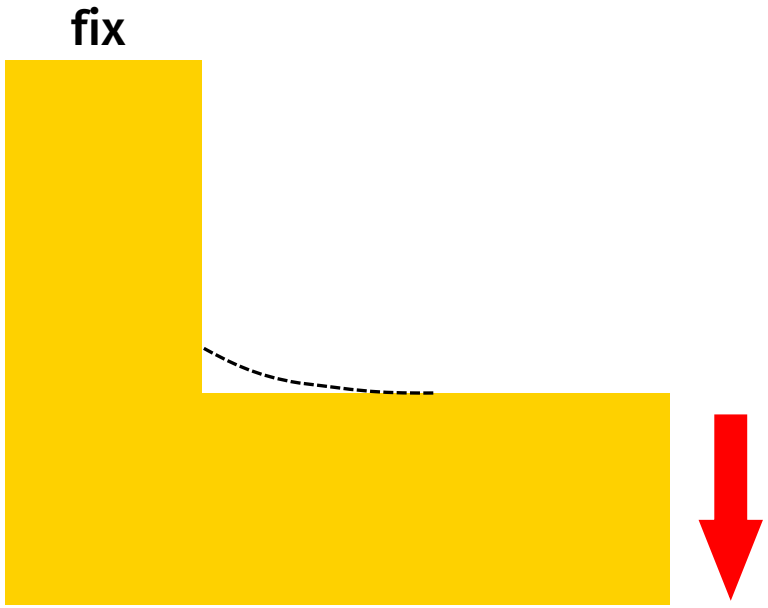
SVS FEM

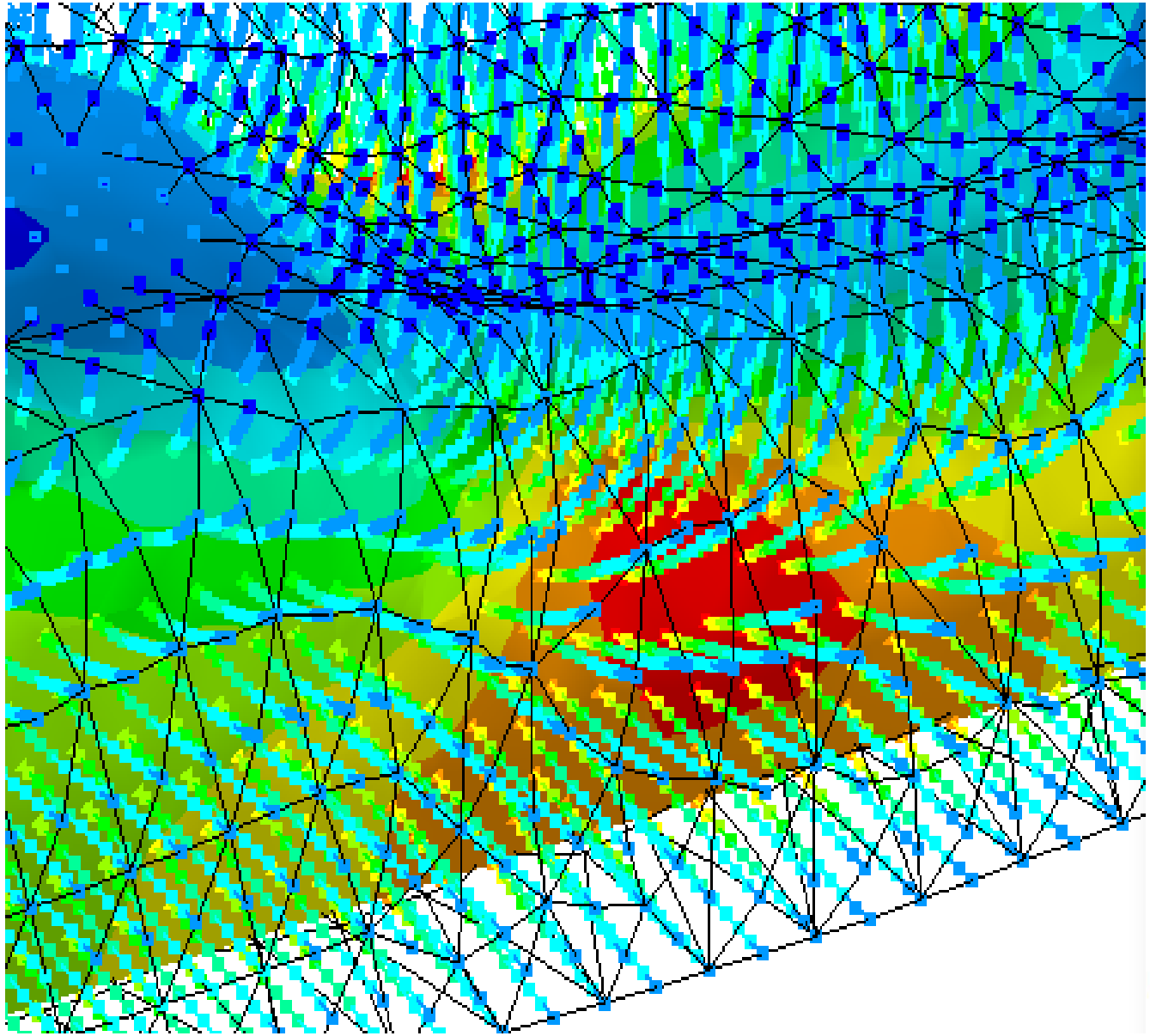
M3Opti
Shape Optimization

Jsme experti v oblasti simulací

M3Opti – BGM Method

- Biological Growth Method sculpting



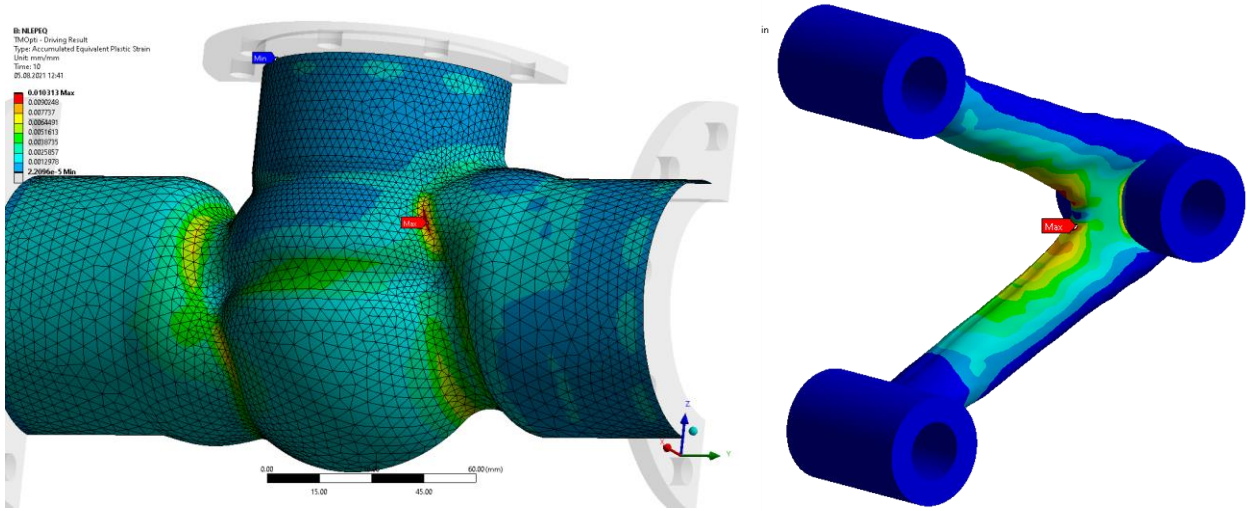


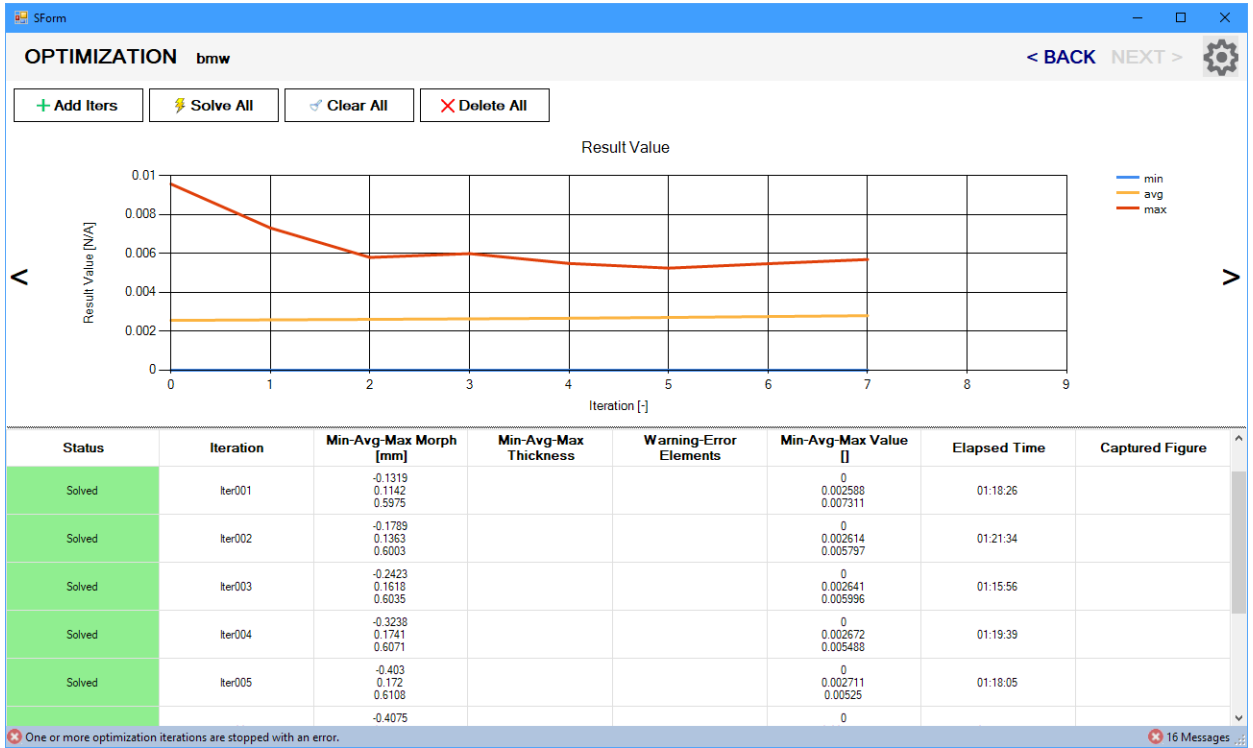
M3Opti - Capabilities

- Typical analyses examples:
  - Stress, Strain, User-defined, …
    - Static Structural, Harmonic, Spectral, Transient …
    - Thermal + Structural
  - Total Heat Flux, …
    - Steady-state or Transient Thermal
  - Accumulated Plastic Strain

- Supported features:
  - Nonlinear Material Model
  - Nonlinear Contact
  - Large deflection

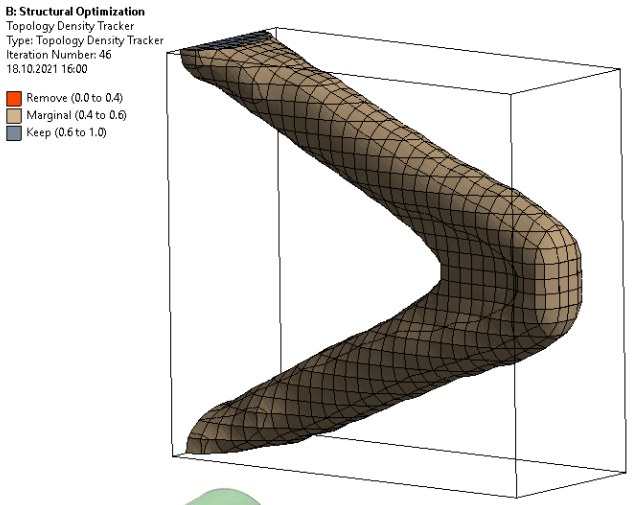
- Typical bodies:
  - Seal, Turbo Charger
  - After Topology Optimization

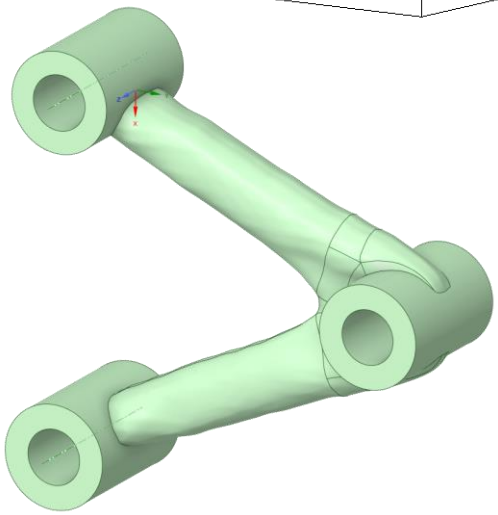


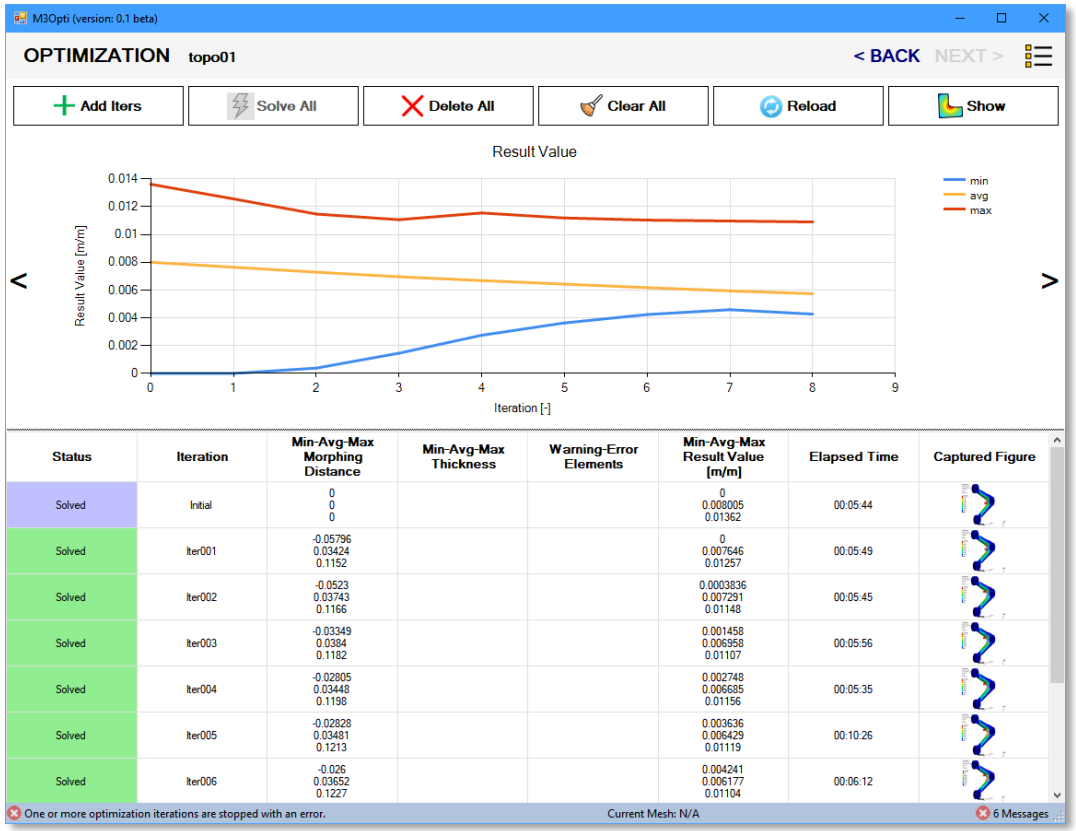


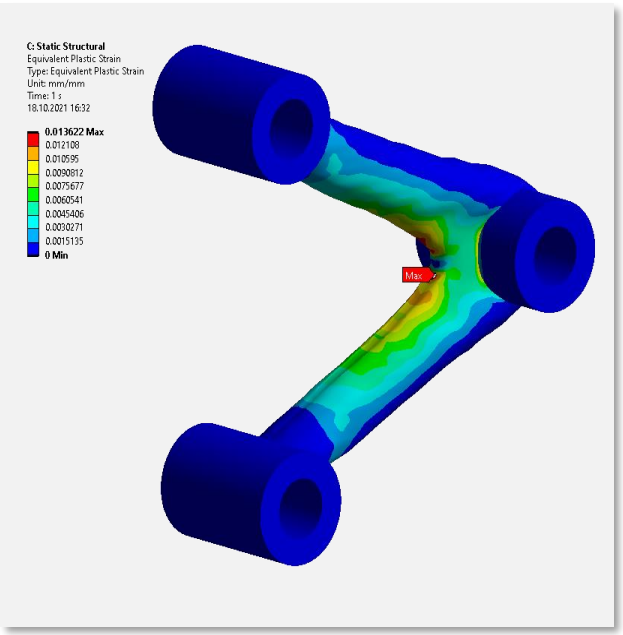
M3Opti – Example

Final step after topological optimization – improved design (all nonlinearities can be included)



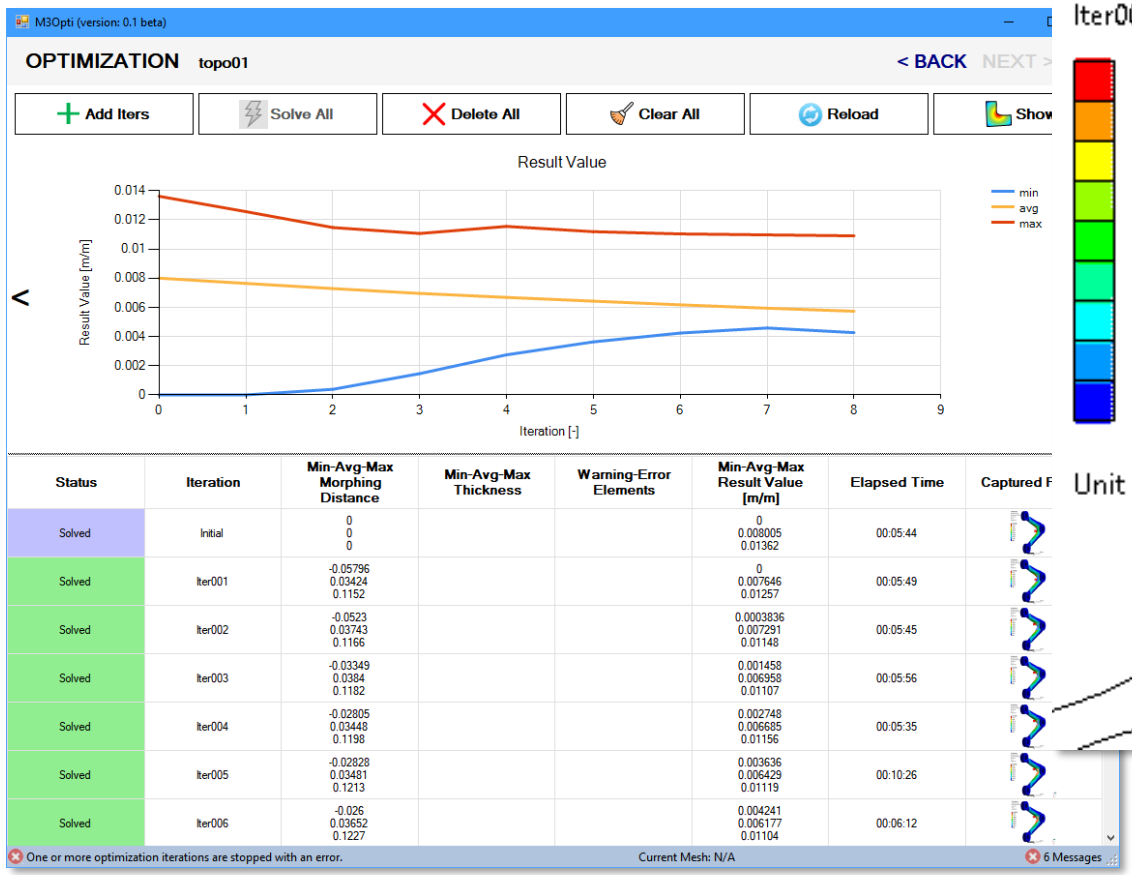


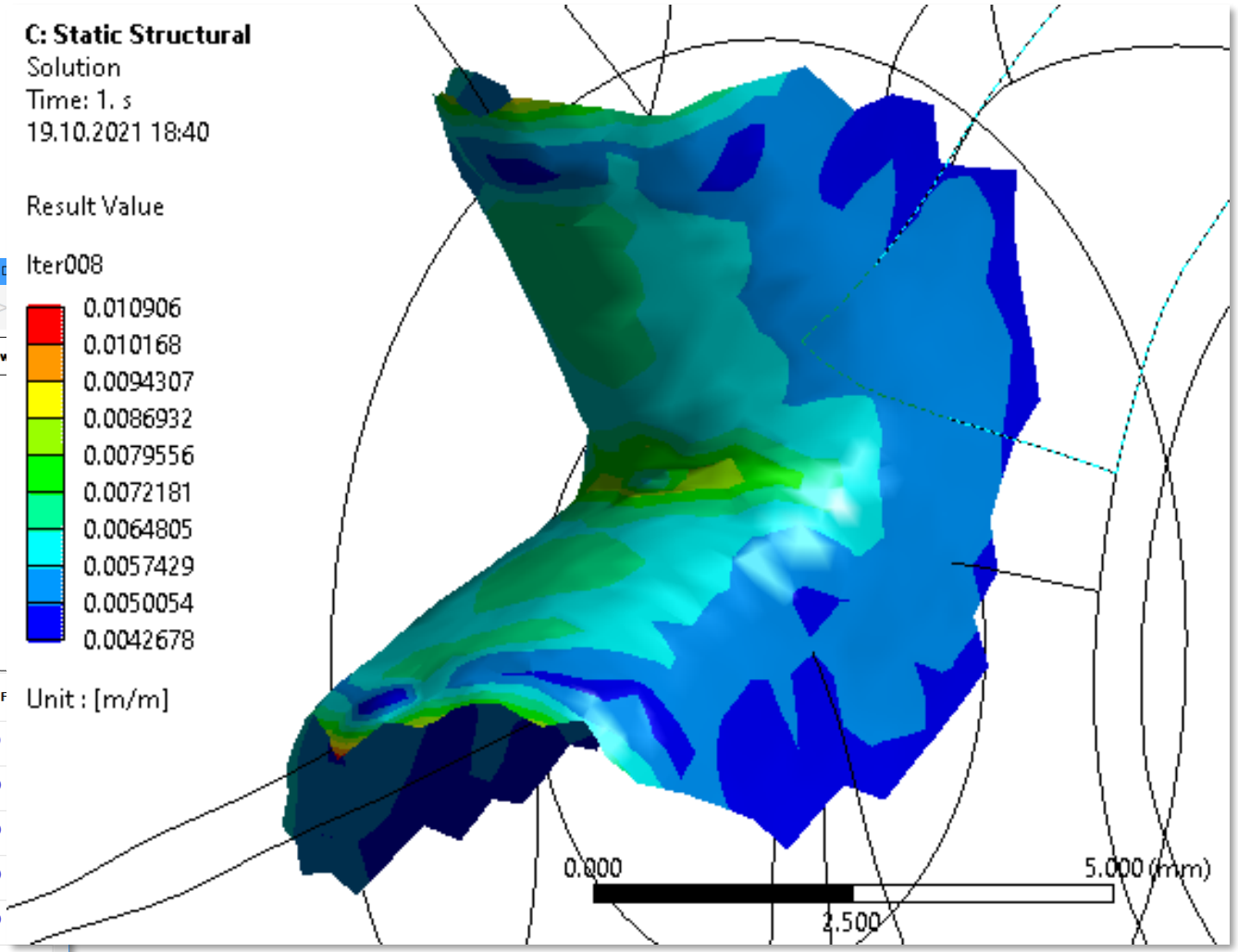




M3Opti – Postprocessing

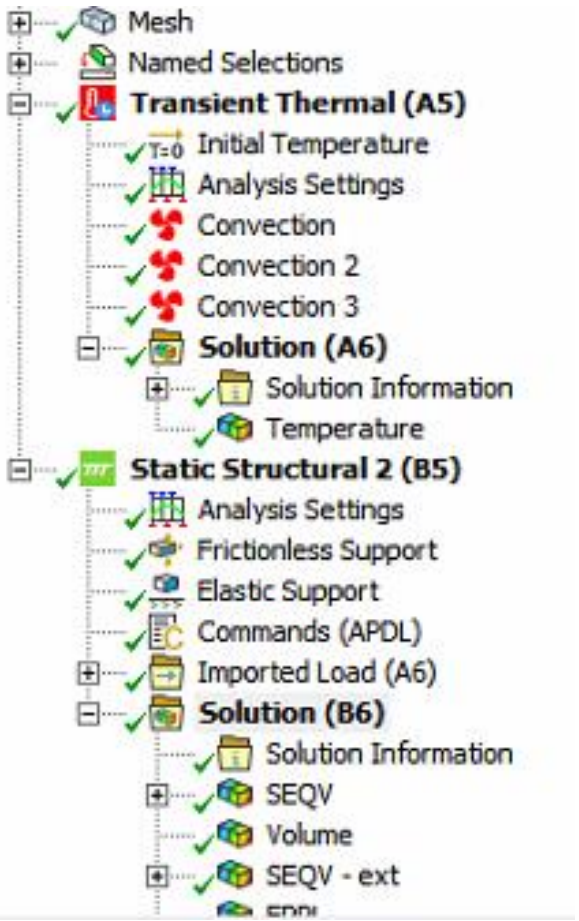
Contour results can be displayed without presented RST file. An animation can be also easily created from iteration steps.

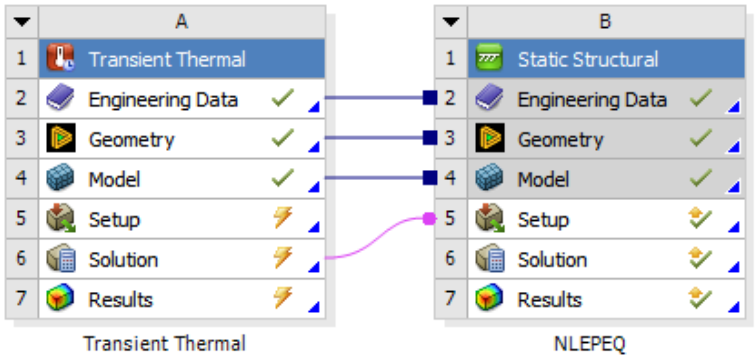


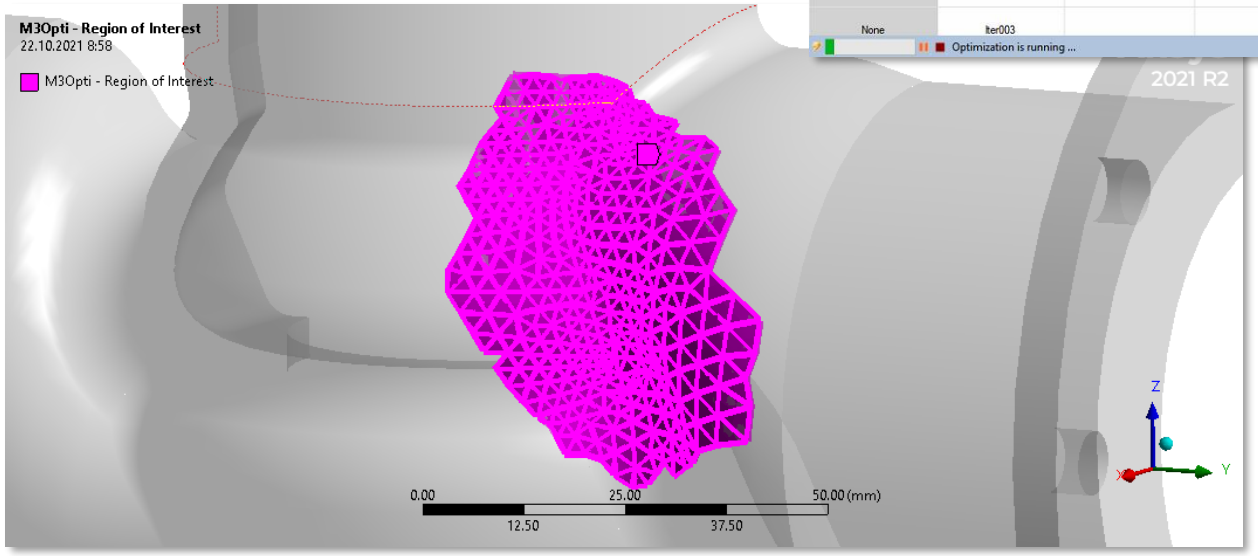


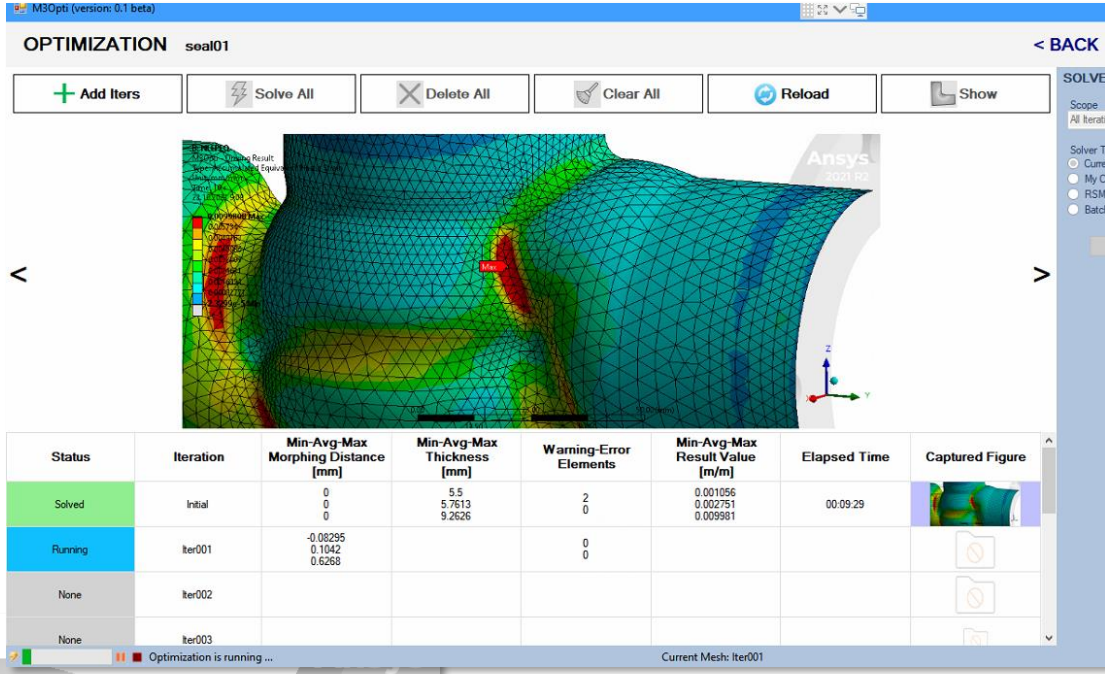
M3Opti – Example

Thermo-structural nonlinear solution of seal housing body – fatigue resistance improved in chosen parts.



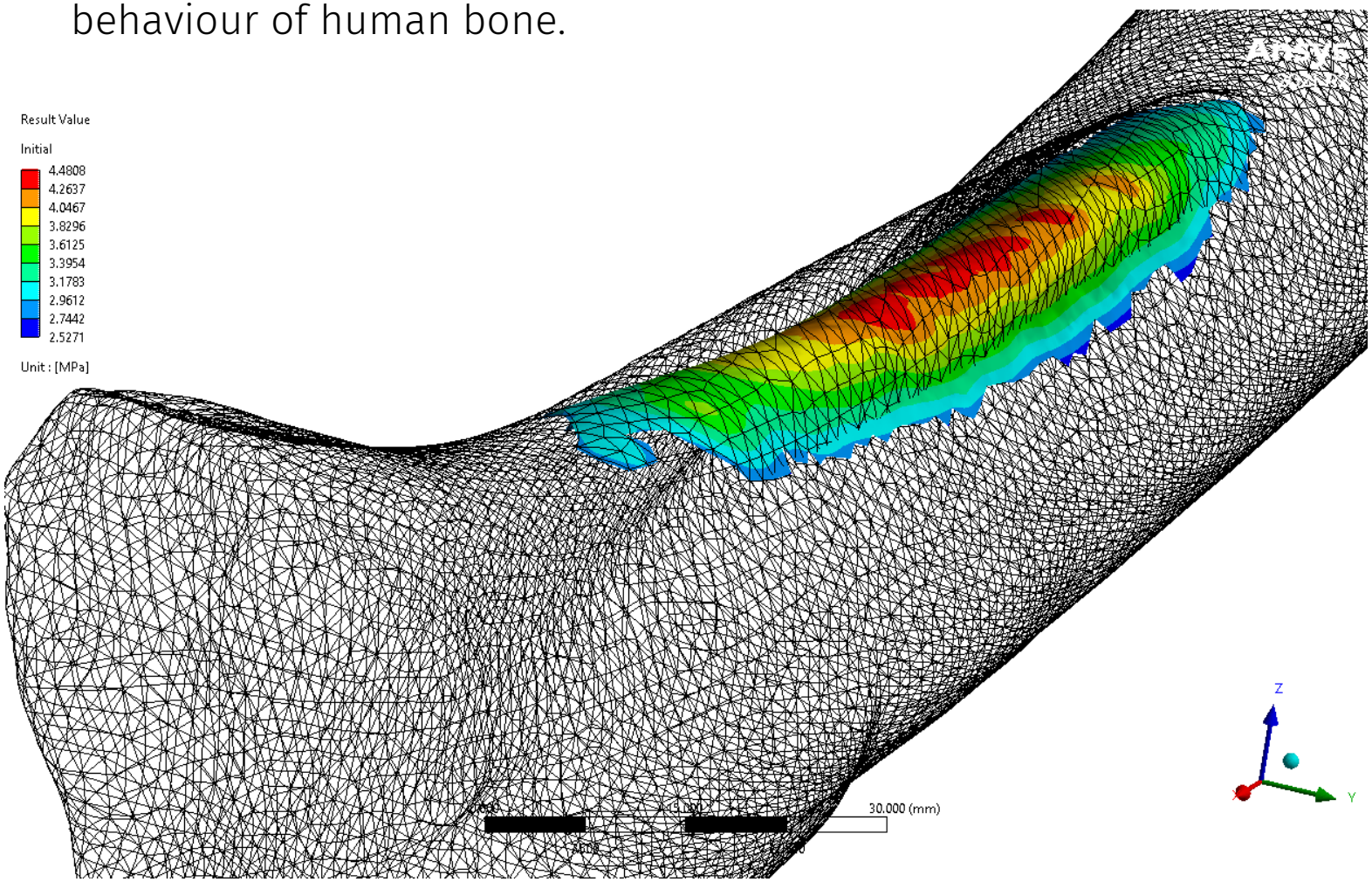


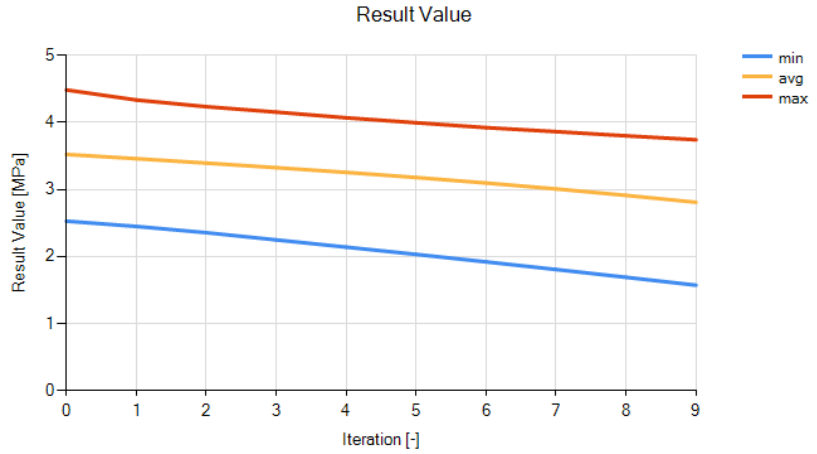


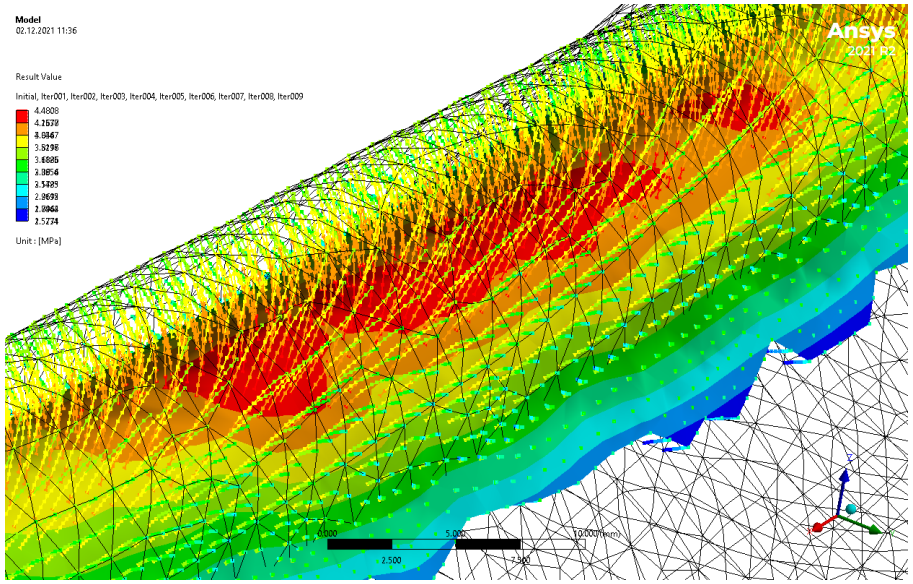


M3Opti – Example

Improvement stress
behaviour of human bone.

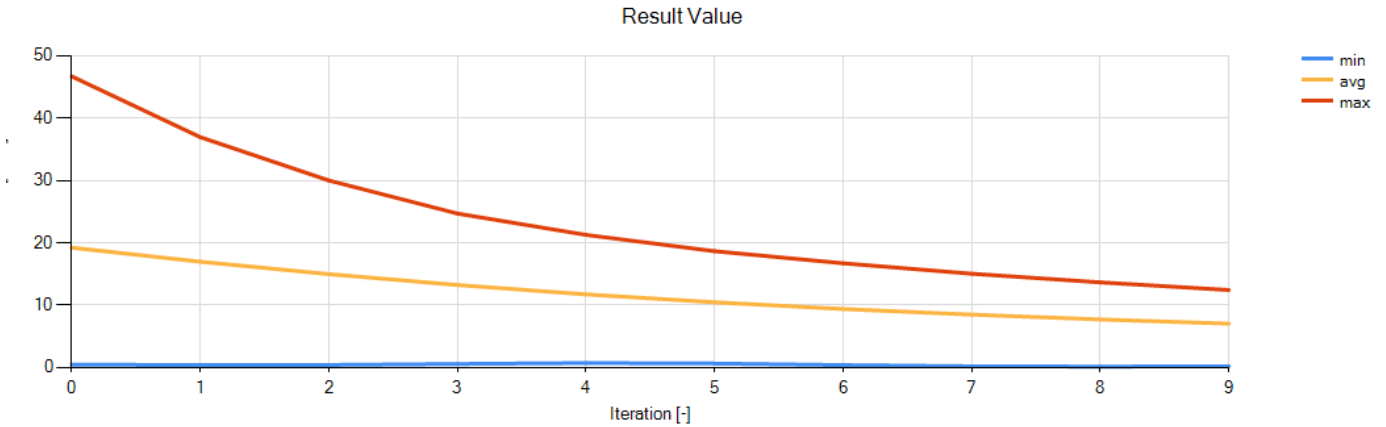


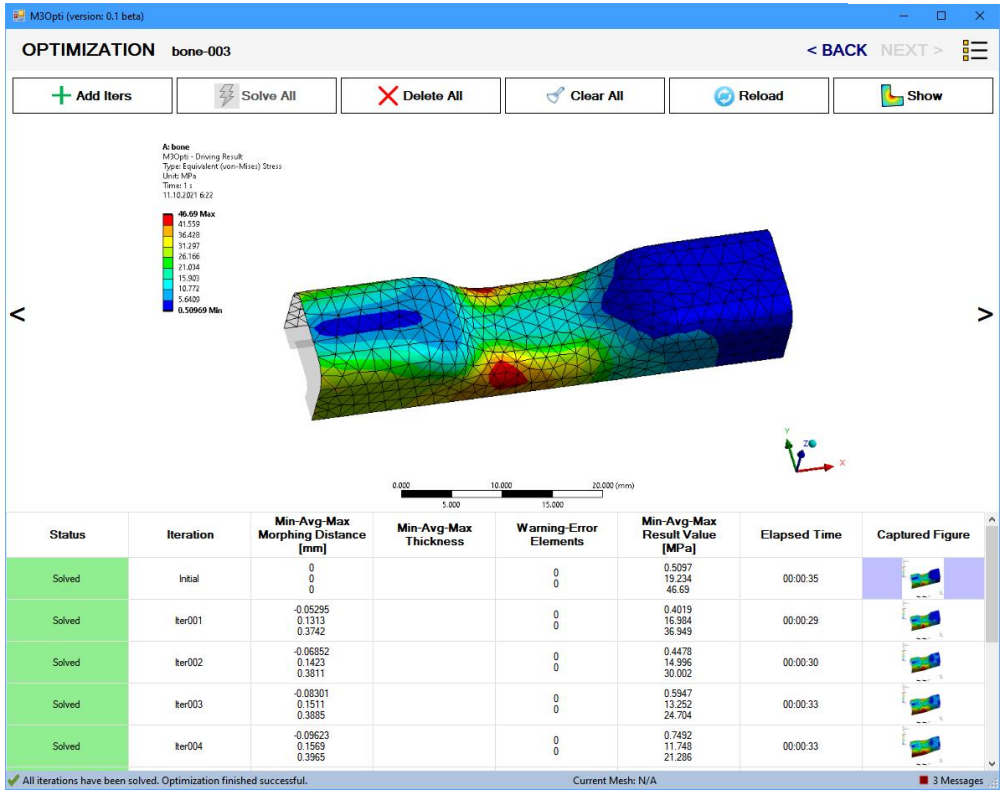


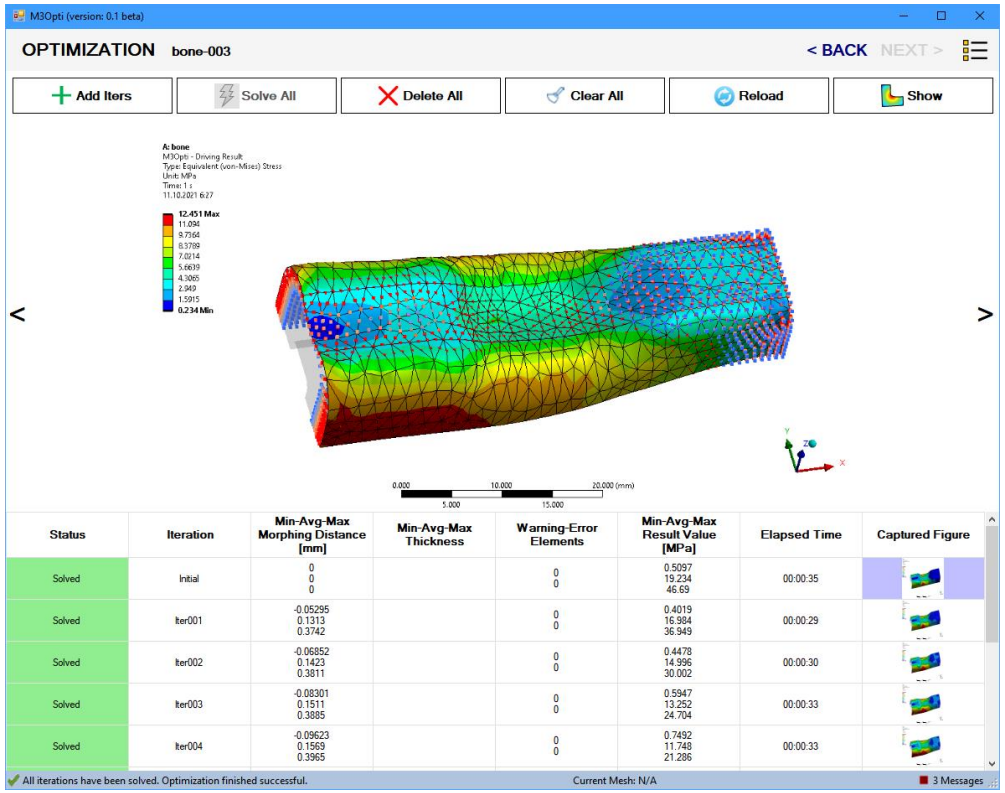


M3Opti – Example

Improvement stress behaviour of specimen structure.





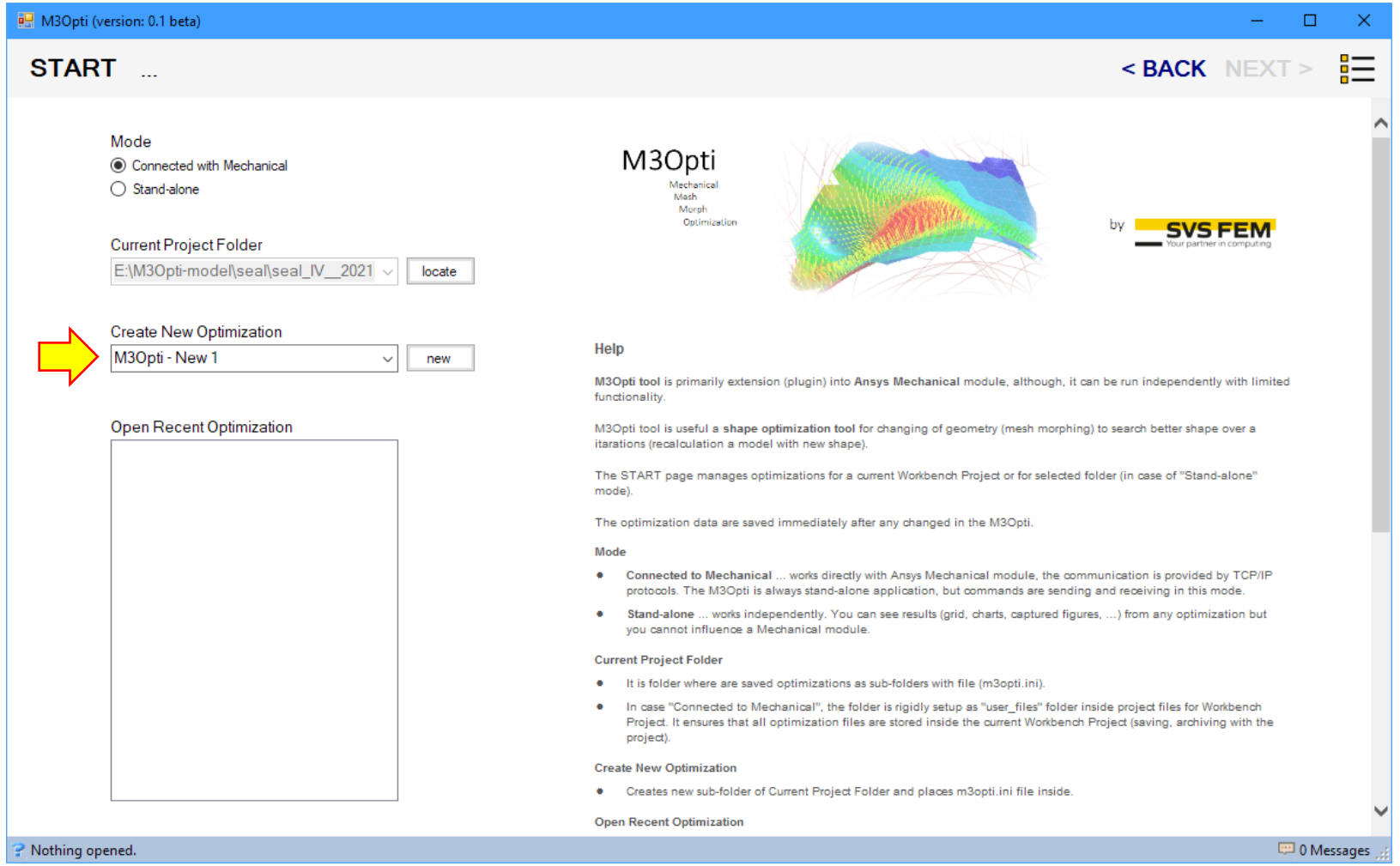


M3Opti – Integrated Help

HELP

Basic Workflow

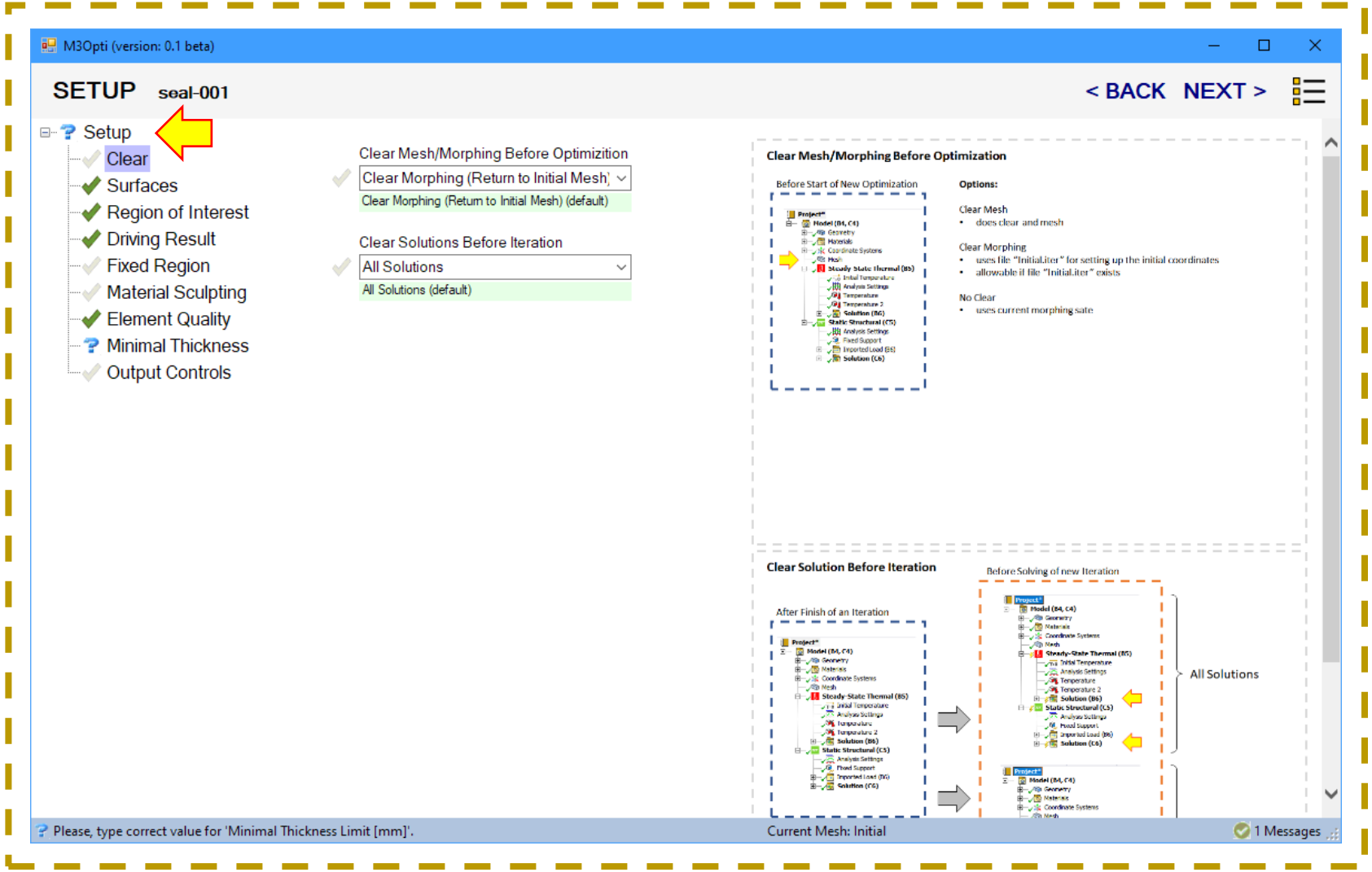
(3) Type you name of your optimization analysis



HELP

Basic Workflow

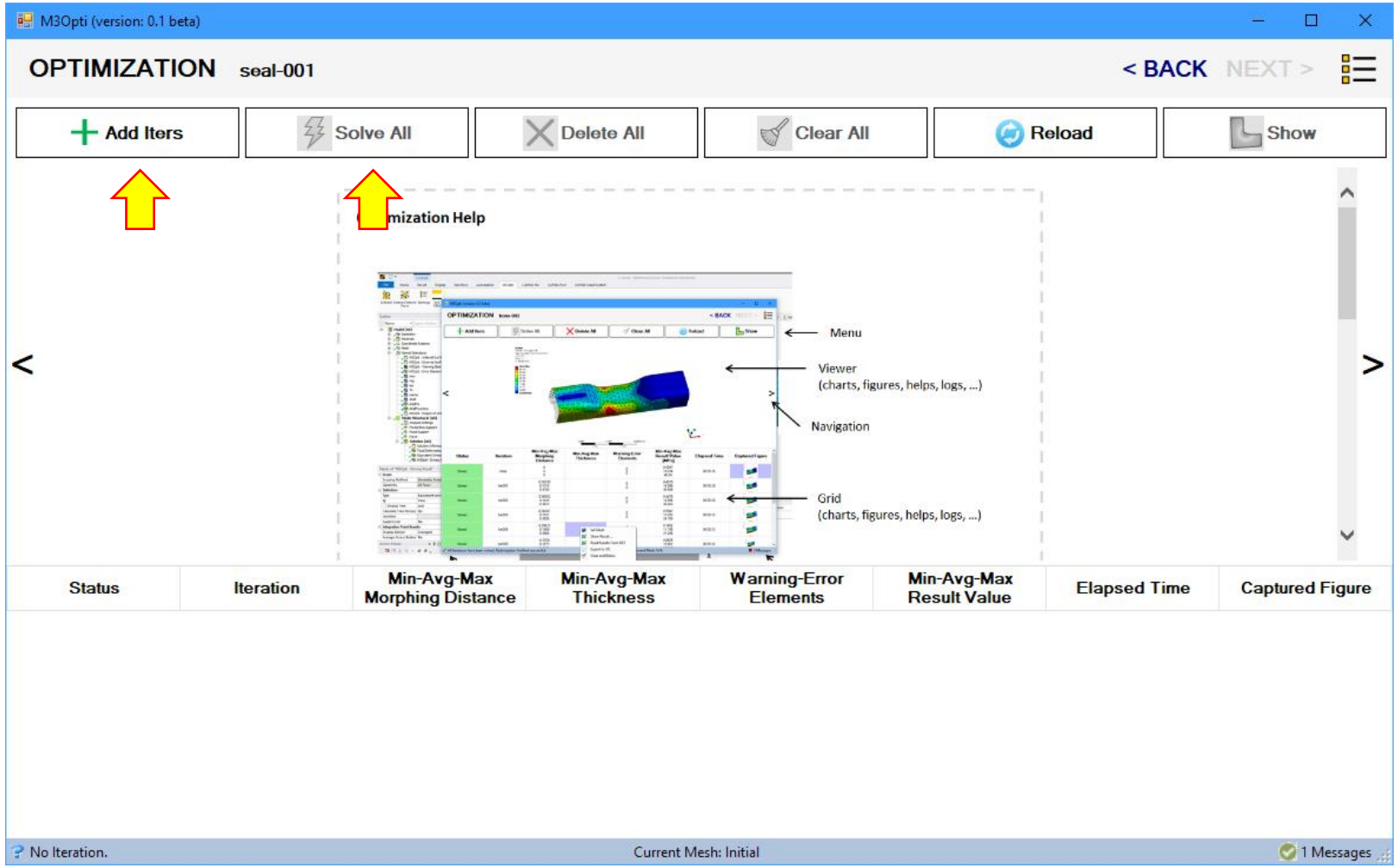
(4) Setup the optimization analysis step by ste[



HELP

Basic Workflow

(5) Add iterations and solve them. Review results.

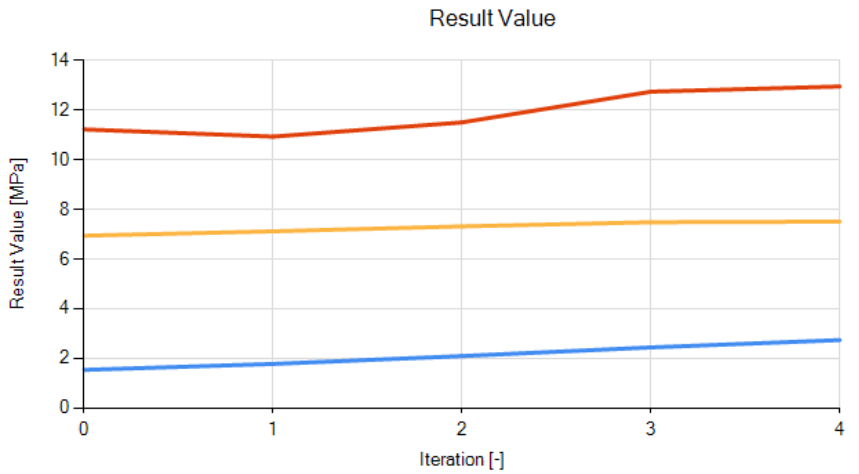


HELP

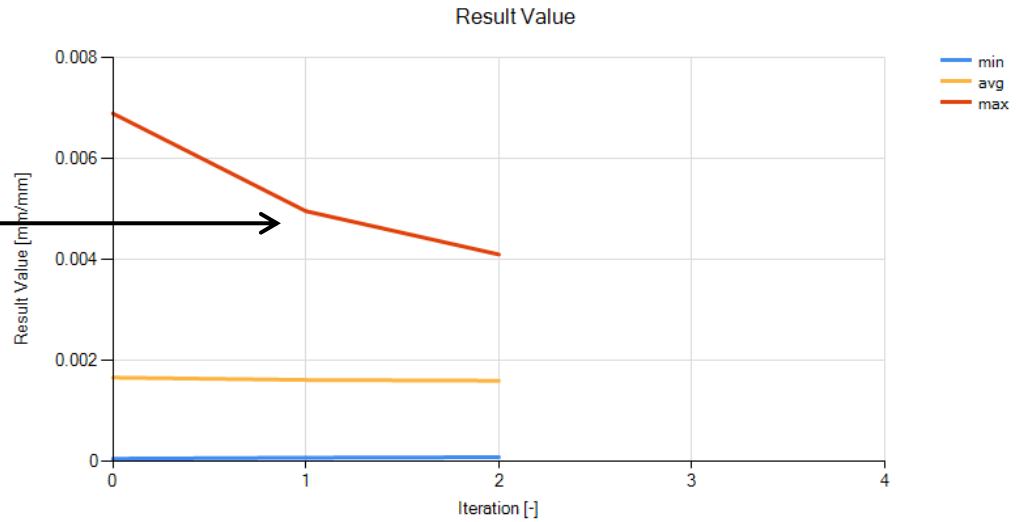
Basic Workflow

(6) Checking optimization progress,

- in general, decreasing of driving result values is main goal of the shape optimization analysis,
- observing maximal/average/minimal values from whole field can show if solution is going well or wrongly



Wrong optimization progress

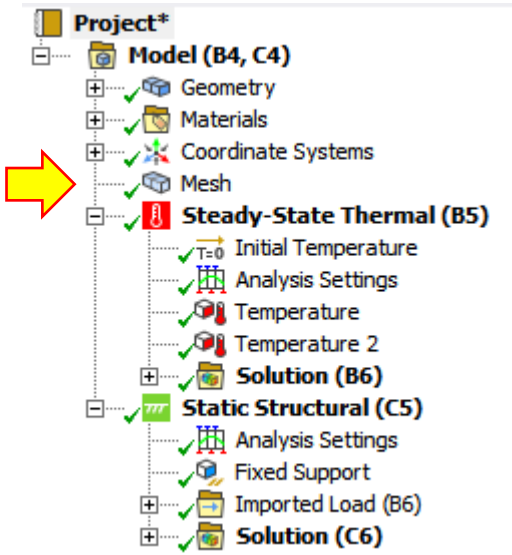


Perfect optimization progress

HELP

Clear Mesh/Morphing Before Optimization

Before Start of New Optimization



Options:

Clear Mesh
- does clear and mesh

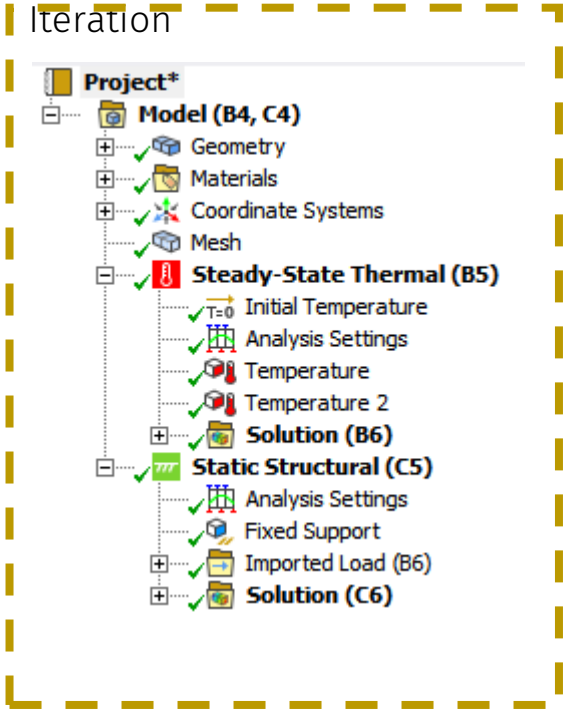
Clear Morphing
- uses file “Initial.coords” for setting up the initial coordinates
- allowable if file “Initial.iter” exists

No Clear
- uses current morphing sate

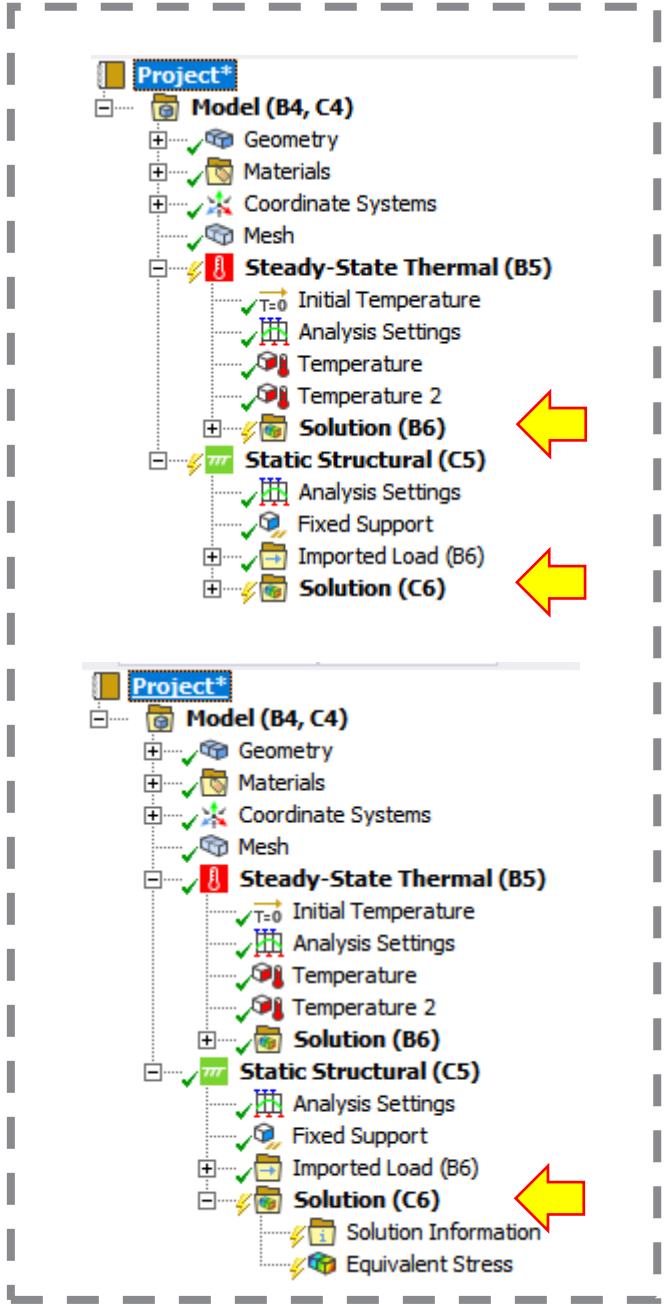
HELP

Clear Solution Before Iteration

After Finish of an Iteration



Before Solving of new Iteration



All Solutions

Only One With Result
(Driving Result Object)

Note:
In case of “Only One With Result” for example same field of temperatures will be used in following Static Structural, solving of Thermal analysis will be skipped every time (assumption small change in temperature field)

HELP

Sculpting Method

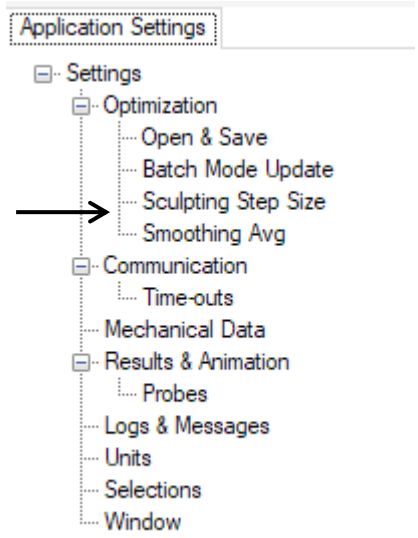
BGM

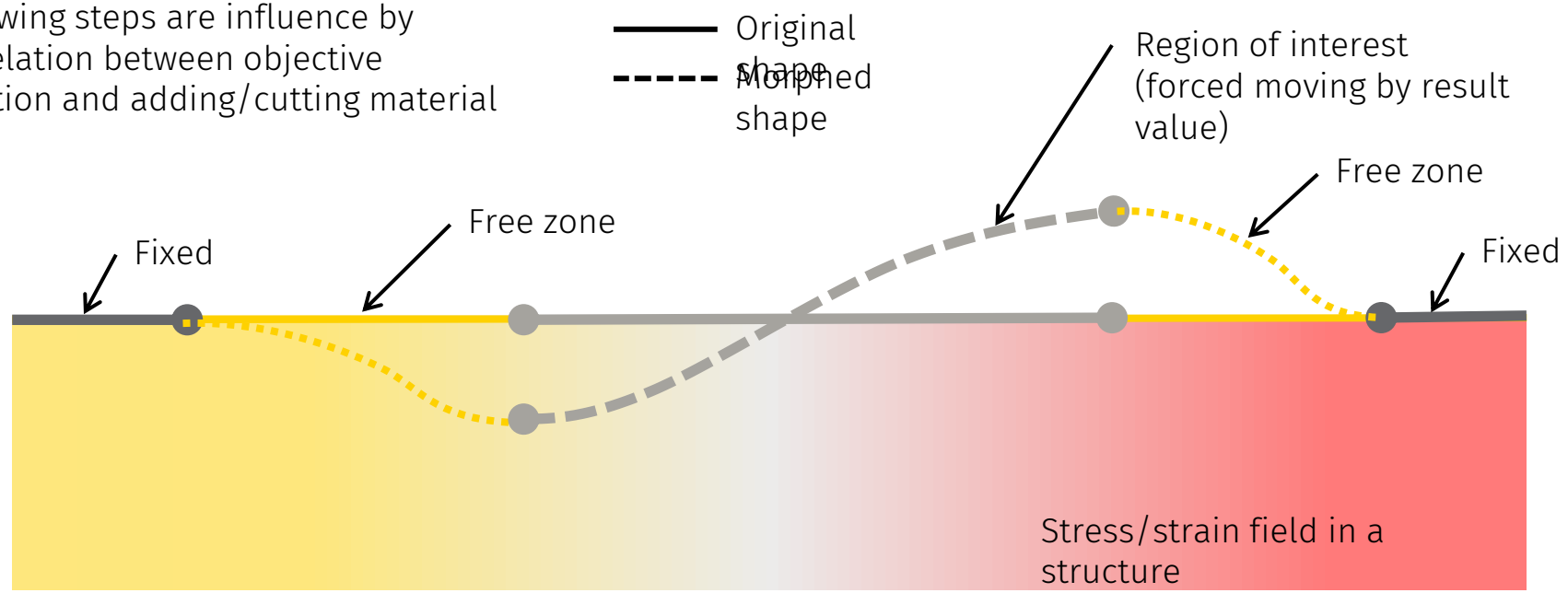
- Biological Growth Method sculpting
- inspired by nature
- add material where “structure” (like bones, trees, …) is overstressed
- **Automatic** … predefined settings
- **Manual** … individual settings

BGM + Correlation Scatter (Beta)

- initial steps are performed as pure BGM
- following steps are influence by correlation between objective function and adding/cutting material

Note:
Automatic predefined settings has been tunned to on typical models. User can customize the setting via BGM (Manual) option and application settings of M3Opti.





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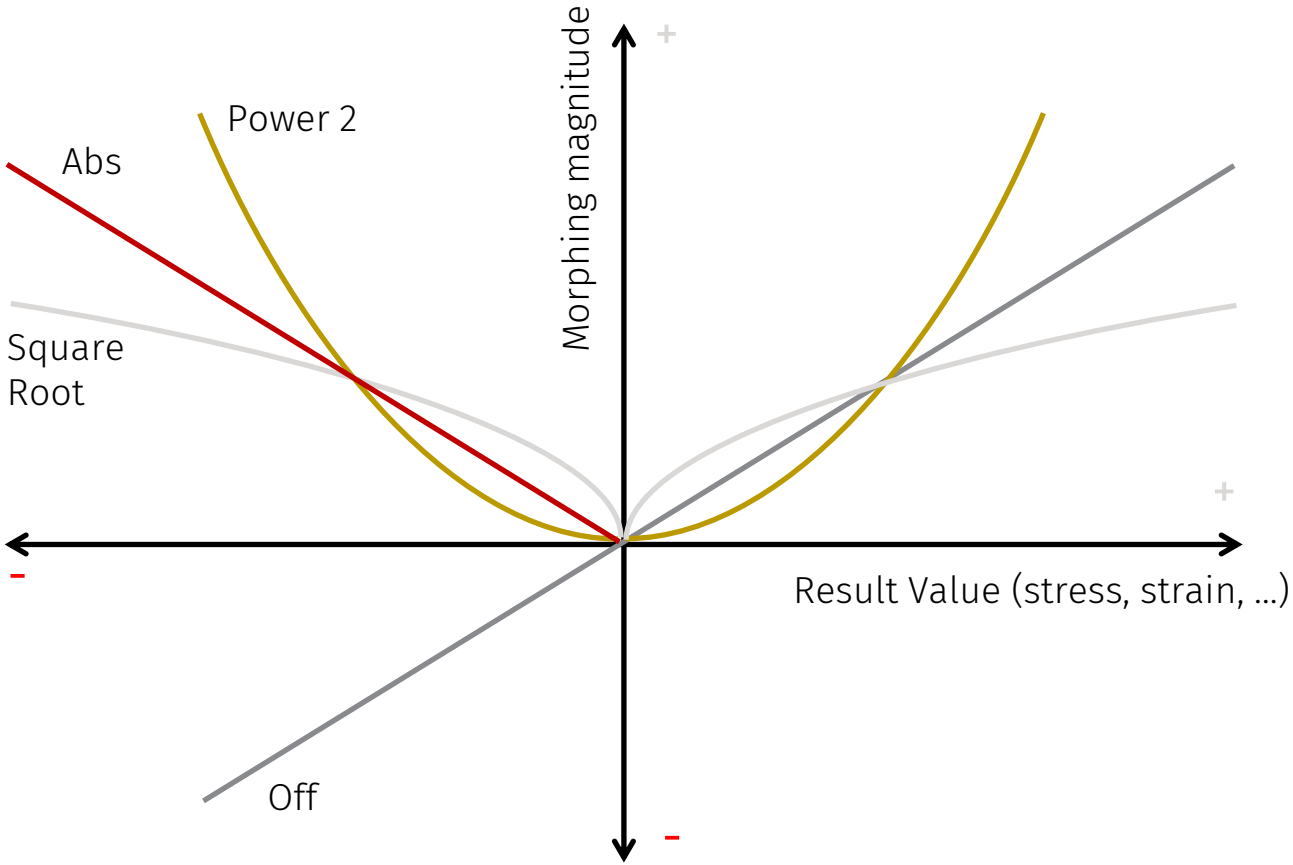
Result Value Magnification

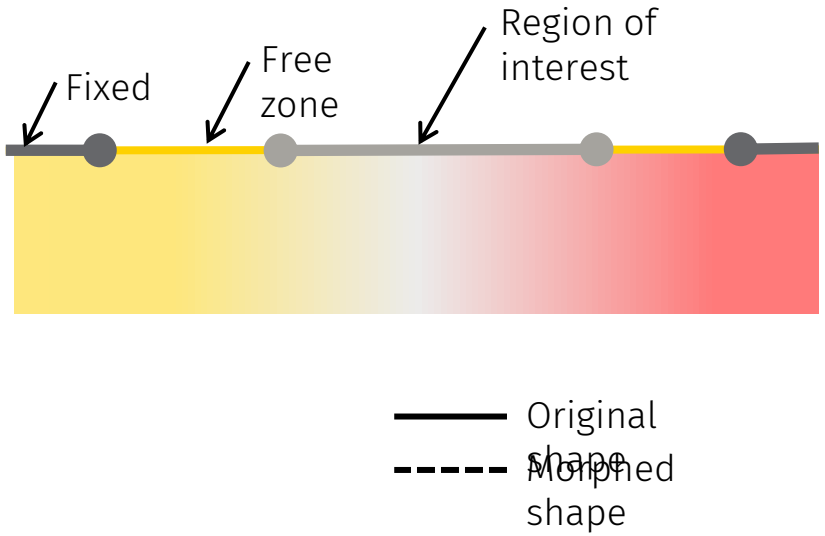


Note:
Typically, absolute value (Abs) should be used. But user can magnify high or low values by power or sqrt function.

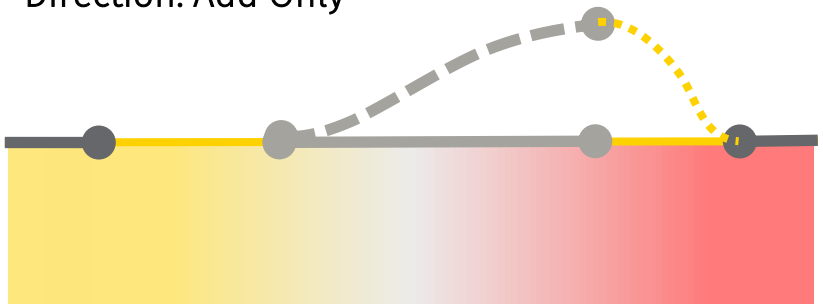
HELP

Sculpting Direction

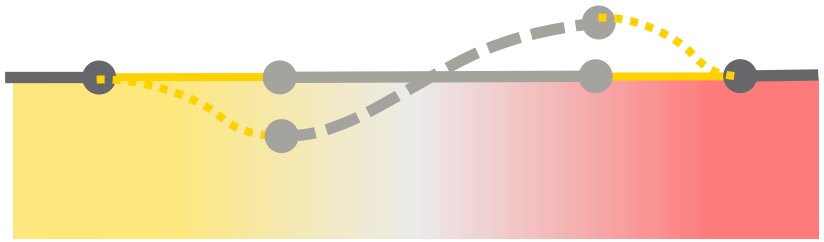
Initial state (original shape)



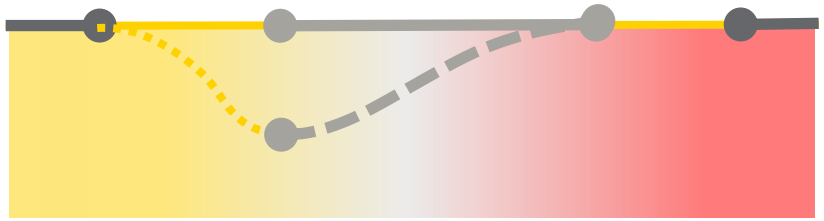
Direction: Add Only



Direction: Add and Cut



Direction: Cut Only



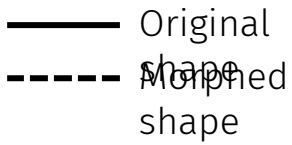
Note:
The setting affects if material will be added or reduced. Threshold (tr) is defined relatively to result values in region of interest:

- Add Only ... tr = min(result values)
- Add Mainly ... tr = 25 % quantile of result values
- Add and Cut ... tr = 50 % quantile of result values
- Cut Mainly ... tr = 75 % quantile of result values
- Cut Only ... tr = max(result values)

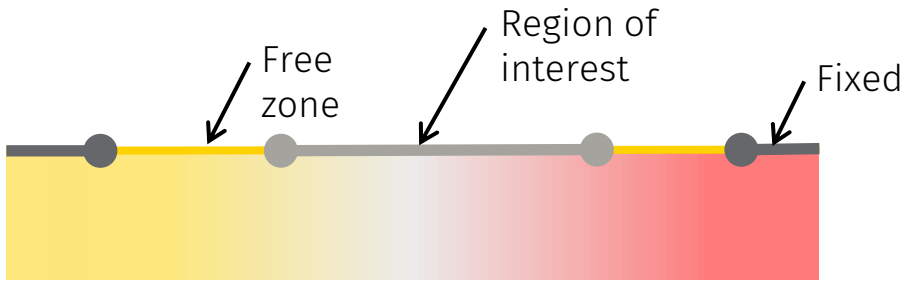
HELP

Sculpting Step Size

Sculpting Step Size Manual	0.002
Sculpting Step Ratio Extra Agressive	1.5
Sculpting Step Ratio Agressive	1
Sculpting Step Ratio Normal	0.5
Sculpting Step Ratio Fine	0.25
Sculpting Step Ratio Extra Fine	0.12



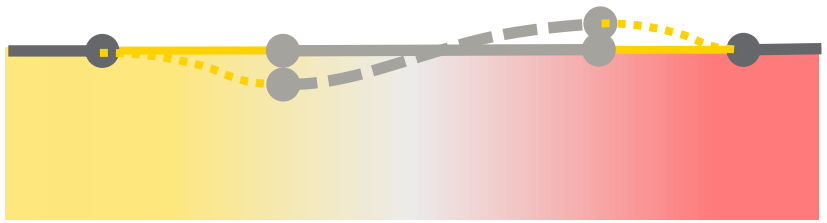
Initial state (original shape)



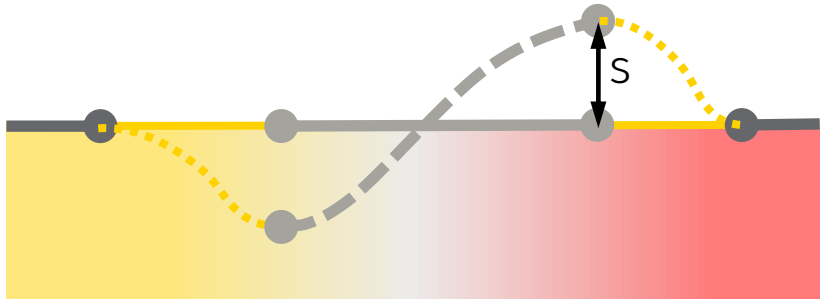
Note:
In general, larger step size increase convergence (faster decrease of stress/strain), but, large step can lead to wrong mesh quality. Automatic predefined settings is relative to element size attached to region of interest. The ratio can be see or changed in Settings of M3Opti.

Final max step size (s) is:
- s = ratio * avg(element size)

Sculpting Step Size: Fine



Sculpting Step Size: Aggressive



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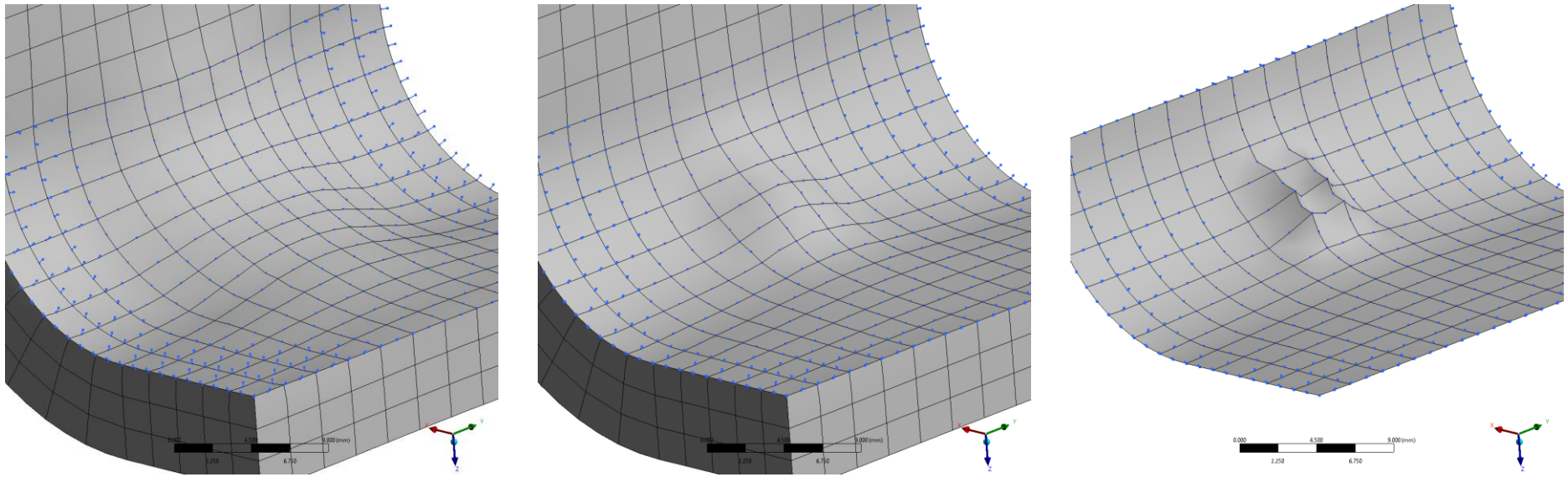
Smoothing

Smoothing level



More smoothing
- adds material in larger area
- better for fine mesh
- can lead to wrong capture of local overstress

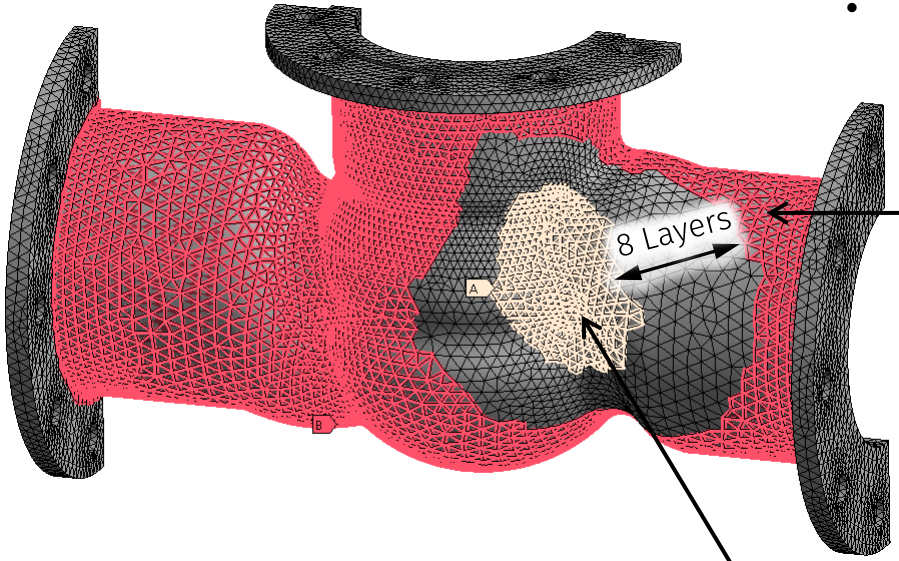
Less smoothing
- adds material more locally
- better for coarse mesh
- can lead to wrong element quality

HELP

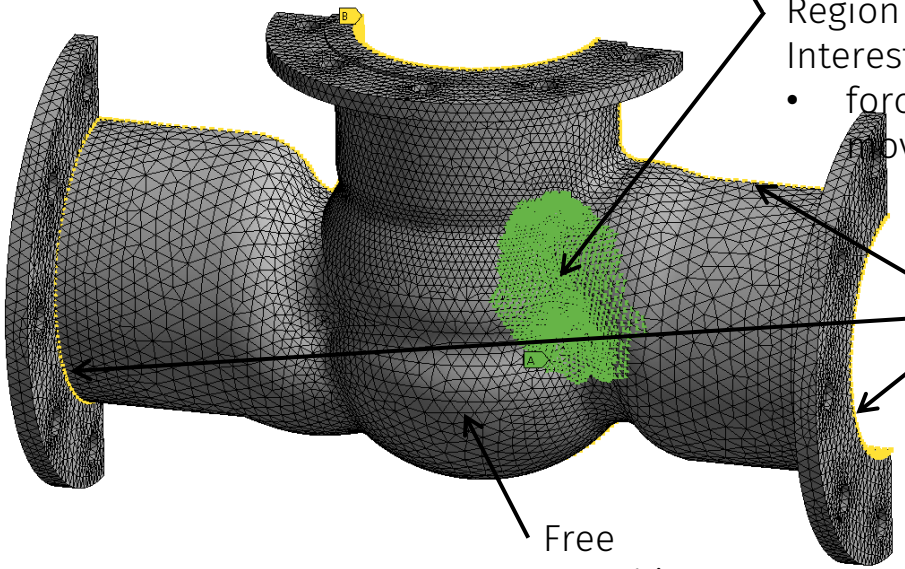
Fixed Region

Fixed Region Definition = Automatic

Notes:
- Internal nodes are fixed if region of interest lays on external
- External nodes are fixed if region of interest lays on internal



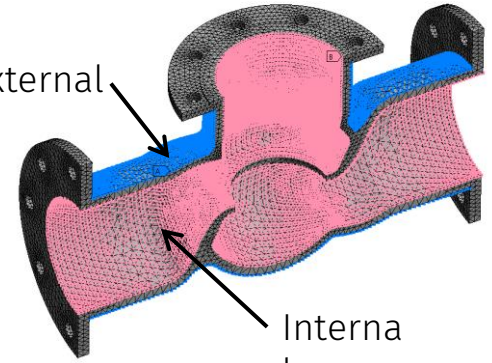
Fixed region
- Only a Few Layers Around Interest Region
- 8 Layers (free morphing)



Region of Interest
- forced moving

Fixed region
- Border Edges

Free morphing



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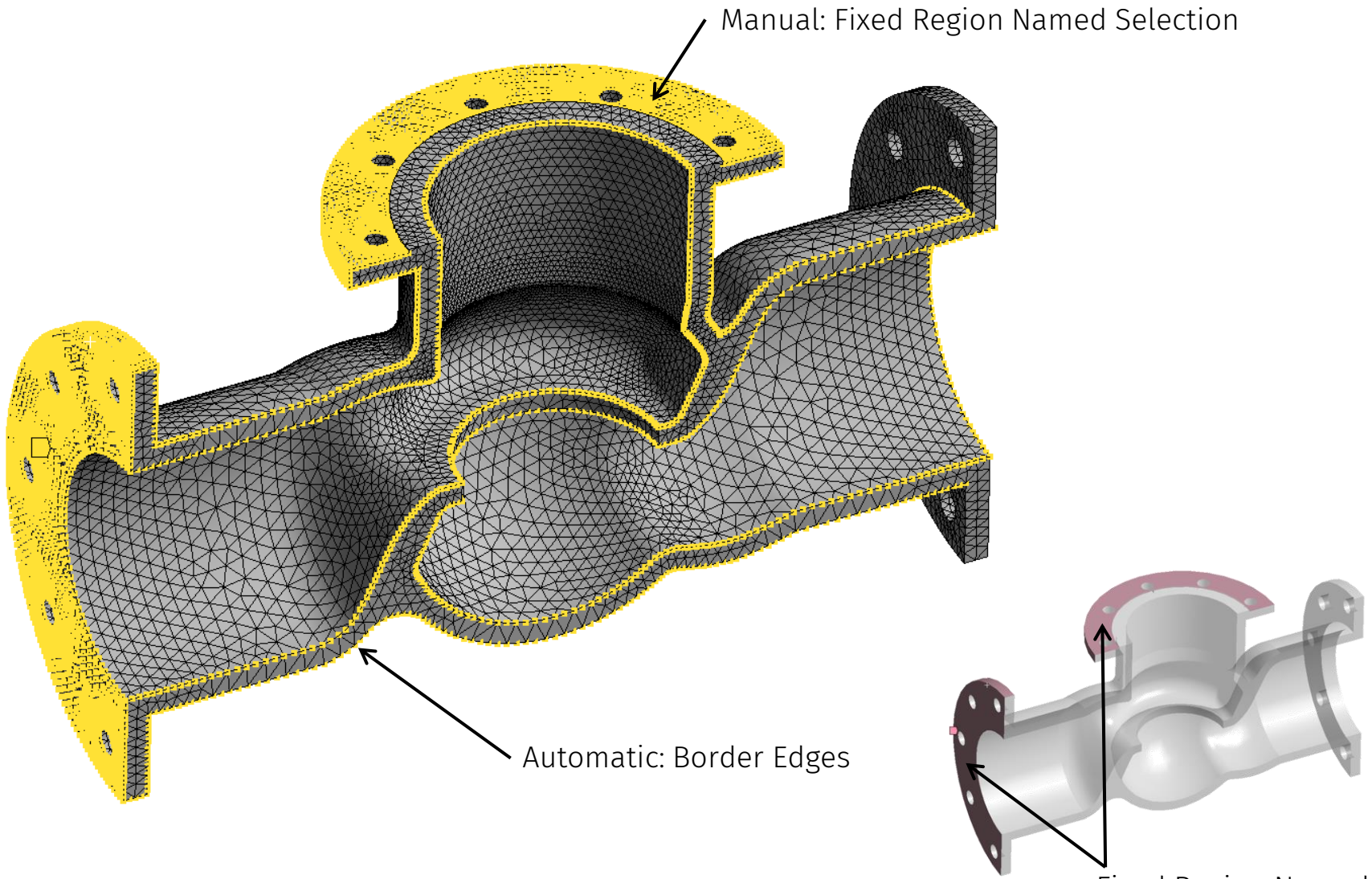
Fixed Region

Fixed Region Definition = Automatic & Manual

- Border Edges
- Fixed Region Named Selection



HELP

Surfaces

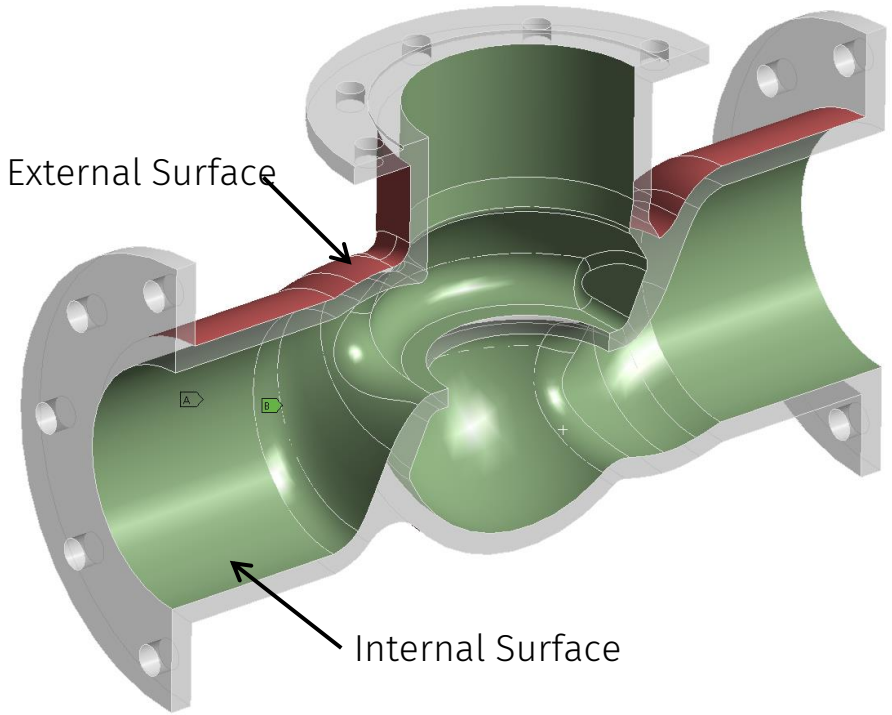
M3Opti Shape Optimization is based on morphing surfaces of a body.

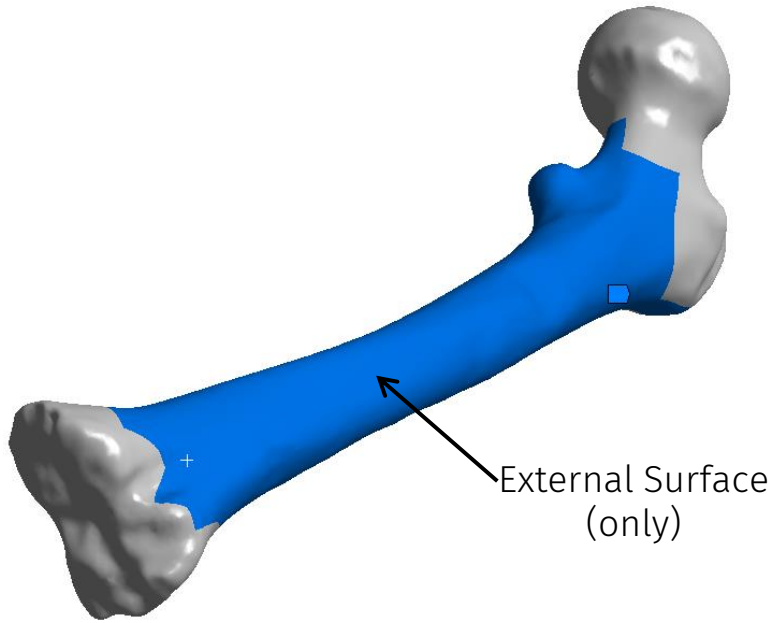
Two body types are supported:

- **Body Type = With Internal Faces** ... thin wall bodies or for bodies where thickness of plate should be checked
- **Body Type = Only External Faces** ... solid bodies (without cavities)

Surfaces are used for:

- specification of bodies which are used in optimization
- opposite surface (to region of interest) is fixed (if automatic fixing is used)
- specification surfaces for wall thickness constrains



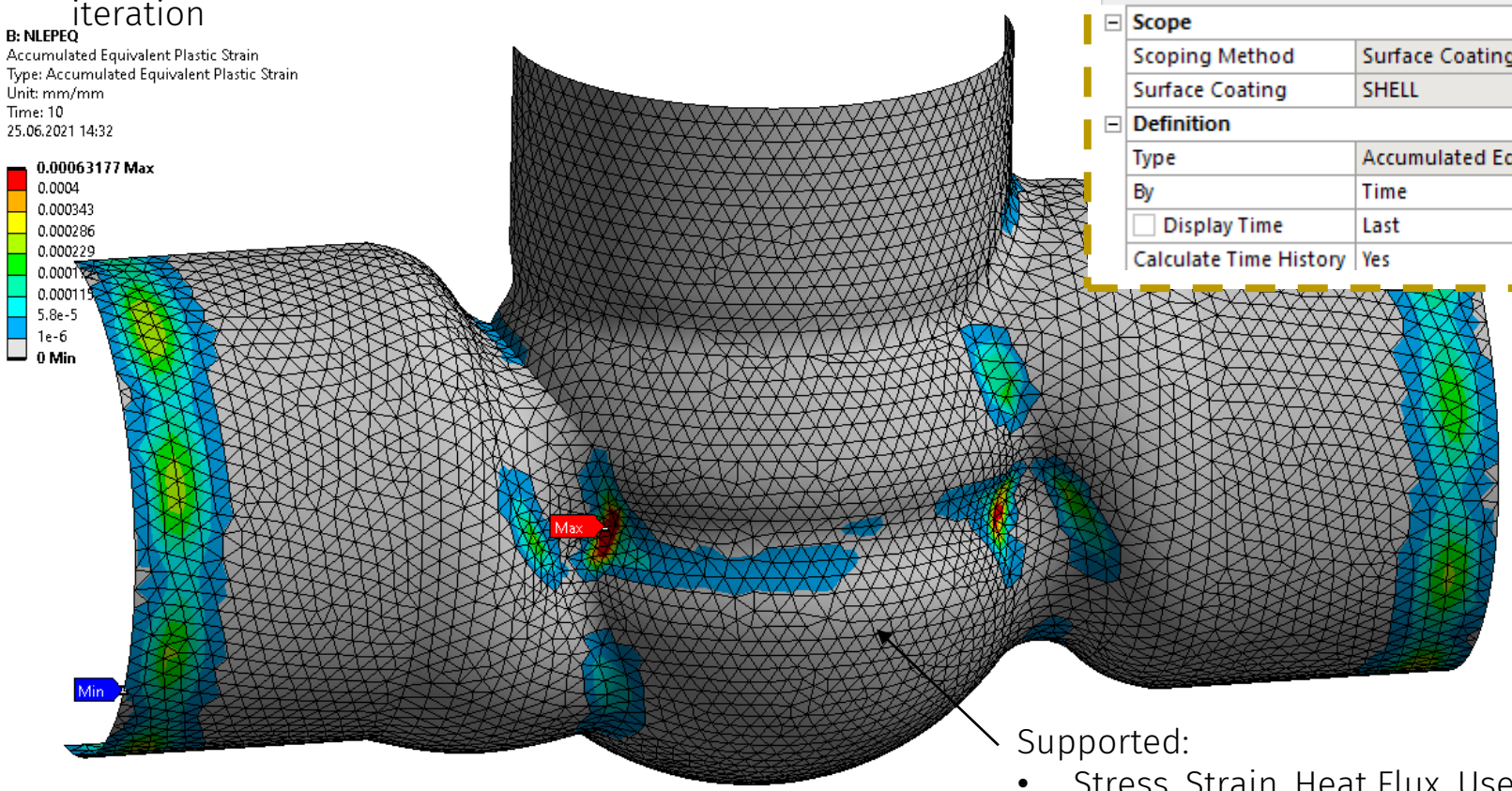


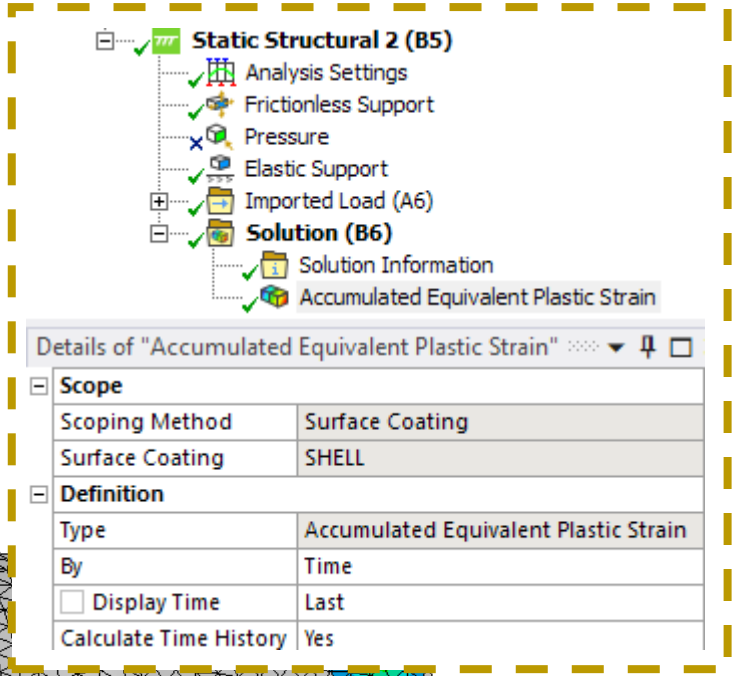
HELP

Driving Result

Driving Result is reference (by name) of result object which will be source of driving values for optimization (mesh morphing)

- nodal values for all nodes in Region of Interest have to be included
- select specific time (or max. over time, …)
- parent analysis/solution is clearing each optimization iteration



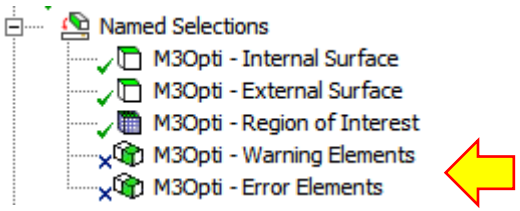


Supported:

- Stress, Strain, Heat Flux, User Defined Results
- Bodies, Faces, Element Faces
- Surface Coatings
- …

HELP

Check Element Quality = Yes



Defined by “Worksheet” Named Selections automatically generated. User can modify criteria individually.

Warning elements
- only for information

Error elements
- bisection of morphing magnitude is used if one or more elements occurred

Worksheet

M3Opti - Warning Elements

Generate

Note: Internal comparisons of values that have units are done in the CAD Unit System. See help for more information.
Current CAD Unit System: Metric (m, kg, N, s, V, A)

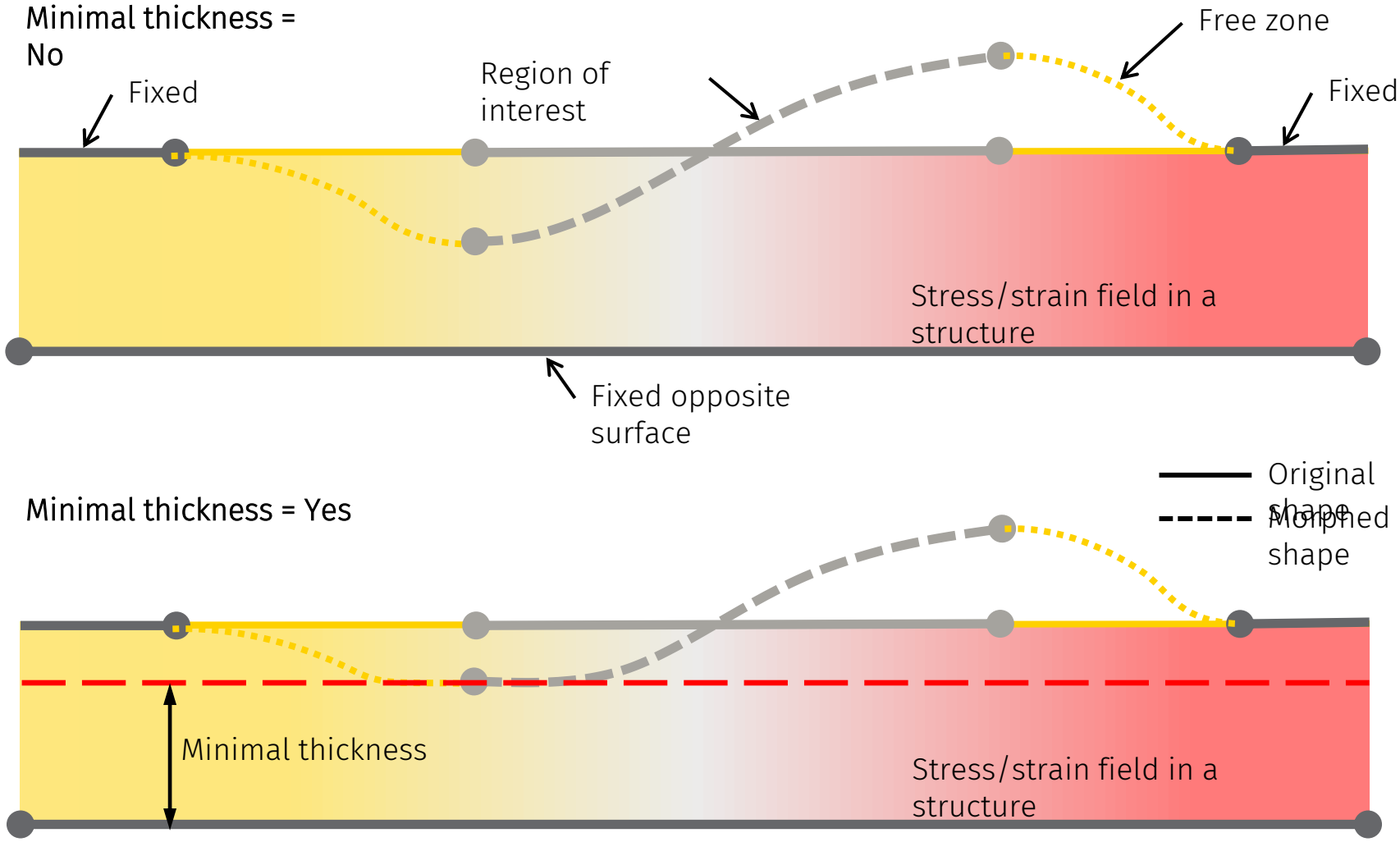
	Action	Entity Type	Criterion	Operator	Units	Value	Lower Bound	Upper Bound	Coordinate S...
☑	Add	Mesh Element	Element Quality	Less Than	N/A	0.2	N/A	N/A	N/A
☑	Add	Mesh Element	Aspect Ratio	Greater Than	N/A	8.	N/A	N/A	N/A
☑	Add	Mesh Element	Jacobian Rat...	Less Than	N/A	4.e-002	N/A	N/A	N/A
☑	Add	Mesh Element	Jacobian Rat...	Less Than	N/A	0.14	N/A	N/A	N/A
☑	Add	Mesh Element	Skewness	Greater Than	N/A	0.9	N/A	N/A	N/A

HELP

Minimal Thickness

Minimal thickness defines constrain

Minimal thickness constrain is available only if External and Internal surfaces is specified.



HELP

Output Control

Output Control defines which files will be saved during solution (each optimization iteration)

Save RST Files

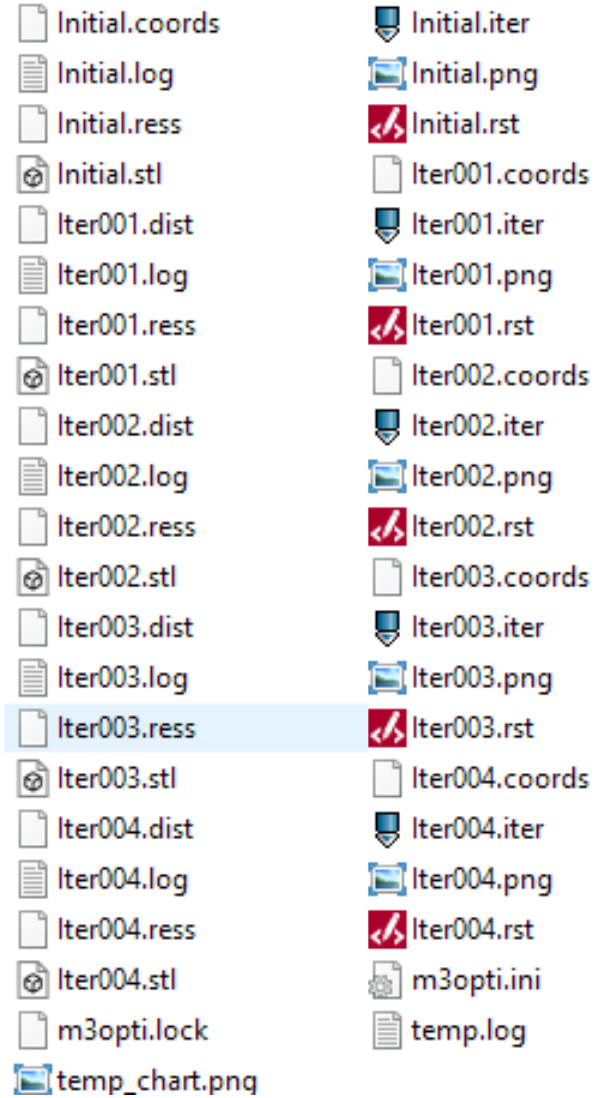
- allows to evaluate all result items for all solution for all time steps

Capture Figures

- captures current screen view for each optimization iteration

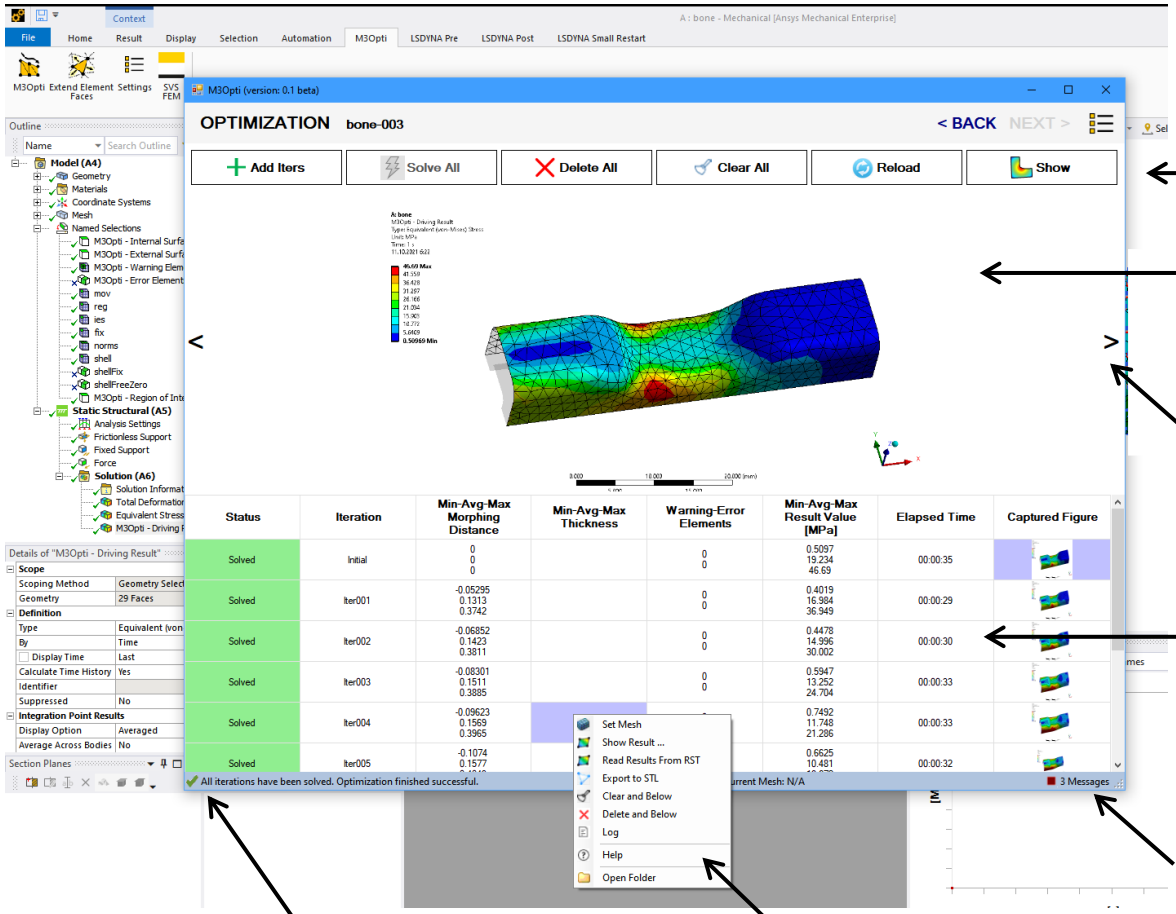
Save Mesh STL Files

- saves external mesh into STL files for each optimization iteration
- STL file could be generated after solution but it can be more time consuming due to re-morphing the mesh



HELP

Optimization Help



Menu

Viewer
(charts, figures, helps, logs, ...)

Navigation

Grid
(charts, figures, helps, logs, ...)

Overall Messages

Overall Status

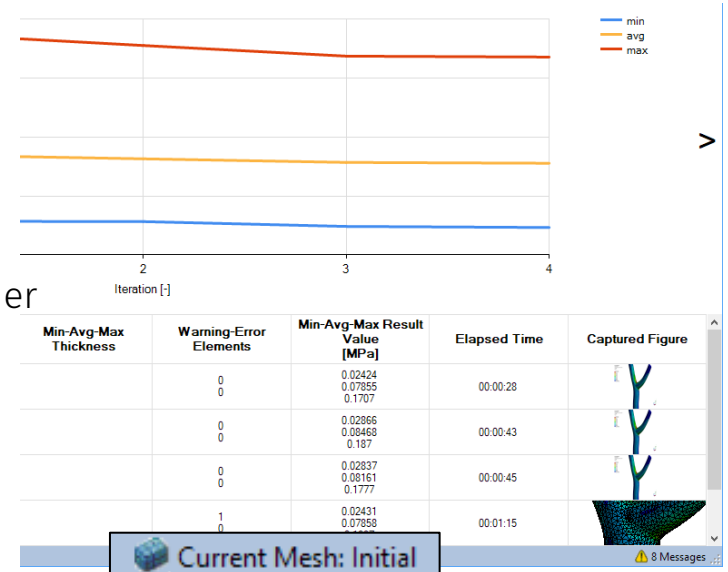
Context Menu Grid
(charts, figures, helps, logs, ...)

HELP

Mesh & Morph State

Status bar shows current mesh/morph states. The tool allows to compare current Mechanical mesh with saved mesh in COORDS files which are saved each optimization iteration.

Mesh & morph states:



Status of current mesh state

No connection
- mesh state cannot be checked in Stand-alone mode

No COORDS file
- no file with morphing (COORDS) is presented in optimization folder
- optimization has not been started or the files have been deleted

No Mechanical data
- no mesh data received from Mechanical
- there is a problem with connection with mechanical

No valid mesh
- mesh is not currently generated in Mechanical

Not checked
- some COORDS files have been found and they are probably suitable with current mesh
- try check current mesh, which morphing mesh shape is matched

Different mesh
- mesh is different than mesh in COORDS file(s) => count of nodes or elements does not match with counts in the file(s).
- the model (current mesh) is not suitable for current optimization, restart of optimization is not available.
- please, clear optimization and start new one.

HELP

Mesh & Morph State

Click to Current Mesh button to see more options:

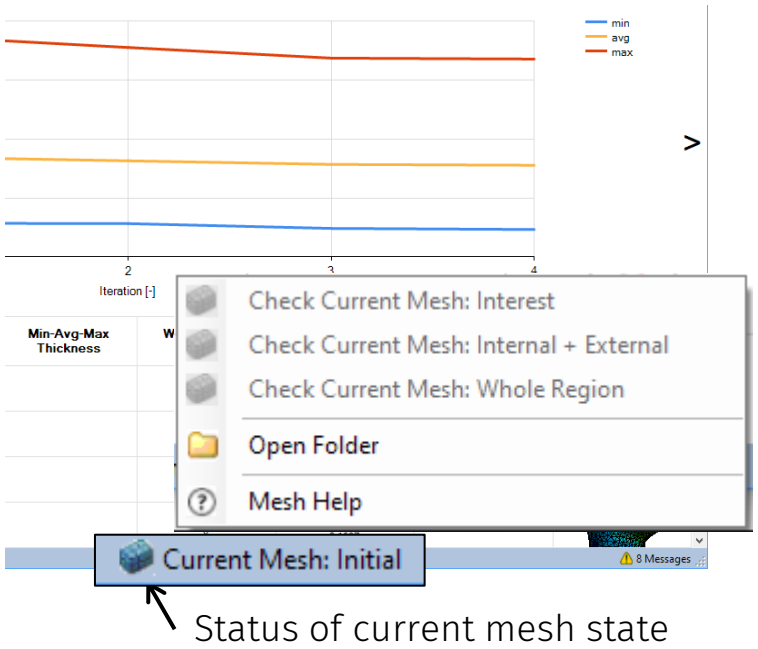
Check Current Mesh: ...
- performs comparison current mesh and morphing (COORDS) files
- tries to found the most suitable file to current mesh
- there are 3 options (fast ... precise)

Check Current Mesh: Interest
- checks nodes only in Interest NS
- fastest
- could be less precise

Check Current Mesh: Internal + External
- checks nodes only in Internal + External NSs

Check Current Mesh: Whole Region
- checks nodes only in whole body attached to Internal + External NSs
- most precise
- could be slow

Open Folder
- opens folder with optimization files



Status of current mesh state

HELP

Optimization Help

Menu

- Add Iterations … adds iterations for current optimization
- Solve All … solves all iterations with “None” status
- Delete All … deletes all iterations with all data
- Clear All … deletes all data
- Reload … reloads grid and chart data from current M3Opti folder
- Show … shows results, animations, …

Columns in Grid

- Status … current status
- Iteration … id
- Min-Avg-Max Morph … morphing distance (minimum, average, maximum)
- Min-Avg-Max Thickness … wall thickness (minimum, average, maximum)
- Min-Avg-Max Value … result value (minimum, average, maximum)
- Warning Elements … count of warning elements
- Error Elements … count of error elements
- Elapsed Time … overall elapsed time per one iteration
- Capture Figure … figure of driving result object

Files per Iteration

- Iter000.coords … nodal coordinates
- Iter000.dist … morphing normal distance
- Iter000.thk … wall thickness
- Iter000.iter … main data (setup, grid)
- Iter000.log … log from solution
- Iter000.png … captured figure
- Iter000.ress … nodal result values
- Iter000.rst … result file (Ansys Mechanical APDL)

HELP

Result Scope

Menu

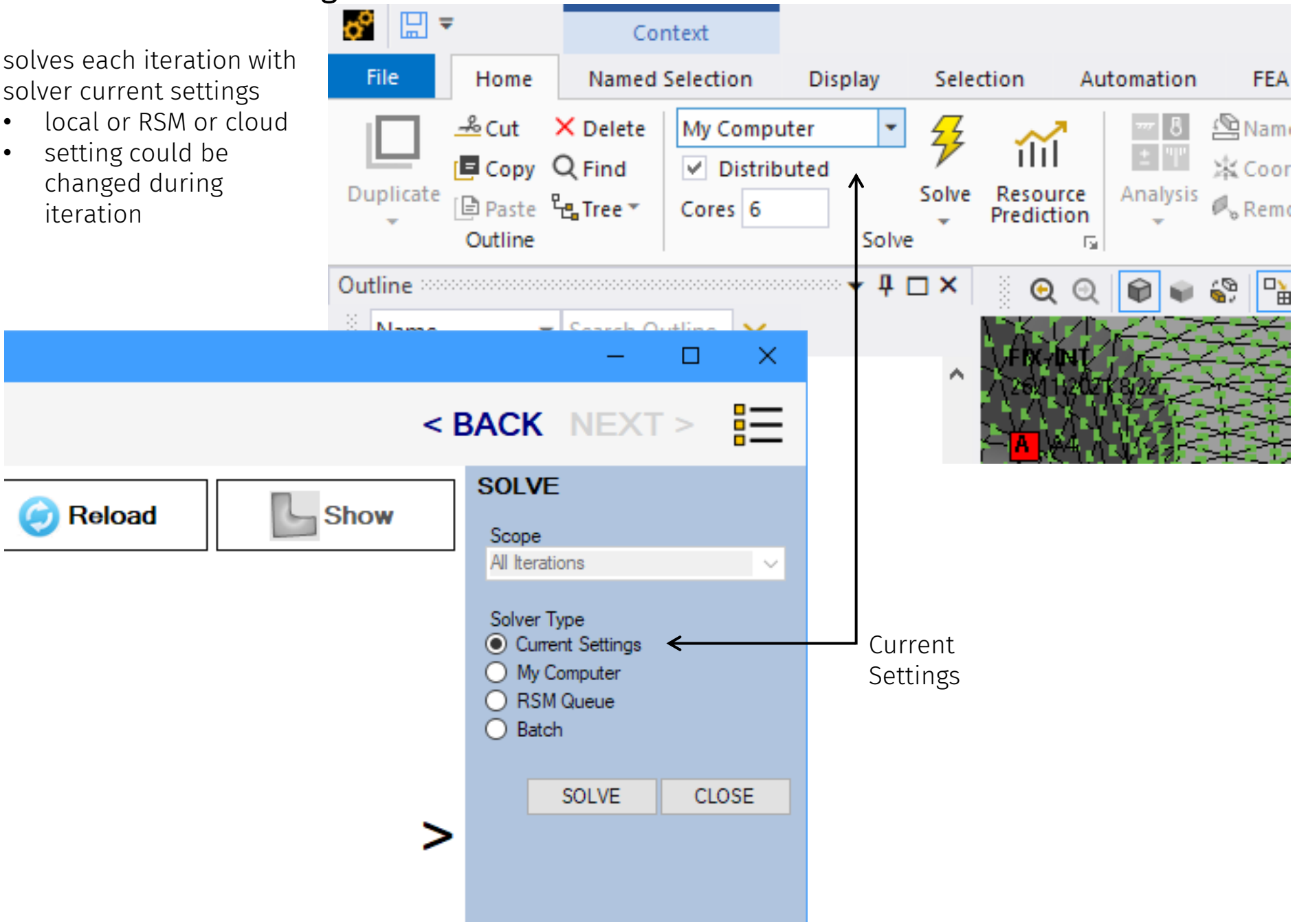
- "0" ---> Initial
- "Inital" ---> Initial
- "inital" ---> Initial
- "Iter001" ---> Iter001
- "iter001" ---> Iter001
- "001" ---> Iter001
- "1" ---> Iter001
- "1; 2; 3; 4" ---> Iter001, Iter002, Iter003, Iter004
- "1 - 4" ---> Iter001, Iter002, Iter003, Iter004
- "1 - 4; 8" ---> Iter001, Iter002, Iter003, Iter004, Iter008
- "all" ---> Iter001, Iter002, Iter003, Iter004, Iter005, Iter006, Iter007, Iter008
- "All Iterations" ---> Iter001, Iter002, Iter003, Iter004, Iter005, Iter006, Iter007, Iter008

HELP

Solve – Current Settings

solves each iteration with solver current settings

- local or RSM or cloud
- setting could be changed during iteration



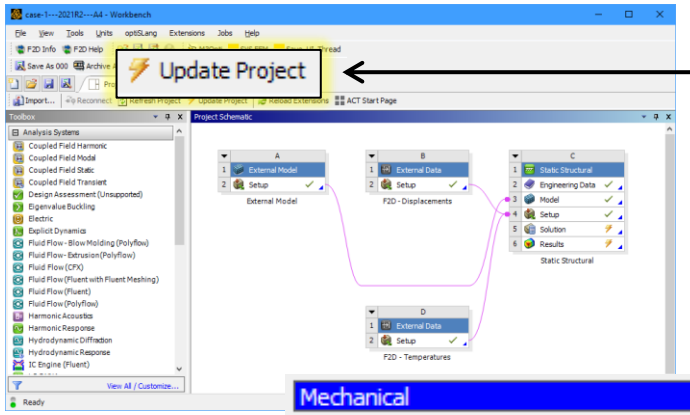
HELP

Solve – Batch

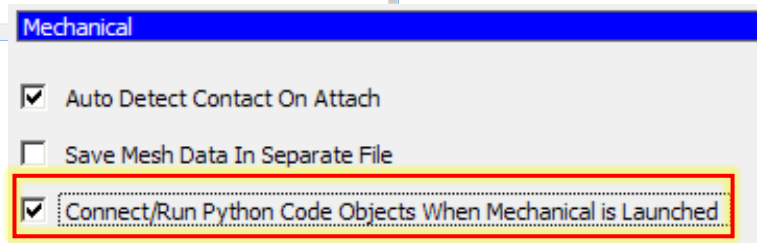
creates files which are necessary to solve all iterations in another computer

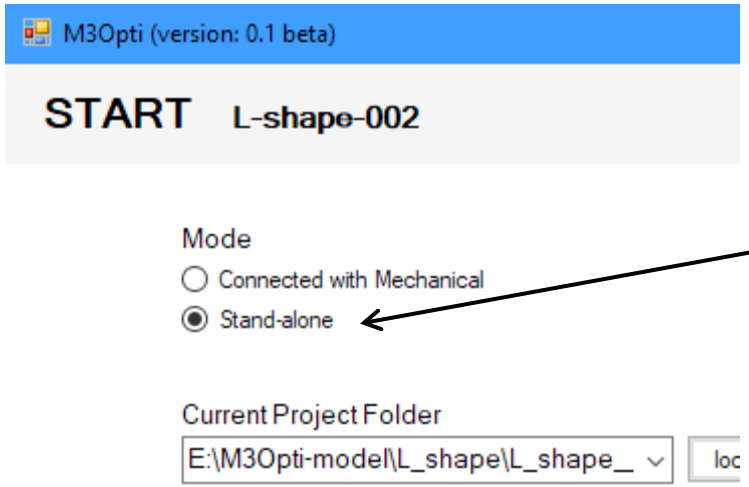
steps:
- save files for batch (button “SAVE”)
- open WB project on another computer
- turn on:
- Update whole project
- after solution is done or during solving, M3Opti can be run in “Stand-alone” mode and solution progress can be seen

available for system:
- Windows
- Linux



open project (WB archive) on another computer and use Update





Stand-alone + Reload

Batch