December 12, 2007

FE Update: Use surface contact for more accurate simulations

Structural behavior in the real world is often quite complex.

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Engineers typically must make simplifying assumptions to do an analysis so they can determine a design direction. Creating an analysis model requires decisions on a range of issues regarding the most appropriate way to represent materials, loads, and constraints. Some examples include:

- Can the material be described as isotropic or must directional properties be considered?
- Is it sufficient to use structural-only element properties or is a multiphysics analysis required?
- Can load transfer from one part to another in an assembly be simplified or would modeling surface contact give a better solution?

Exploring the last question is a good way to illustrate how continual enhancements in FEA codes allow constructing models with higher levels of realworld fidelity and accuracy. For this exercise, lets model a crankshaft-bearing load onto a connecting rod. Older or more limited FE codes may restrict users in their choice for representing load distributions to points, lines, or pressures. Under these circumstances, a widely used technique to simulate crankshaft bearing load is with a simple linear arc of loads, say 60° around a reaction-force vector. However, this simplification cannot capture several physical complexities in the actual parts which can have important design consequences.

First, due to the mechanical relationship between the real rod, bearing, and crank journal, there will often be more force acting in the center of the load arc and less at the extremities. Second, the angle of the real load distribution is directly related to the clearance and stiffness between mating components more clearance yields a smaller arc with greater local forces at the center. These differences will likely result in a different stress in the radii of interest on the connecting rod when comparing the real expected response to the simplified case, because the radii of interest is near the load zone. Third, when making comparisons between designs, changes can affect the load distribution. This, in turn, affects the comparison. So, in this case, using surface contact rather than simple “linear-load” methods can provide a more precise view of the stresses in the parts. The benefits of this information are more insightful design decisions which can affect part optimization, quality, and cost.

Accurate load distributions between components in FE models come from simulating contact between them using multiple deformable bodies. This is often called surface contact because users define which surface on a part is expected to contact another surface on another part. For the connecting rod, users would tell the software to expect surface contact between the crank journal and rod bore. A contour map of contact forces from a crankshaft would show a load reaction unevenly distributed in the rod bore.

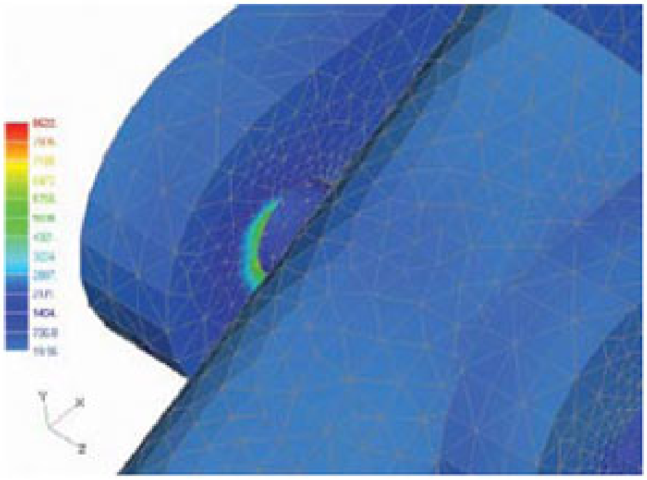
Resulting stresses in the rod near this area are more accurate than results from simple linear-load assumptions.

While it is clear that simulating load distributions with contact surfaces provides a more accurate mechanical response in an analysis, the engineer is faced with the questions of how much more difficult and how much extra effort is required in setting up models using this approach?

The most recent versions of some FEA software greatly reduce the time and work involved. For example, the Automatic Surface Contact Generation in NEi Nastran V9.1's lets users tell the program to find, create, and activate appropriate surface contacts. The software can also run with the efficiency of a linear solution. When the only nonlinearity is contact, the user can run the FE model with surface contact and the linear solver. This approach lets the analysis finish faster and with the benefits of surface-contact load distributions.

It is also interesting to note that software developments that make contact possible have other benefits. For instance, it's easier to connect two surfaces with dissimilar meshes, such as "welding" the surface of a tetrahedral mesh to a hex- meshed surface. "Welding" two dissimilar shell meshes together cuts hours off projects that involve extracted mid-plane models where it is common that meshes on multiple surfaces do not line up. The feature is also useful when joining surfaces of imperfect CAD geometry. Interested readers can find additional examples of how to use surface contact to improve model fidelity and accuracy at neinastran.com/surfacecontact.

The applied load distribution in a rod bore is assumed constant across a 60° arc and constant through the Z-axis thickness. Although the assumption produces only a rough estimate of stresses, it's a frequent FEA practice



A linkage assembly is made with surface contact and run with linear material properties. With NEiNastran V9.1, surface contact works with the linear solution sequence and runs faster (12% of the time in this example) than with a nonlinear solution.

Consider the connecting rod in tension combined with some crankshaft twisting. The skewed load distribution is accurately simulated with multibody contact conditions in the FEA. The color contour, generated by NEi Nastran V9.1, represents a more realistic load distribution of contact forces than would come from simplifications.