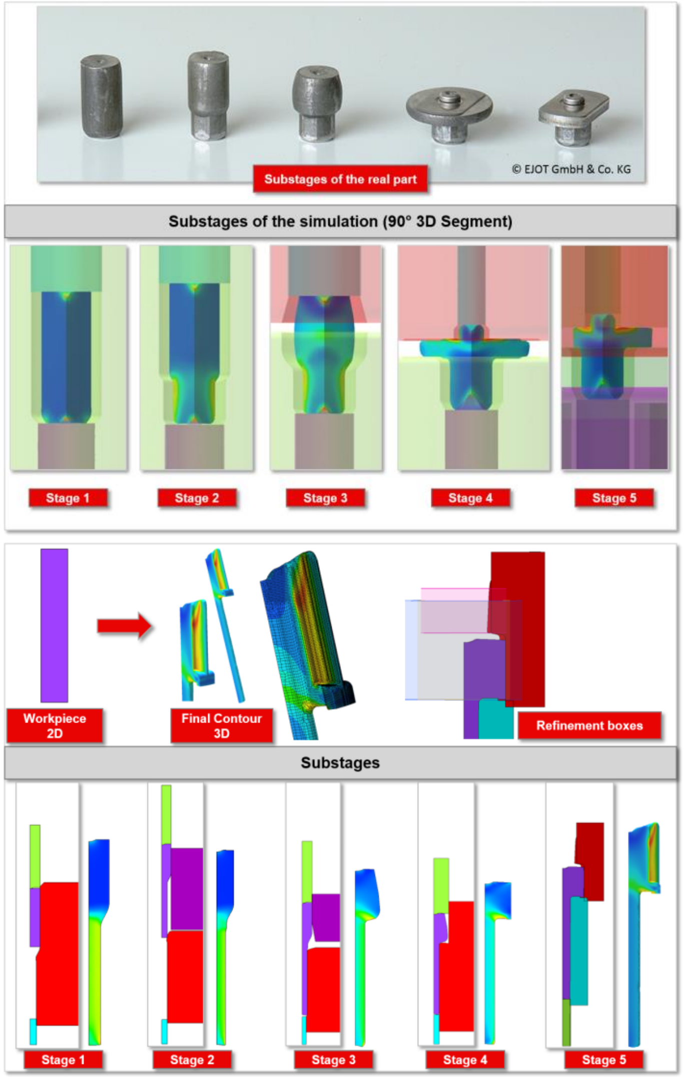
Advanced modeling techniques

Creating and automating process chains

- A majority of forming processes requires multiple stages until the product has its desired shape.
- To accomplish this, Simufact Forming allows you to extract results from every process and use these for the next stage of your process chain.
- You can do this manually or set up a so-called stage control.
- The stage control connects the single stages of your forming process chain. It automatically transfers the results of the previous stage to the next one and runs the simulation.
- You can set up complete multi stage processes and start the whole chain with a single click.



By default, the position of the workpiece is not changed when transferred from one process to the other.

You can manually define translations and rotations between every stage.

The stage control also supports 2D > 3D transitions!

You can find many processes utilizing the stage control feature in the Demos&Examples. For example in the category **Cold forming > Multistage processes**!

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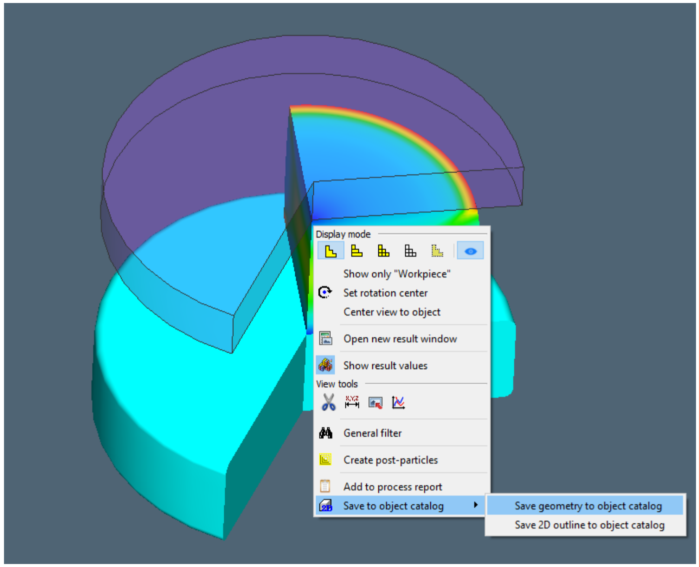
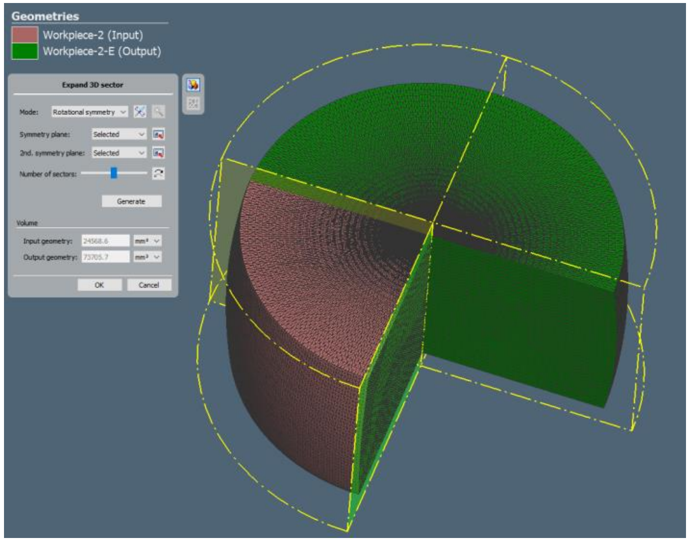
Advanced modeling techniques

Expanding of axisymmetric Geometries

- 2D and 3D axisymmetric Geometries can be expanded around the symmetry axis.
- One option is the ‘Expand results’ button in the result toolbar. The geometries and the results get expanded by a certain degree.
  - The expansion angle can be specified in the ‘Result expansion’ tab in the settings.
  - This is possible for 2D and 3D results.
  - The expanded geometry can then be saved in the object catalog.
- Geometries can also be expanded directly in the object catalog via right-clicking → ‘Modify geometry’
  - For a 3D sector select ‘Expand 3D sector’
  - For a 2D geometry select ‘Rotate axis to 3D’





💡 Results also get expanded if present.

💡 To import a geometry with results, right-click in the object catalog and select ‘Geomatries‘ → ‘From results‘

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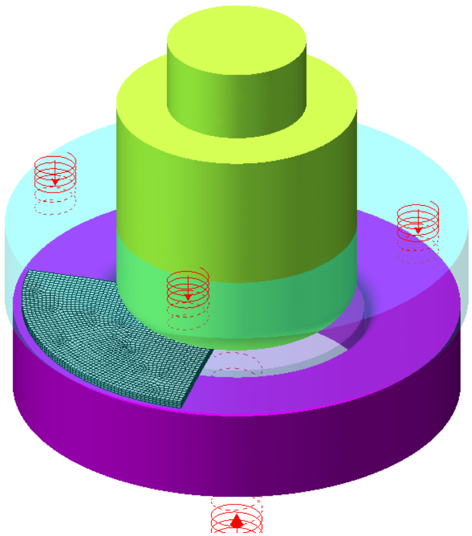
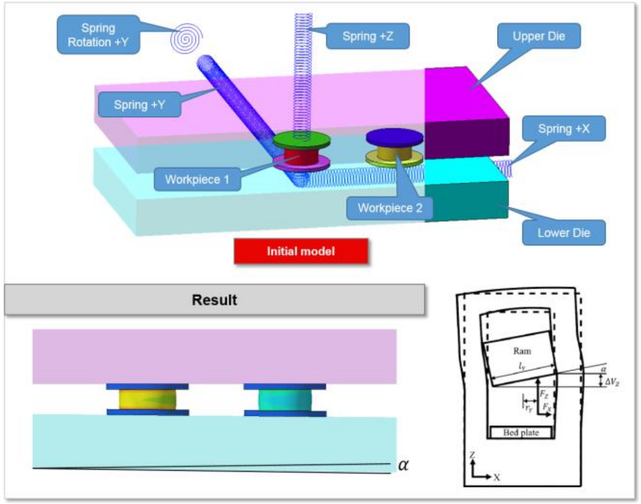
Advanced modeling techniques

Spring-loaded dies and other applications of springs

- Generally speaking, springs in Simufact Forming are objects that apply a force on a body.
- The applied force is defined by an initial force, a spring stiffness and a direction.
- Two types of springs are available:
  - Die spring: They are typically used to model spring-loaded dies in forming processes. They can apply forces in global coordinate directions and have a fixed range of deflection.
    Typical application: Blank holders
  - Generic spring: They apply forces on a die in the global coordinate directions or along the axes of a local coordinate system. They can apply rotational torques or use a special stabilizing function. However, you cannot define a maximum deflection.
    Typical application: Press elasticity





When using springs together with a segment symmetry in your model you should make sure, that the option Adapt forces and energies to workpiece symmetry is checked in the forming control!

To use local coordinate systems you will need a so-called die insert!

Generic springs are not available in FV simulations!

For detailed information about the topic of springs please see the respective chapter of the Application tutorial!

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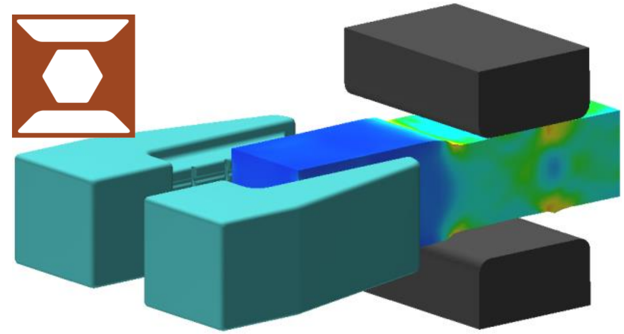
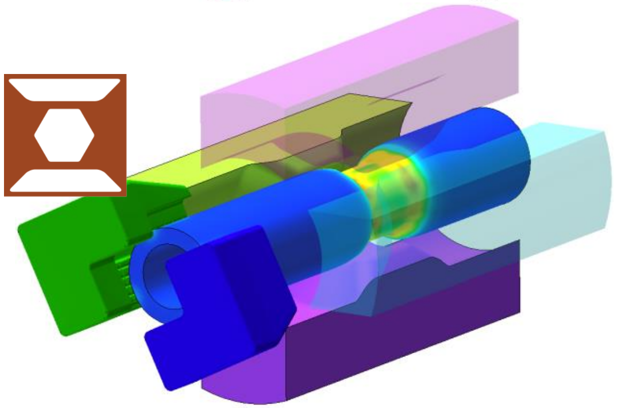
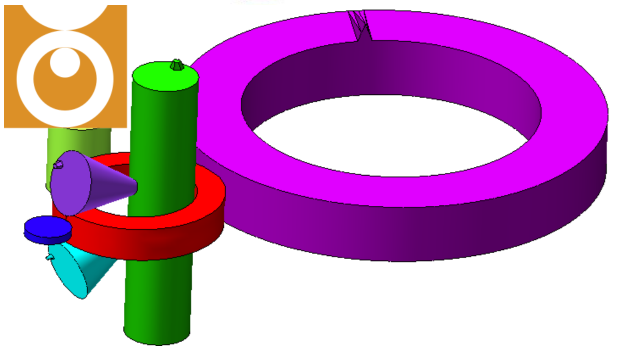
Advanced modeling techniques

Non-standard die movements: table presses, kinematics

- Typically the default forming and press direction in Simufact Forming is the –z-direction.
- If you need to deviate from that you can use the so-called table press.
- The table press can move dies in any global coordinate direction as well as prescribe rotational movements.
- Combined with a local coordinate system and a die insert, the table press can prescribe movements in any possible direction.
- There are more complex forming processes however which require specifically developed kinematics. For example:
  - Open die forging (Cogging, radial forging, shell forging, etc.)
  - Ring rolling (RAW, MERW, …)
- These are accessible through the relevant application modules.







For more information about table presses, rotation axes and local coordinate systems please see the relevant part of the ring rolling chapter in the Application tutorial!

You can find specific information about the kinematic modules by clicking Open tutorial in the relevant Demos&Examples model!

You can create your own kinematics using the so-called user-defined kinematics. Please see the Scientific tutorial for more information!

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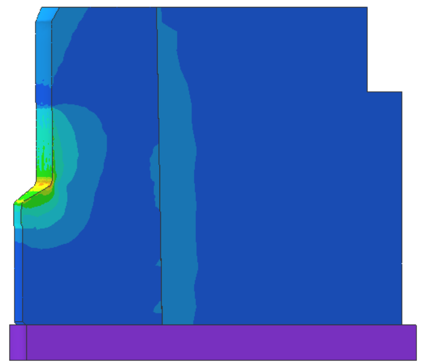
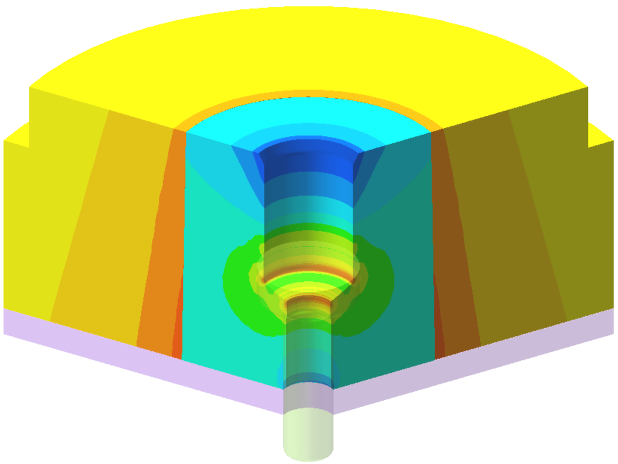
Advanced modeling techniques

Die load analysis

- Simufact Forming offers extensive possibilities to simulate the load on your dies.
- You can calculate many determining factors which might reduce the lifespan of your dies or the accuracy of your product. Such as:
  - Contact pressure
  - Internal stresses
  - Elastic deformation
  - Abrasive die wear
  - Temperature
- Simufact Forming allows decoupled die load analyses where the simulation of these loads and the simulation of the actual process are separated. This increases simulation speed and efficiency significantly.
- Calculation of die loads is also used to predict the strength of reinforcements, which is state of the art for most cold forming applications.





For complete die load analyses you need to use deformable bodies for the dies.

Contact pressure and die wear can be calculated for rigid dies as well.

Fully coupled analyses come with very high computational costs. Decoupling them saves a lot of ressources.

See the „Die wear, die load and reinforcement“ tutorial chapter for extensive information about this topic!

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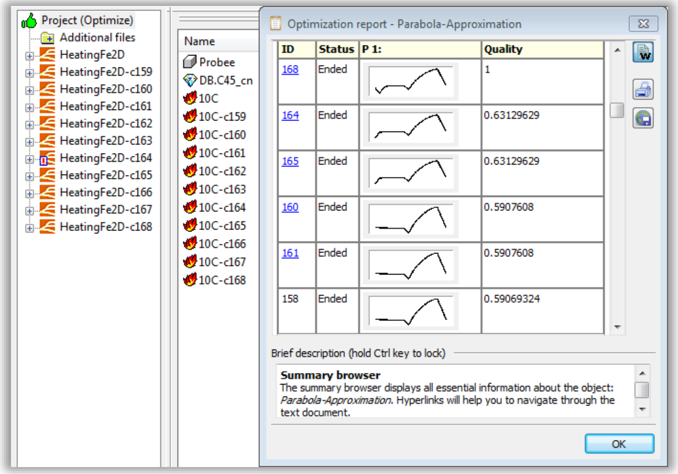
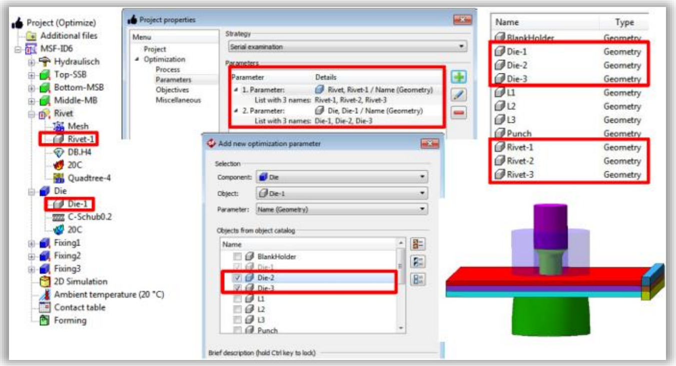
Advanced modeling techniques

Optimization: Parameter identification, Geometry variation

- Calibrating and optimizing simulation parameters can be a very time-consuming task.
- Simufact Forming offers an optimization feature which can automatically create various variants of processes.
- The two main features are:
  - **Parameter identification:** Simulation parameters such as the friction coefficient or the heat transfer coefficient are varied over the course of numerous simulations to approach a defined goal (e.g. workpiece temperature). Different optimization strategies are available.
  - **Geometry variation:** Simufact Forming can exchange geometries over the course of multiple simulations and evaluate the result quality.





You can find some examples of optimization cases in the Demos&Examples under **Tutorial > Optimization**!

Please find more information about the optimization possibilities in the respective chapter of the Application tutorial!

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Troubleshooting

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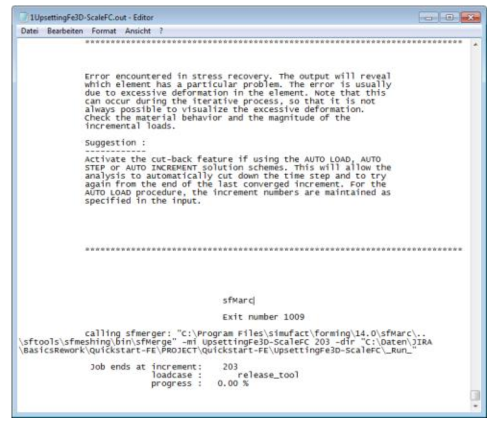
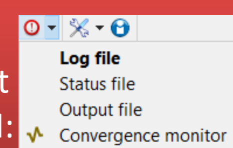
Troubleshooting

Exit codes

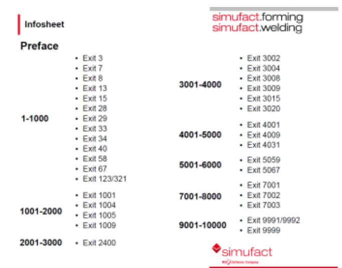
- When the simulation ends, the solver will write an exit code at the end of the .out, .log and .sts file.
- Along with the exit code a message will be displayed describing the reason for the end of the simulation.
- A successfully finished simulation will end with exit code 3004.
- All other exit codes indicate an error during the simulation which caused a premature stop.
- In case of an unexpected solver crash no exit code can be written.
- In addition to looking up the exit code in the infosheet you may want to search for error messages in the .out and .log files.
- Therefore simply open these text files in a text editor and search for the "error" keyword.



Access the solver output from the GUI:



Please see the respective infosheet for a complete list of all exit codes and their description. There you will also find some advice on how to resolve the issue.



You can find every infosheet via **Help > Infosheets > Simufact Forming**. This one is called Exit_codes_en.pdf.

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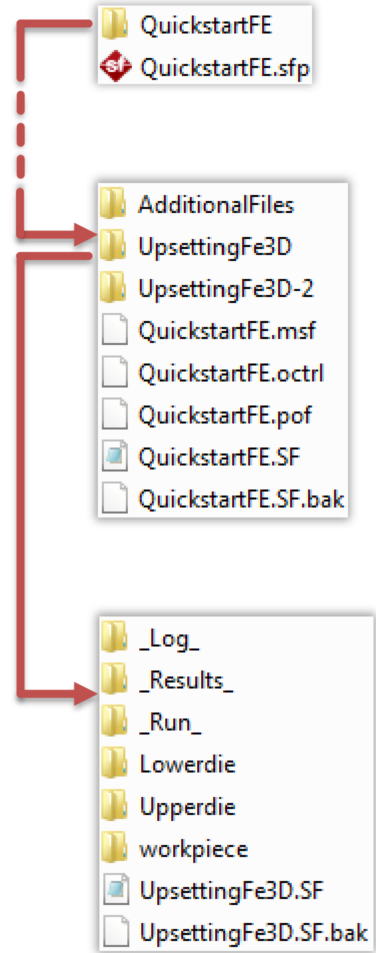
Troubleshooting

File structure: working and result directories

- A complete Simufact Forming project always consists of both the .sfp-file and a folder with the same name.
- This folder contains all of the information about the project.
- In PROJECT/*project name*/… you will find the single processes of your project as well as the AdditionalFiles folder.
- A process folder contains, amongst other, the _Log_, _Results_ and _Run_ directories.
  - The _Run_ directory contains all information that is necessary for the solver to be able to calculate the model.
  - The _Results_ directory contains the result files after they have been imported by the GUI.
  - The _Log_ directory contains a .log-file which records all actions of the GUI during the calculation.



If you move a project on your hard disk or want to pass it on to someone, make sure to always keep the project folder and the corresponding .sfp file together!

If you are in contact with a Simufact support employee you might be asked for the contents of your _Run_ directory.

The _Run_ directory contains amongst others the .sts, .log and .out files as well as the .dat-file.

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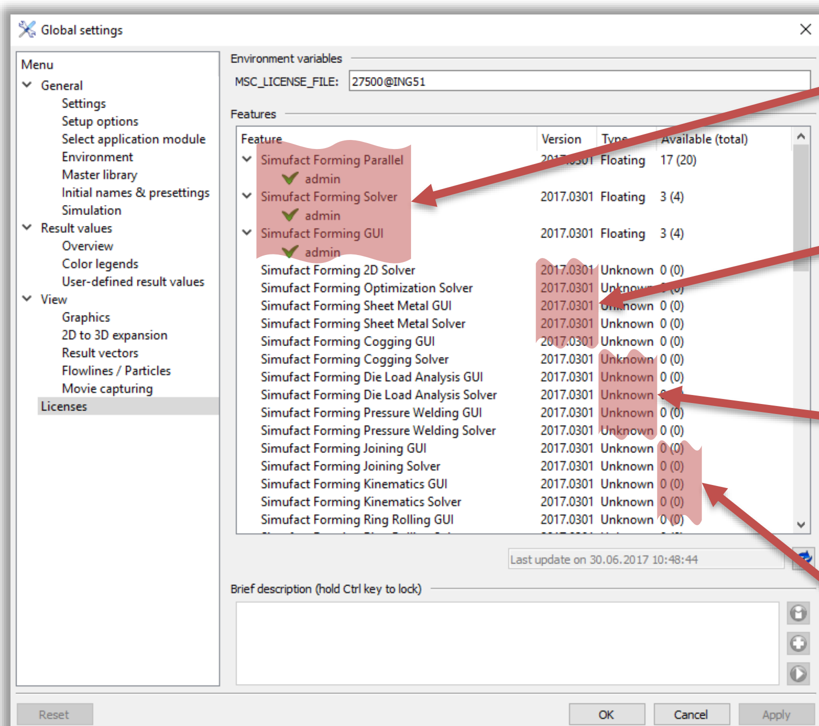
Troubleshooting

Licensing

- Licence server (service) provides the license → MSC Licensing.
- It comes as a separate download, installation and documentation.
- Environment variable MSC_LICENSE_FILE=port@server is generated during the installation process and can be changed later via your OS.
- You can check your license status in the Simufact Forming GUI.



From Simufact Forming:
List of all possibly available license features.

From Simufact Forming:
Required maintenance end date (or later) of the license version.

From the license server:
Type of a valid license – all invalid, expired or not available licenses show the type "unknown".

From the license server:
Number of currently and overall available licenses as well as the users who are using them.

You can check your license situation via **Extras > Options > Global settings > Licenses**.

If the program does not start due to a missing license you can access this page by clicking the details button of the error message.

If the shown dialog page does not open or opens very slowly, the license server is probably not available.

For troubleshooting with the licensing please see the MSC licensing documentation!

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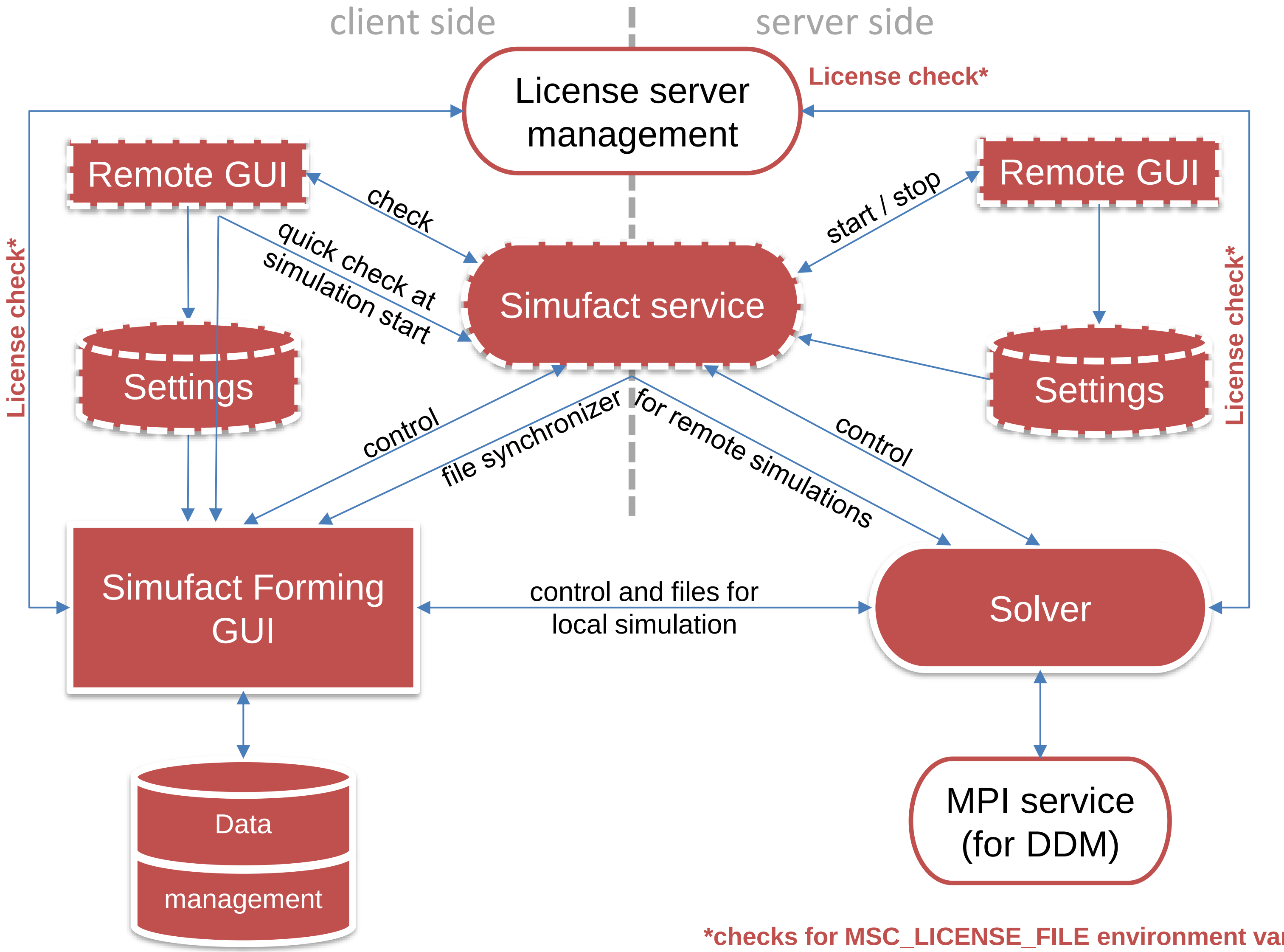
Troubleshooting

System environment when using Simufact Remote



*checks for MSC_LICENSE_FILE environment variable

Parts of the environment with the dashed outline are only needed for remote calculations.

If you encounter a persisting problem with any Simufact product, feel free to contact our support team. For more information please see the support section on http://hexagonmi.com/simufact !

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Simulation quality

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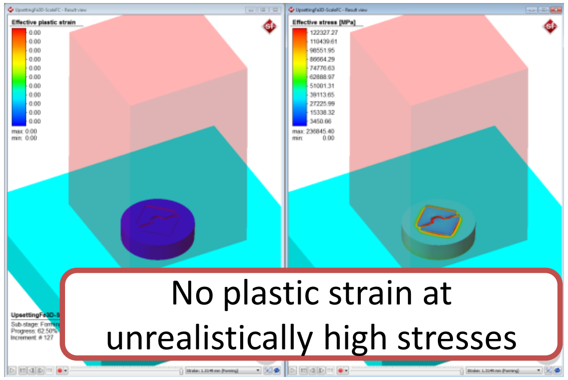
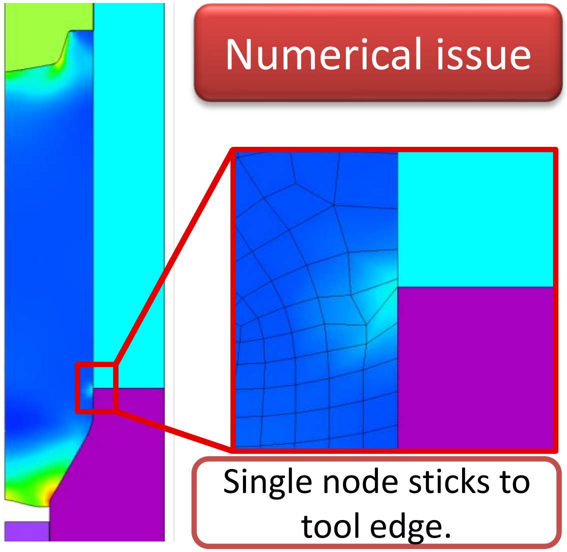
Simulation quality

Checking for plausibility

- A simulation is the solution of a mathematical problem.
- The solution achieved can only be as accurate as the input that was used to describe the problem.
- Wrong input data can have obvious effects on the simulation but they might be more subtle as well.
- Simufact Forming tries to ensure that the input data is correct (e.g. automatic unit conversions and model checks).
- However you should always critically check your results:
  - Are the tool movements (velocities) correct ?
  - Is the material flow realistic?
  - Are the forming forces or effective stresses in a reasonable range?
  - Are the temperatures as expected?

Incorrect flowcurve data





Don‘t just check the final result. Some errors may only be visible during certain stages of the process.

Use the THS plot to check tool movements, forming forces or the workpiece volume.

Apart from wrong input data numerical problems are possible. Check the mesh for deformations or dramatically increased local result values (so-called hotspots).

Use the .sts-file to check the convergence behavior of the simulation

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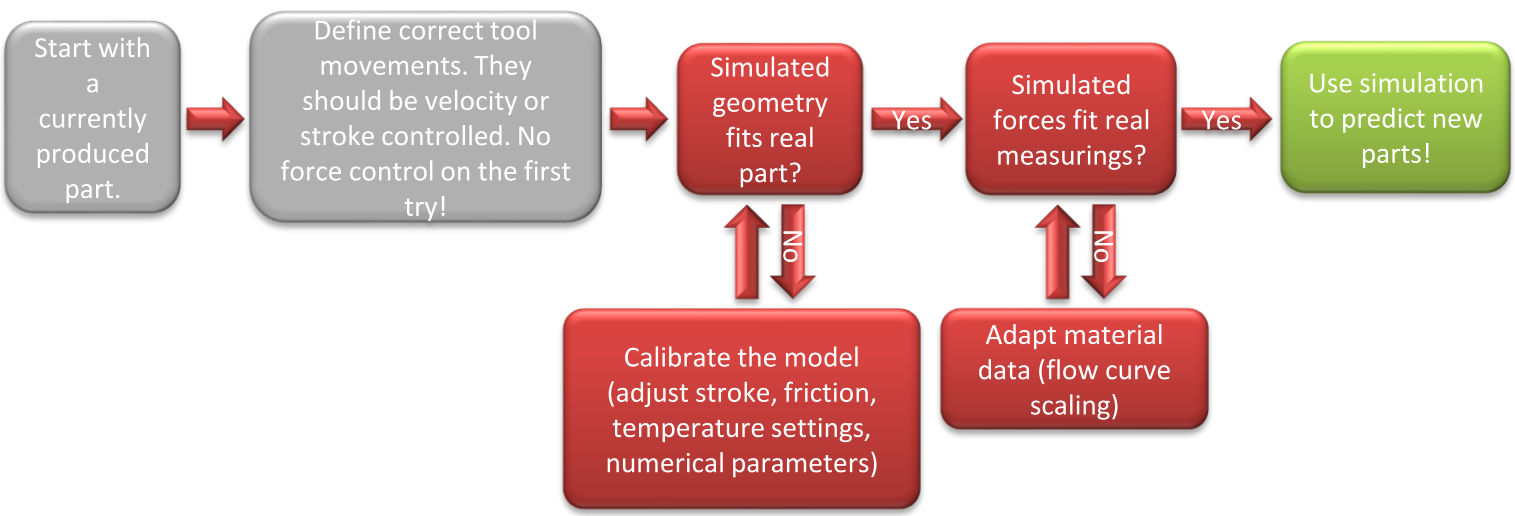
Simulation quality

Calibrating the simulation

- When setting up a simulation model a lot of assumptions are made about all the boundary conditions and input parameters that are used.
- To achieve the best possible simulation results you should calibrate these parameters so that the results fit the reality as well as possible.
- Best practice is to start your simulation efforts with a part that is currently produced by your company and of which the production process is running without bigger issues.
- Calibrate your simulation model in such a way that it fits this real part.
- Then you can use these calibrated parameters for your future simulations and achieve reliable results!



Calibrating your simulation is import to achieve reliable results.

It is not recommended to directly start your simulation efforts with a problematic part that is causing issues during production. Use a well running part to calibrate the simulation first!

You can do sensitivity studies to see which parameters have a negligible effect on your process and which are crucial!

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User customization

well formed

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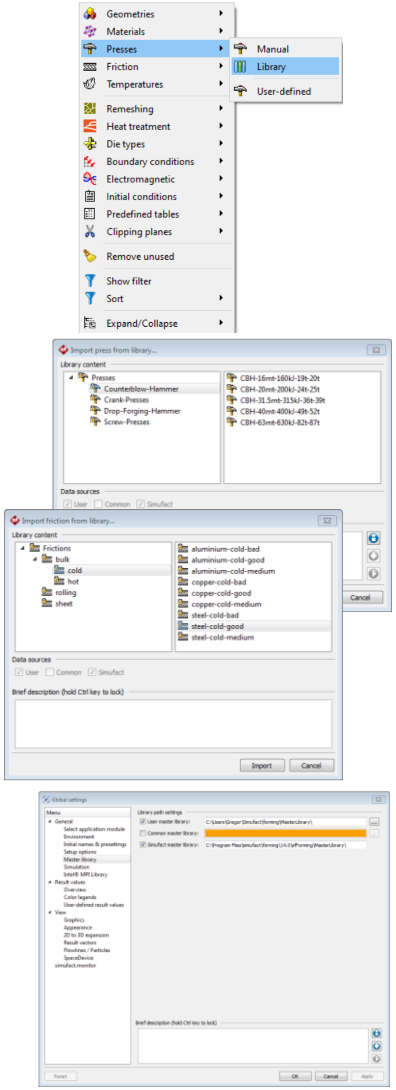
User customization

Employing the library feature of Simufact Forming

- Simufact Forming does not only come with an extensive material library but offers more libraries for e.g. friction objects or press objects.
- The settings for these objects are based on literature data or our experience.
- In addition to these, you can create your own libraries.
- The library feature follows a certain structure:
  - Simufact master library: Comes with Simufact Forming. You cannot change the items, but they might be changed with new versions of Simufact Forming.
  - User master library: A library that can be filled with objects by and for the user, so they are readily available for new projects.
  - Common master library: A shared library between multiple users (usually a network drive). Commonly used objects (e.g. presses) can be stored here and every Simufact user in the network has access to them.



Adding objects from a library to the object catalog creates copies of the object which are independent from the original library entry.

You can create copies of items in the Simufact master library if you want to edit them.

New versions of Simufact Forming will not affect the user and common master library!

You can find the library settings in the Global options. Please see the infosheet linked in the dialog for further information!

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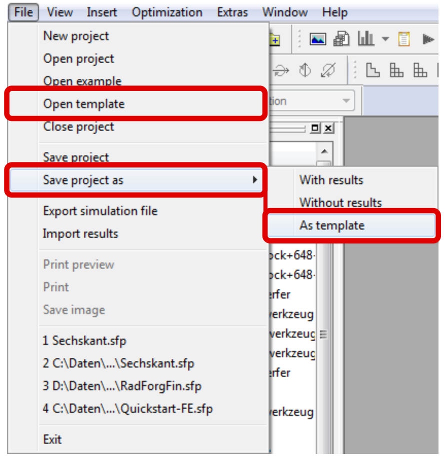
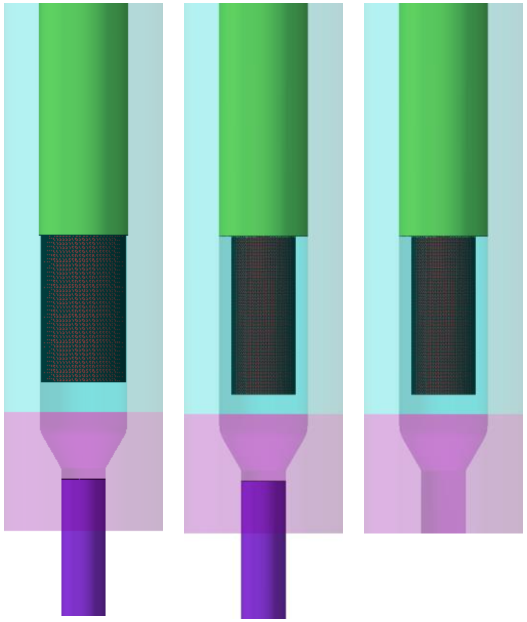
User customization

Facilitate repetitive tasks with project templates

- Often times you don’t create a completely new project but rather change smaller aspects of already existing ones (e.g. exchange a geometry).
- To speed up this process Simufact Forming offers the possibility to work with project templates.
- You can save every project as a template via **File > Save project as > As template**.
- The project is saved without results in the template directory of Simufact Forming.
- You can open a template via **File > Open template**.
- You can now adapt the project to your needs, save it under a new name and run your simulation without having to set up everything again.





Please note that the template is only safe from overwriting if it is opened via **File > Open template**.

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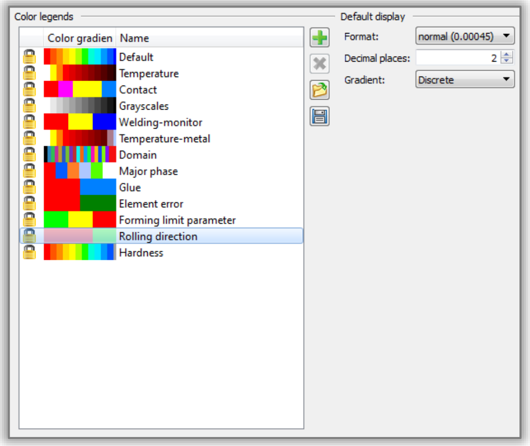
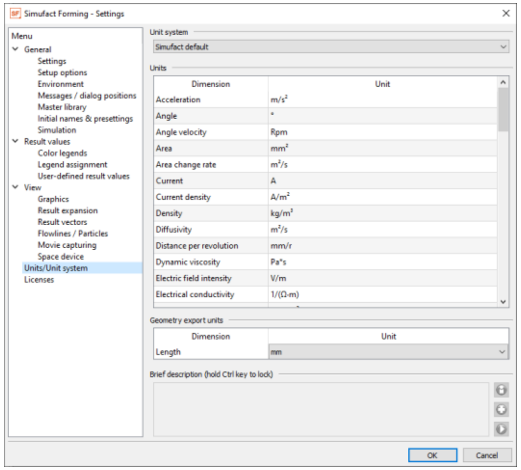
User customization

User-customizable GUI and global settings

- Simufact Forming can be customized in many aspects.
- You will find all global settings in the menu bar via **Extras > Options > Settings**.
- For example, you can choose between multiple GUI languages.
  - e.g. English, Japanese, German, Russian and more
- You can customize the content of the GUI in many aspects:
  - Define default values, for directories, color legend settings, result values or third-party programs
  - Change the appearance of the view area such as default colors, 2D to 3D expansion settings, flow line or particle display options





Most dialog pages in the global settings dialog have their own infosheet. Click the button on the bottom right for more information about the possible settings.

All settings are stored for each user under the directory `%appdata%\Simufact\simufact.forming_<version>` in the `simufact.forming.ini` and `simufact.forming_<version>.ini`. You can copy these files to a different installation to set up the same configuration.

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User customization

User-customizable unit systems

- Simufact Forming can also be individually customized to provide results in different unit systems.
- You will find unit settings in the menu bar via **Extras > Options > Settings > Unit/Unit system**
- Other unit setting combinations can be defined in the user defined unit system.
- The input and output values in Simufact Forming always have corresponding units which you can choose as you desire. Simufact Forming internally takes care that all values are in consistent units. The same Forming projects may be used by different users with different units. This is different from many general FE programs, where the user is responsible to maintain consistent units.

There are 5 predefined unit systems available: Simufact default, International system of units (SI-m system), SI-mm unit system, Imperial unit system, United states customary system

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