TU Graz
Graz University of Technology

Institute of Materials Science, Joining and Forming
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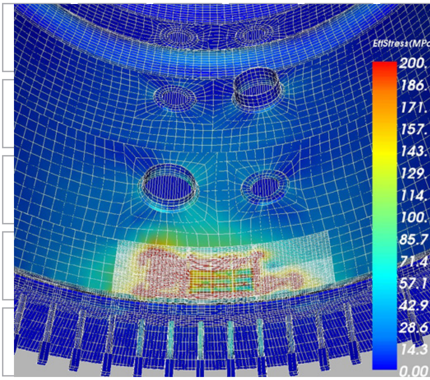

Post Conference Workshop
Optimal Design & Computational Weld Mechanics
Prof. John Goldak
26. September 2018 1:30 - 6:00 pm

12th International Seminar
Numerical Analysis of Weldability
23.-26.9.2018

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Introduction

1:30 - 2:00 PM. ***Fundamental Phenomena in Weld Mechanics.***

Transient temperature, microstructure changes, displacement, strain and stress are the fundamental fields that must be managed in welding technology. We begin with four simple tests in which these fields vary in time but not in space; the zero stress test, the zero strain test, the Satoh test and the 3-Bar test. These tests show how these fields interact in a thermal cycle for a low alloy steel to generate the final displacement or distortion, residual stress and microstructure. The computer models of each of these tests runs in less than one minute. Videos of the 3D graphics of these tests enables the changes and interactions to be clearly seen. These are the fundamental building blocks of CWM. They play a fundamental role in the CWM of complex structures such as nuclear reactors, pipelines, ships and tractors. Because the only input data required for each of these tests is the alloy composition and the thermal cycle, i.e., temperature as a function of time, these tests are easy and quick to run for different alloys and different thermal cycles.

2:00 - 2:30 PM. ***Transient Non-Linear Mechanics in the Weld Pool Region.***

Armed with an understanding of how the fundamental fields interact in welding technology, we now consider how the power from the arc generates a molten weld pool. Unlike the simple tests in the first session, heat flows from hotter weld pool to colder HAZ regions. As the liquid metal in the weld pool solidifies, the alloy components segregate to form grains. As the grains cool, they shrink because of thermal contraction but when the microstructure phase changes, e.g., from austenite to ferrite, bainite or martensite, the specific volume expands. The thermal and mechanical properties depend on the crystal type, composition, the size and shape of the grains and the presence of precipitates. The user does not have to be an expert on material science of how the microstructure evolves. The videos of the 3D graphics enables one to see how the temperature field and the microstructure field evolve. Computing this transient temperature field for a given weld procedure is the first step in a CWM analysis for a given weld procedure for a typical weld procedure takes a few minutes. One must specify the width, depth and length of the weld pool, the net weld power, i.e., arc efficiency x voltage x current, the weld speed, the weld path, the start point on the weld path and the end point on the weld path.

Given the transient temperature and microstructure at each point in the weld structure, one can compute transient stress, strain and displacement at each point in the weld structure. The same algorithms are used to compute this stress as were used in the simple tests in the first session of the seminar.

2:30 - 2:50 PM. ***Developing a Weld Procedure for Overlay Weld Repair of a Submarine Hull.***

Because the submarine hull is made from HY-80 steel, overlay welds must use a temper-bead weld procedure to produce a microstructure with the required tough- ness. Temper-bead welds use the thermal cycle of one pass to temper the hardened zones in the previous weld passes. The CWM analysis that we used to develop this weld procedure will clearly show the transient temperatures, evolving microstructure, stress, strain and distortion in overlay welds of 52 weld passes. The agreement between the results predicted by the computer model, VrWeld, and experimental results is remarkably accurate.

2:50- 3:10 PM. ***Designing a Overlay Weld Repair for AECL's NRU Reactor Repair in 2009-2010.***

In May 2009, the NRU reactor was producing more than 80% of the worlds isotopes for medical and industrial tests when a heavy water leak was detected and the reactor was shut down. The strategy chosen to repair the reactor was to use overlay welds to restore the wall thickness of the vessel wall in ten patches where the reduction in the wall thickness by corrosion had been reduced to unacceptable levels. Goldak Technologies Inc. did the CWM analysis of the design of the overlay weld procedure for each weld patch was done before a mockup of the weld repair was done for that weld patch.

3:10 - 3:30 PM. ***Hot Tap Welding Pipelines with Temper-Bead Welds.***

Branch pipe connections made on operating pipelines must consider the effect of the pressure and flow rate in the run line on the cooling rate and hardness of the welds on the run line pipe. Temper bead welds are used to control the HAZ hardness. Cooling rate tests on the run line pipe are made to estimate the cooling rate. Computer models to simulate such cooling rate tests and the hot tap welds that include temper bead welds will be discussed.

3:30 - 4:00 PM. ***Design of Welded Structures to Maximize Fatigue Life.***

It is often claimed that more than 80% of fatigue failures in welded structures are associated with welds. Tensile residual stress are known to reduce the fatigue life significantly. CWM offers several approaches to maximize fatigue life. We will show that weld procedures can be developed that have essentially zero residual stress. We will demonstrate that CWM provides methods to predict fatigue life of welded structures that are more accurate than the strategies recommended by current IIW and ISO standards.

4:00 - 4:30 PM. ***AWS Code for Verification and Validation of Software for CWM.***

Given a software package such as VrWeld, should a decision maker trust predictions from the package in making a decision? Verification & Validation provides guidelines that the decision maker is advised to consider when assessing the extent that such predictions should be trusted in making a specific decision.
The short answer is that mockup tests should be designed for the specific decision to be made. The decision maker should assess the correlation between the predicted data and the data measured on the mockup to decide to what extent the model predictions should be trusted. The process of correlating predicted and experimental data will be discussed with particular emphasis on large data sets, e.g., fiber data and DIC.

4:30 - 5:30 PM. ***Discussion.***

Prof. John Goldak

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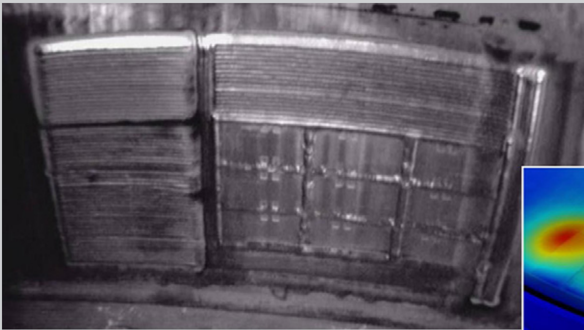

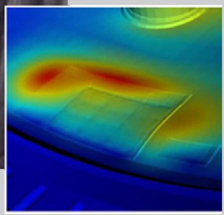

Post Conference Organization

Venue of the Workshop: Hotel Schloss Seggau, Seggauberg 1, 8430 Leibnitz - Austria	
Post Conference Workshop places are limited so early registration is advised:	
To register please contact: Bettina Foessl	Registration fee: € 100,-
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