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Creep analysis

I know what you are thinking. No, this is not about some "creep" you are working with at work. Creep is also associated with terms like "stress/rupture" and refers to a material condition where, at elevated temperatures, under certain load conditions, a material will continue to change geometry. Why is creep analysis important? Well, there are two reasons. First, it is required by "the Code," which is basically all pressure containment codes throughout the world. This analysis is important for both static and rotating equipment. Yes, is it complicated, and API-530, ASME Section III, Subsection NH, Appendix T and ASME Section VIII are examples of codes that discuss this subject. What is now an old rule (to the young folks, "garbage in, garbage out") applies here as well. What is interesting about creep analysis is it can be a wonderful piece of work or complete useless junk and have the same appearance. Yes, the pretty graphs, plots and reports that convince us everything is correct — or is it?

There are two basic playmakers with creep analysis. The first is called "load controlled" stresses and the second is called "strain controlled" stresses. Many textbooks have been written about this, but here is the condensed version of what is happening in each. Load controlled stresses are stresses that are constantly present and are not a function of time. Remember the old "fiber board" shelf you put in your closet? With no weight on it, a few weeks later it had sagged. Examples of load controlled stresses would be weight and pressure in static equipment. It could be centrifugal stresses in rotating equipment. Strain controlled stresses are, in general, a function of time. A good example of strain controlled stresses would be thermal stress. Another would be a local stress that would redistribute the loading by local yielding.

The next question is, "How do you go about this analysis?" Like I said earlier, it is not a simple analysis. One of the biggest mistakes is attempting to do this analysis with an elastic approach. A good example is cracking furnace tubes. Sometimes an elastic analysis is done and the results are compared to material "stress/rupture," or creep data. While this is a good estimate of what may be going on, it typically does not give accurate results and may even give incorrect results. Most problems in industry have several components of creep, which involve steady state and transient conditions. In industry, transient creep is most often overlooked in design and failure analysis. This is because it involves start-ups and shutdowns. Sometimes the transient creep may be the governing factor in the design.

It is my viewpoint that in order to perform an accurate analysis for creep, an elastic plastic model incorporating creep should be conducted. For many cases, these problems need to be a transient analysis.

In general, a methodology one may use is as follows:

1. Gather good data on the material you are evaluating. This may come from both the Code data or from the manufacturer of the material. Having several sources of information is important because the data can vary. It is important to have the material properties from the vendor that is supplying the material if at all possible.

2. Develop a numerical tensile test. Now this may sound "off the wall," but it is important to validate your numerical model. Run the test model at "creep" conditions that would lead to stress rupture and determine your model is calculating accurate results. This model should be compared to the actual creep data results. If you cannot get the numerical tensile test run correctly, forget about the real problem because the results will get garbage.

3. Develop a detailed model of the geometry of the problem of interest. The mesh may have to be refined several times to capture local conditions that may affect the results. Nonlinear elastic plastic models with creep are very sensitive to mesh design and element types.

4. Perform a Code analysis in accordance with the governing Code.

As with many of these complex systems, this analysis should be led by a professional engineer competent to do the work using a multidiscipline approach.

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