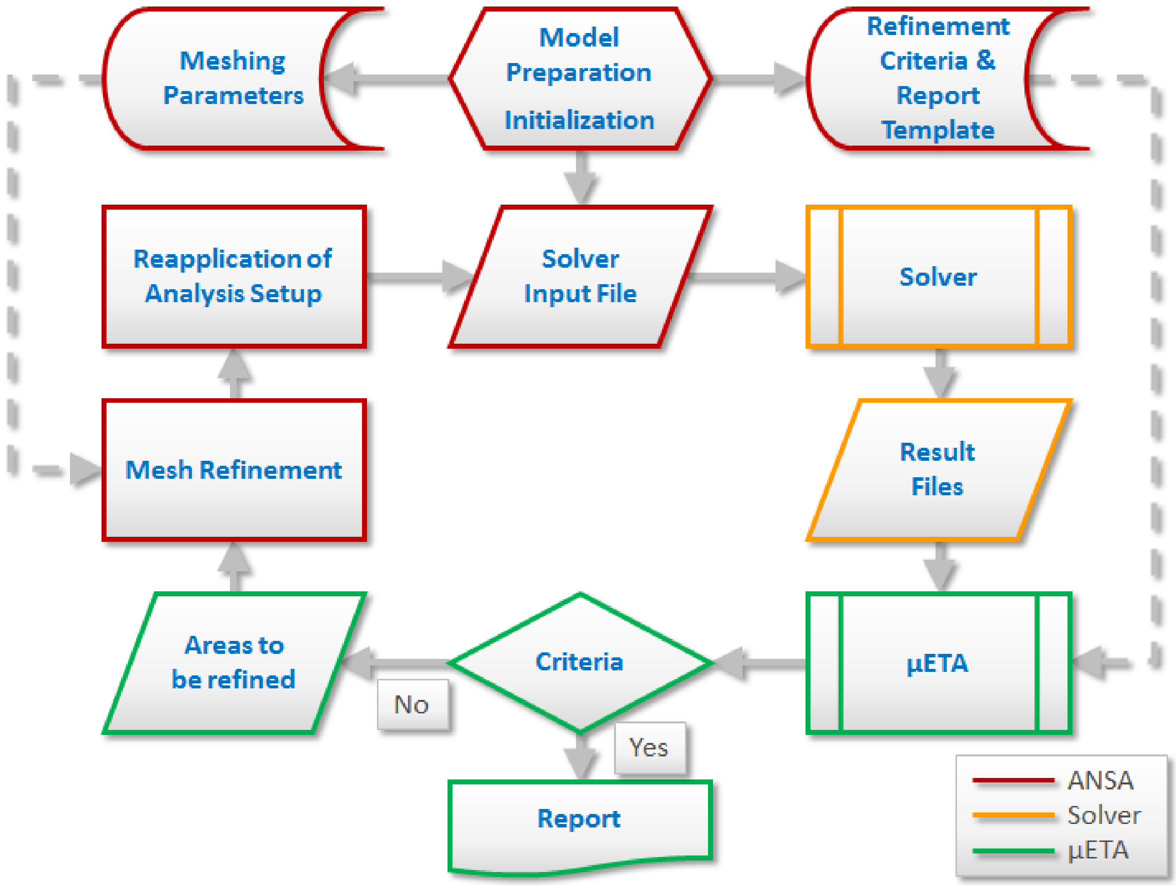
BETA
SIMULATION SOLUTIONS

physics on screen

Results-based mesh refinement with ANSA / META pre- and post- processing suite

Introduction

Ideally, a mesh should represent the initial shape of a structure in such precision that will ensure the accuracy of the results. Furthermore, especially for small features, where stresses are higher, the description should be even more accurate. Generating, however, a fine mesh globally would add up to computational costs. In addition, it is not always obvious which areas should be manually refined while h-adaptive meshing within the solver lacks in user control and has restrictions such as the inability to refine important areas (i.e. areas on which boundary conditions have been defined). As solvers can do the refinement only in orphaned mesh it is not possible to reduce the discretization error in critical areas. BETA CAE Systems offers the ability, through ANSA / META pre- and post- processing suite, to optimize the mesh refinement process achieving accurate results, reduction of computation time, and controllability over the process.



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The Results based mesh refinement Process

The process can be easily set-up in ANSA through a simple purpose-built interface integrating all the necessary settings and it is available for NASTRAN and Abaqus as a provided user script. The refinement process takes advantage of the meshing capabilities of ANSA and the filtering functionality of META

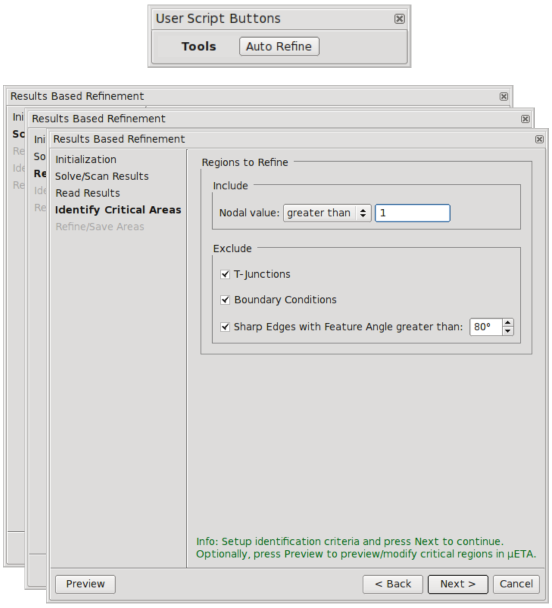

Figure 1: Interface for results based refinement

The prerequisites, for running the mesh refinement process, include all the parameters related to meshing and model setup, the criteria for the identification of critical areas, the maximum number of iterations and optionally a report template.

For the identification of critical areas, the analyst is able to manually select the areas for refinement or set and combine a series of criteria for automatic identification. Additionally, it is possible to define custom criteria calculated by the META post-processor and not the solver.

The commonly used error estimation calculations are based on various nodal calculations which vary from simply averaging from the neighbor elements to calculation discontinuities and errors

Once the refinement process starts, the pre-processor exports a solver input file and initializes the solver. The solution procedure is monitored by the pre-processor and when it finishes successfully, the post-processor is called. The result files are read and the areas in need of refinement are identified, according to the criteria previously set. If no such areas are found or when the maximum number of iterations is reached, a report is created and the process ends. Else, the identified areas are communicated back to the pre-processor.

At this stage, the engineer has the option to let the process continue without any interruption or pause to review and modify the critical areas.
Then, the preprocessor applies the mesh refinement. When finished, the analysis setup (application of loads, constraints etc.) is reapplied automatically, a new solver input file is exported and the cycle continues.

Example case: Mesh refinement on a Bracket

Figure 2: The Bracket consist of a reasonable but still complex CAD geometry

In this example, a model of a bracket (Figure 3) is used and by applying the afore mentioned process we acquire accurate von mises stress results through refinement on critical areas. As criterion for the mesh convergence the *Probable Error* was used. The criterion is calculated in META by reading stress results exported by NASTRAN.

A moment of 75kN is applied on the two upper holes while all other holes are fully constrained (Figure 4). All boundary conditions were created through a set builder, a special ANSA entity which can be automatically recreated after each refinement iteration. The initial average

mesh size was set to 10mm second order tetra elements, adequate but still not capable to accurately capture all geometrical features.

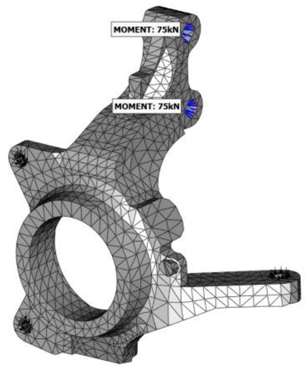

Figure 3: Loading conditions on initial mesh

The process was setup to run until the probable error dropped below unity in areas where the stress was higher than 20MPa, excluding areas on sharp corners after the second iteration. After the initial run, several areas with high stress values were recognized (Figure 5). In most of them, the probable error values were higher than the requested (Figure 6).

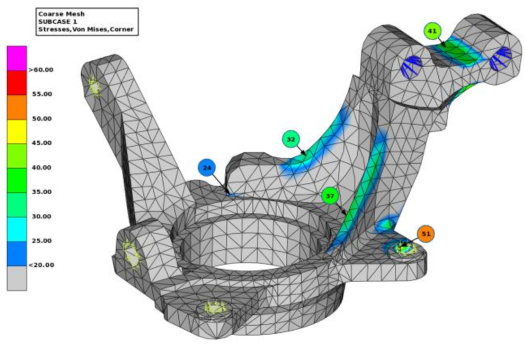

Figure 4: Von Mises Stress results at first iteration

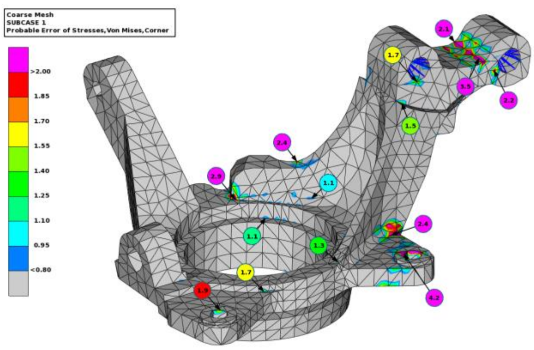

Figure 5: Areas where the probable error is more than 1 at first iteration

The process is paused after solving the model for the first time, and the areas that require refinement are highlighted. (Figure 7).

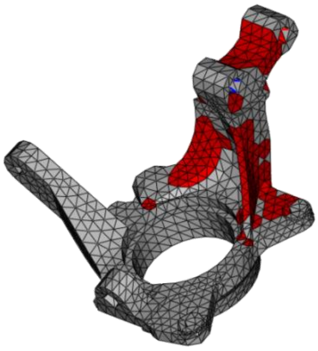

Figure 6: the process can be paused to confirm of alter the areas to be refined

Upon confirmation, the areas are refined and a new version of the model is solved again. The probable error is reduced in some areas but further refinement is needed in certain fillets (Figure 8). Additionally, at the next iteration, high errors appearing in sharp corners are ignored and no further refinement is applied on them.

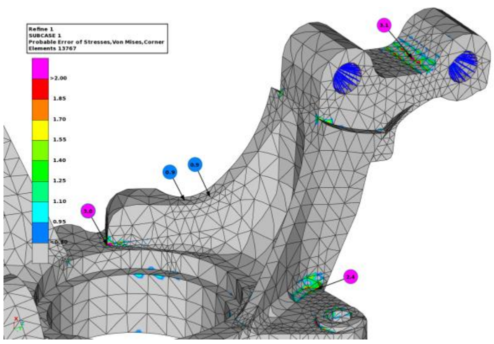

Figure 7: Probable error after first refinement

After four iterations the probable error is reduced close to zero (Figures 9) at the areas of interest.

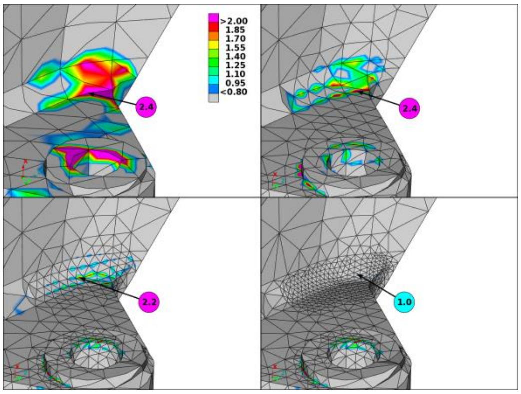

Figure 8: Probable error values are minimized after four iterations

The element size at the refined areas is about 1mm and the total number of elements after all iterations reached about 25.000 tetras. Meshing the whole model with a 2mm element length would produce over 240.000 elements.

Benefits

Realization of such refinement process within ANSA & META package verified, that even for relatively small models, the analysis time to achieve accurate results is greatly reduced. This is achieved with the least possible increase in the number of elements and with minimum time spent assuring, an error-free procedure. These benefits are magnified if the models size and complexity increases