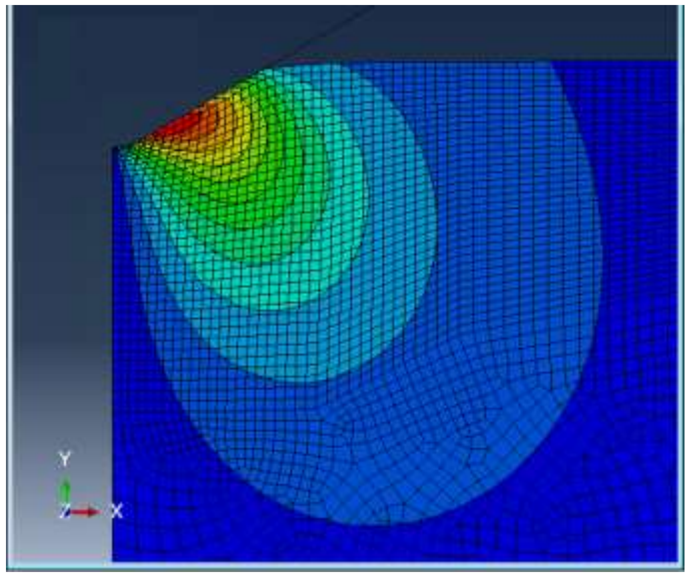
MECH 493 project:

Finite Element Modeling of Indentation Mechanics

Prof. G. S. Schajer, Renewable Resources Lab
www.rrl.mech.ubc.ca

Background and Research Goal



Interest in indentation modeling is motivated here by its potential to be a non-invasive method for measuring residual stresses. Residual stresses are "hidden" stresses that exist in materials, typically created by production processes such as shaping, welding and heat treating. The are self-equilibrating, so exist in the absence of any external loads. They are important because the add to the service stresses that are considered during design, and can create total stresses than are much greater than anticipated, thereby leading to faulty design and component failure. It is therefore very important to be able to measure residual stresses so that their size can be known and taken into account during the design process.

Since residual stresses exist in the absence of external load, the usual stresses measurement method of measuring the change as the load is added or removed is not available. Instead, the load can be partially removed by removing some stressed material and measuring the resulting change in the surrounding material. This is the basis of the popular hole-drilling and slitting methods. However, the removal of some stressed material damages the specimen and can make it unsuitable for further service. The indentation method is attractive because the "damage" it produces is just a small indentation, which is typically does not affect component functionality.

The load vs indentation depth response and the in-plane displacement response are both influenced by the presence of in-plane residual stresses, with tensile residual stresses decreasing required indentation force and increasing in-plane displacements, and the opposite for compressive residual stresses. Here, the interest is to quantify the indentation response using finite element modeling so as to provide a calibration procedure so as to evaluate the residual stresses from practical indentation measurements.

The project involves:

1. Getting up to speed with an existing 2D finite element model of the indentation process
2. Extending the finite element model to include the elastic compliance of the indenter. At the moment the indenter is simplified as being rigid
3. Use the experience from the 2D model to construct a 3D model of the indentation process. This model needs to be optimized to give reliable results while requiring a minimum o f computation time.

The required finite element work will be of a sophisticated level because it involves non-linear material properties. The target 3D model will be challenging to design so that it can run in a reasonable time, but success will be very satisfying. The project is suitable for 1-2 independent-minded students who have completed and did well in the MECH 462 finite element course and who are interested in working further in this field.

This project will be done in the Renewable Resources Lab under the supervision of Prof. Gary Schajer. General guidance will be provided, but it is hoped that student(s) will display substantial initiative and will work largely independently, that way multiple brains will be active !