

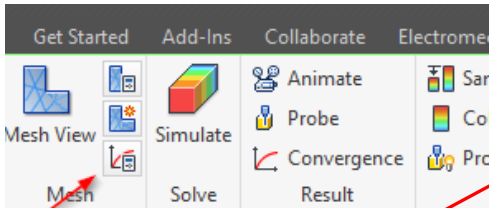
## How to ensure accuracy of stress analysis results and convergence in Inventor Stress Analysis

- **Issue:**
- As mesh settings change, Stress Analysis results may change and you want to understand the accuracy of your stress results in Inventor Stress Analysis. Inventor stress analysis have high value not as expected and increase as growing is mesh.
- **Causes:**
- As mesh density is increased, the value of the results in Stress Analysis vary.
- **Solution:**
- The solution is to employ an iterative computational technique in Inventor Stress Analysis called *convergence*. Each iteration modifies the mesh, re-runs the simulation, and compares the results to the previous results.

Performing a convergence study in Inventor Stress Analysis refines the mesh and reduces the size of the elements, which will theoretically increase the accuracy of the next iteration of results. As mesh elements decrease in size but increase in quantity, the computational requirements to solve a given model increase. As mesh elements decrease in size, they reach a point of diminishing returns on the level of accuracy compared to the computational overhead and time required to compute the result. This means that a simulation requires much more time to compute the results, but the result may change by an insignificant value.

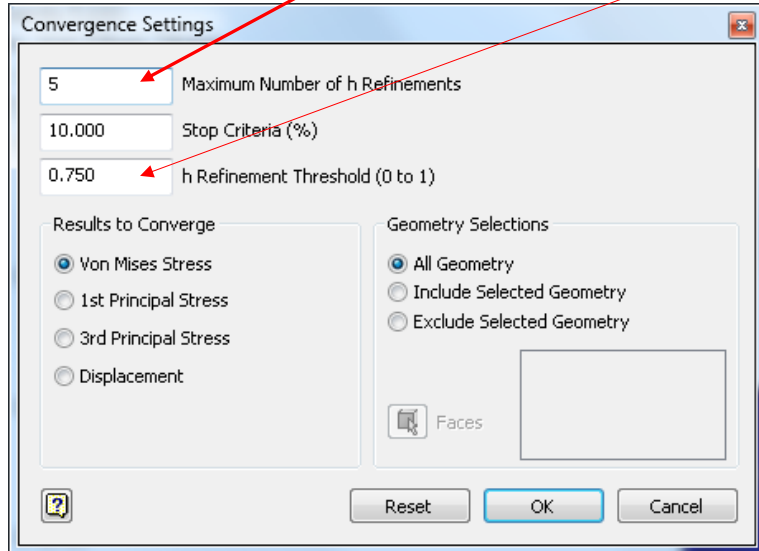
Access the Convergence Settings at:

Ribbon: Stress Analysis tab    Mesh panel    Convergence Settings



The Maximum Number of h Refinements will determine the total number of iterations that will be attempted. Iterations will stop if the Stop Criteria is met before the Maximum Number of H Refinements is met.

h Refinement Threshold (0 to 1) in the Inventor Stress Analysis



Inventor Stress Analysis uses triangular meshes with both p-refinements (polynomial formula to describe displacements) and h-refinements (h is the size of the circumscribed circle of the triangle). p-refinements are not exposed in the user interface but h-refinements are.

In the first 2 to 3 iterations of the FEA calculation, Inventor uses p-refinements only. The first iteration is done with a linear formula and in the next iterations Inventor uses a parabolic formula. In subsequent iterations Inventor can additionally use h-refinements if the user chooses so by entering a value other than 0 in the "Maximum number of h refinements" field in the above Convergence settings dialog.

The h refinement threshold parameter controls the decision making process of where to refine the mesh geometry, not how to refine the mesh geometry. It determines where the refinement process is focused around stress singularities and stress concentration areas.

Modifying the parameter determines how many elements are reduced in size around an area where the results of a first analysis are not converging. (Results will not converge when the elements used in the calculation are too big to accurately calculate the stresses). If you put in a number closer to 1, only elements in the direct vicinity of poor convergence will be made smaller, but if you put in a number closer to zero, elements farther away from the area of poor convergence will also be made smaller, which could lead to capacity problems (exhausting your machine's RAM by creating too many elements).

Example:

For example, in an equivalent stress calculation case:

When setting the threshold value to 0.75, Inventor tries to refine the mesh in all areas where the equivalent stress is within 25% of the maximum stress value.

If the threshold value is changed to 0.5, the refinement zone will be wider and would comprise areas where equivalent stresses are above 50% of the maximum stress value.

Once Inventor has determined where to refine, based on the above rule, the mesher makes the actual refinements based on its internal algorithms.

Example:

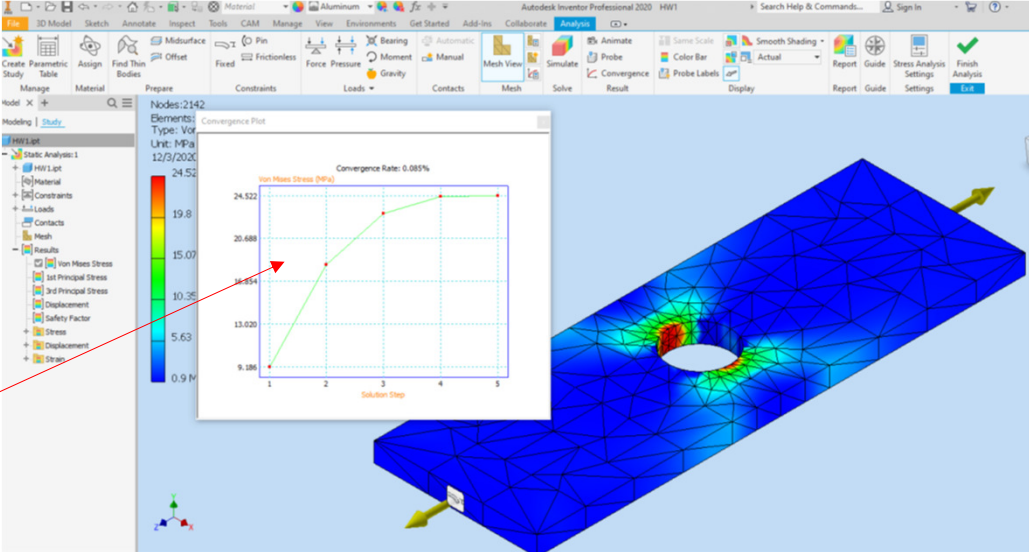
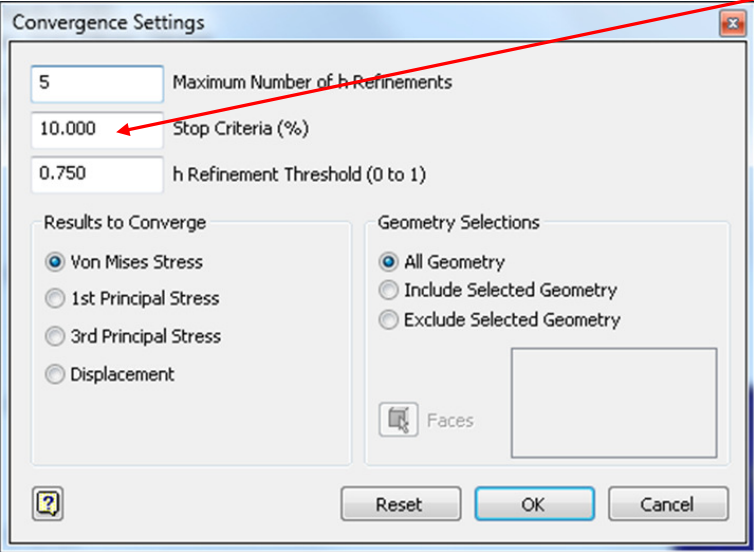
Consider a part that has two areas of stress concentration. The real stress is 100 MPa in one place and 50 MPa in another. In this case you might be interested in obtaining accurate FEA results for both values.

If you keep the Refinement Threshold value at 0.75, Inventor produces accurate stress results in the vicinity of the 100 MPa area, but stresses in the 50 MPa area may not be accurate enough (because 50 MPa is smaller than  $0.75 \times 100 \text{ MPa}$  and the area will not be considered for refinement). In this particular case, you have to lower the threshold to 0.5.

Note 1: Changing the h refinement threshold value when the Maximum number of h refinements = 0, does not have any impact at all on the existing mesh. This means that the "Update mesh" context menu will not become available.

Note 2: The h refinement threshold is not related to the Local Mesh Control functionality

Stop Criteria (%)  
Ceases refinement when the difference between the last two results is less than the specified (%) value.



### Convergence Plot

The Convergence Plot command displays the plot within a dialog box. The plot shows: The number of refinements required for the solution to converge, if convergence is achieved, or the number of solution steps requested for the required refinements. The values associated with each refinement.