T004: Small Defect Detection

Introduction

Best practices are described for the detection of small defects in 3D simulations.

Problem Description

Small defects can be challenging to detect in 3D simulations because their scale is so small compared to the overall model size and mesh detail. By taking advantage of specific methods and tools, users can better predict the presence of small defects such as laps and "flow-throughs".

Solution

The following pre-processing and post-processing considerations should be followed to maximize small defect detection. The provided .pdf presentation provides more details on the topics described below.

Mesh Settings

Element size or element density should take into account the size of the smallest defect that you would like to detect. Defects must be at least 1-3 times larger than the minimum element size in order to be modeled. It is impossible to detect a 0.060" lap if the smallest element is 0.100". Element size in the vicinity of the lap would need to be at least 0.060" (but even this might not predict the lap). Instead, an element size of 0.020" or smaller is ideal. One technique to minimize element size near folds is to utilize "Strain rate magnitude" when meshing.

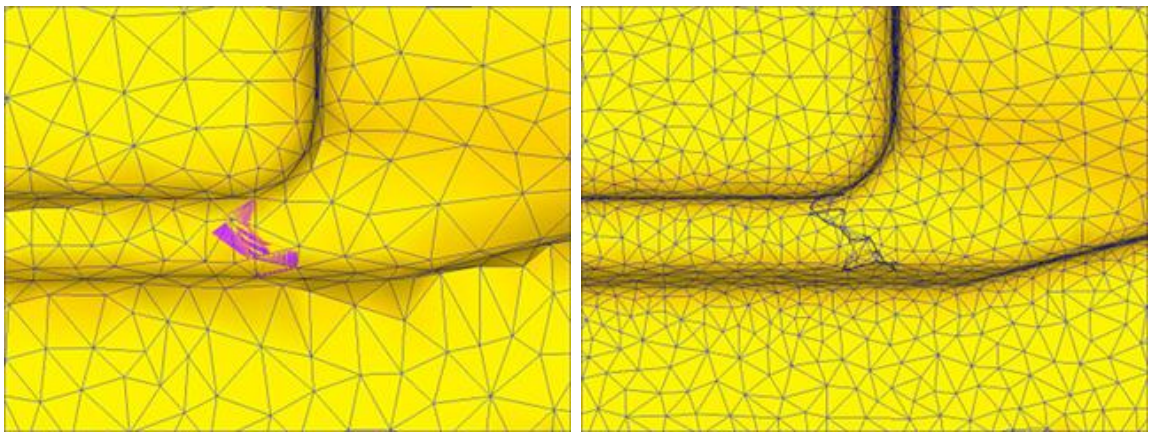


Figure 1: Coarse mesh global remeshing (left) and fine mesh with local remeshing (right).

The selected remeshing method determines how laps and folds are handled throughout a process. The default Global remesher removes laps and replaces them with fold highlighting markers. This is done to ensure an accurate, clean mesh throughout the simulation. Alternatively, Local remeshing will not remove laps, thus preserving fold detail in the mesh. A self-contact inter-object relationship must be defined when using Local remeshing.

Material Data

Proper material data is critical to the prediction of small defects. The selected material data should always cover the temperature range under consideration. Also, flow softening effects are particularly important to the process of lap formation. Softening must be accounted for in susceptible materials, such as aluminum, in order to maximize the ability to detect laps. Without softening, converging flow may appear to "push out" without forming a lap. Many DEFORM material definitions include flow softening characteristics.

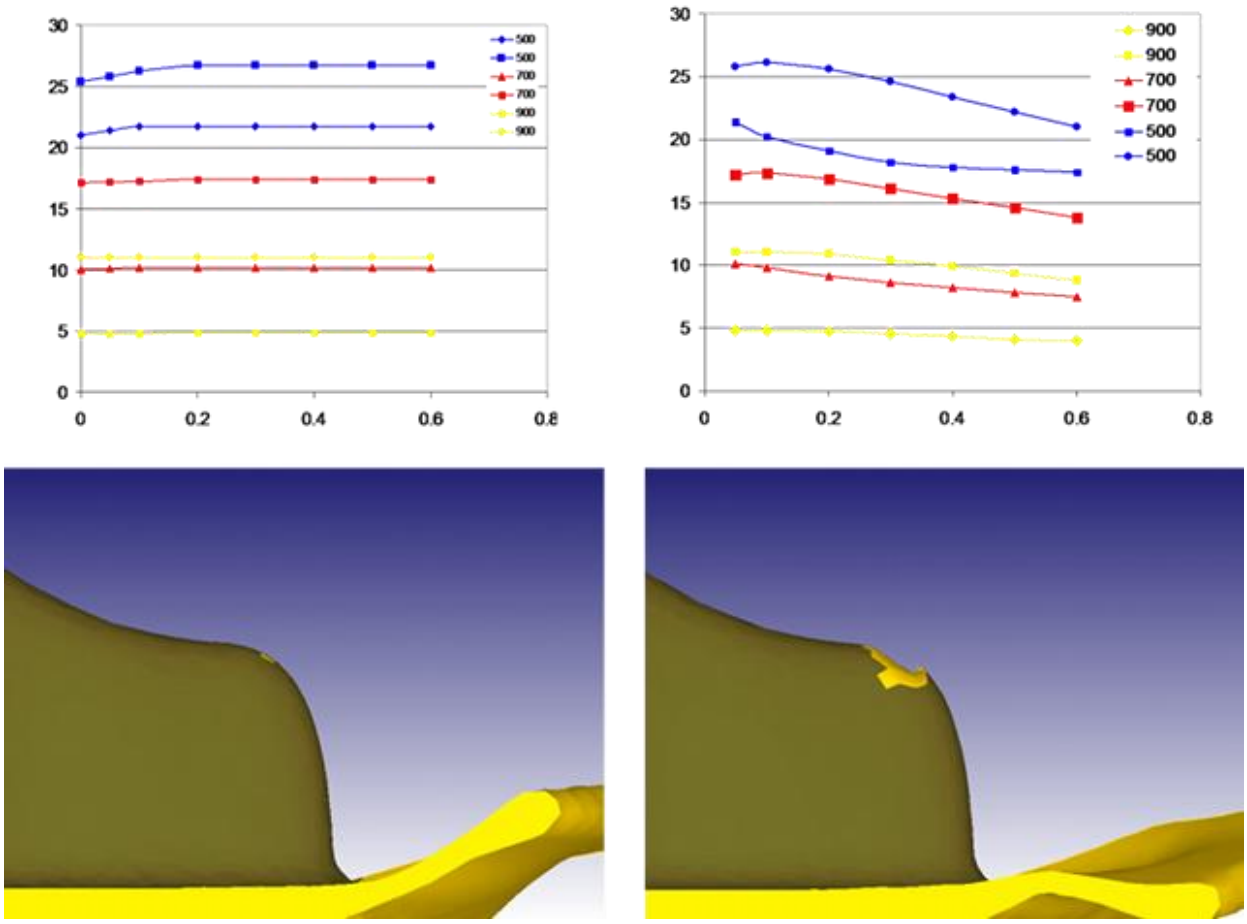


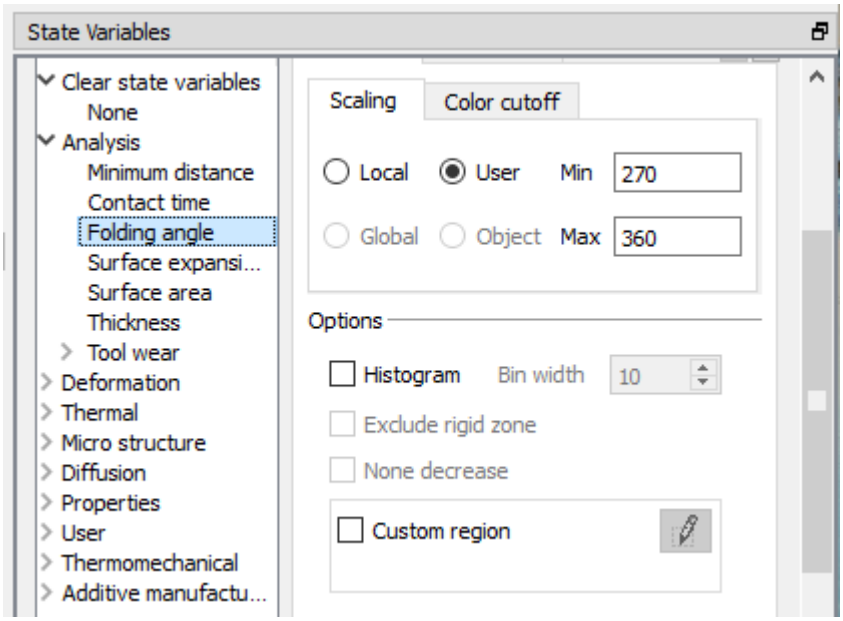
Figure 2: Flow stress curves and results without (left) and with (right) flow softening.

Post-processing Techniques

There are several post-processing features that can be employed when inspecting for small defects. First, close examination of results is recommended and cannot be overstated. Animations may be the best tool for identifying defects because they show material flow and defect evolution. Some defects may not be seen in the very last step, but can be clearly observed forming during an animation of the process.

Second, automatic fold highlighting should be turned on if folds are indicated in the object tree at any step. Fold highlighting tracks folds that were removed during global remeshing.

Next, the "Folding angle" state variable can be turned on with a 270-360 user-defined scale, the "General" colorbar and "Print friendly" display. Plotting the fold angle contour in this way will enhance the contrast of small radii and laps in the display. Turning on the "Surface patch+" display will also enhance the display of edges and folds.



Finally, an adaptive offset FLOWNET should be applied when flow defects such as "suck-ins" are a concern. The FLOWNET can identify flow defects that may not be visible on the mesh surface.

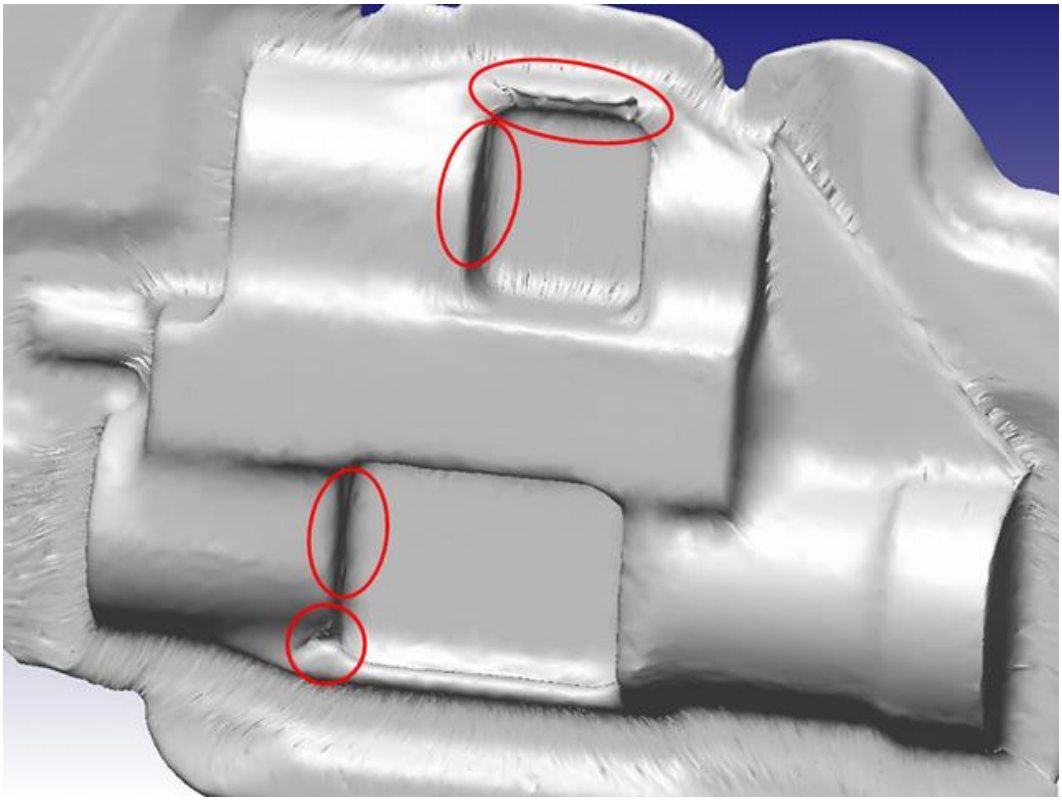


Figure 3: Offset FLOWNET surface results clearly showing defect locations in a forging. Courtesy DLA, FDMC & Consolidated Industries.

Related Information

The attached .pdf presentation can be referenced for more information regarding small defect detection.