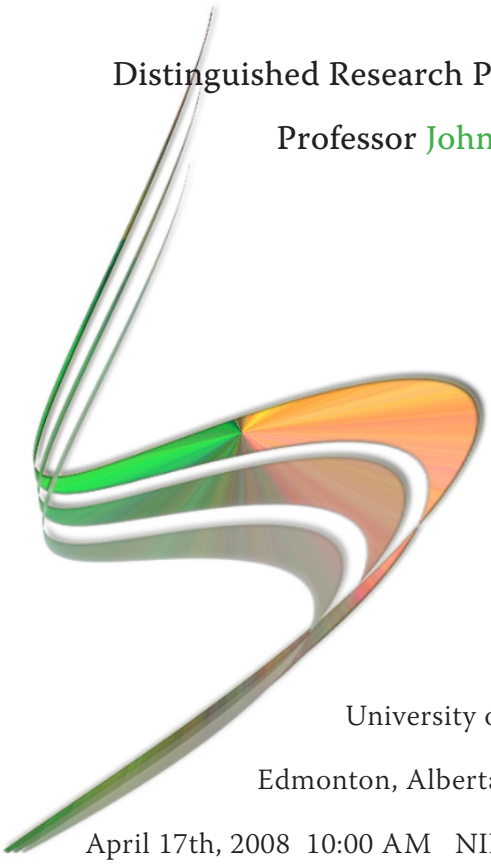

Distinguished Research Professor

Professor John Goldak

Seminar

University of Alberta

Edmonton, Alberta, Canada

April 17th, 2008 10:00 AM NINT 6-011

Computational Weld Mechanics: Current State and Future Trends

Computational weld mechanics (CWM) deals with the continuum mechanics in and near a weld heat source such as an arc, laser or electron beam. CWM involves a set of coupled problems. The first is the conservation of energy. In most cases, this can be solved to compute the temperature distribution in the solid outside of the liquid and plasma regions of the weld heat source. It requires a model of the weld heat source that adequately describes the distribution of energy in the weld pool. This heat source model does not predict the shape of the weld pool. More sophisticated models. solve the quasi-static momentum equation together with the conservation of mass and momentum are able to predict the weld pool shape including the effects of arc pressure, surface tension and hydrostatic stress. Even more sophisticated models include inertial, Lorentz and Marangoni forces in the weld pool. The ultimate in sophistication include the magneto-hydrodynamics of the plasma.

The evolution of microstructure during solidification, solid state phase transformations and grain growth can be simulated with density models that compute scalar fields, such as phase fraction, or synthetic microstructure models that have a representation of individual grains and follow their nucleation and growth.

Stress analysis is visco-elastic-plastic in the solid and Newtonian flow in the liquid. The thermal expansion of individual phases due to changes in temperature and to phase changes drive the evolution of stress and strain.

These models are 3D, nonlinear transient, coupled PDEs. We solve them using FEM methods. Because weld heat sources are often small relative to the structure being welded, they were first treated as singularities. Even today to highly localized nature of weld pools is an essential aspect of numerical models in CWM. Although they are computationally intensive they can now be solved comfortably on modern desktop computers. Managing the complexity of the geometry and the process is a significant challenge. To be useful to industry, it must be designer driven.