

▶ JANUARY 31, 2018

*Speaker
Series
Seminar*

OPTIMAL DESIGN OF WELDS AND WELDED STRUCTURES

8260 Parkhill Drive Milton
8:00 AM-4:30 PM

"It is often claimed that more than 80% of fatigue failures in welded structures are associated with welds. Tensile residual stress is known to reduce the fatigue life significantly."

SPEAKER PROFILE:

John Goldak is a distinguished Research Professor, Mechanical & Aerospace Engineering, Carleton University. John Goldak is best known for his research in the computational mechanics of welds. In particular for the development of a heat source model for arc welds that is widely known as the Double Ellipsoid Weld Pool Model. In 2011, The Welding Science and Engineering Conference created The Pioneers of Computational Weld Mechanics' award to honor the contributions of Professor Yukio Ueda of Japan and John Goldak to the development of computational weld mechanics. He is a Fellow of the American Welding Society and of the Canadian Welding Association. He is a member of the Canadian Academy of Engineering. He is Founder and President of Goldak Technologies Inc. (GTI), (goldak-vrwweld.com), a company dedicated to developing software for design driven analysis and the optimization of welds and welded structures. GTI was awarded the John S. Hewitt Team Achievement Award by the Canadian Nuclear Society in 2011 as a major player for its computational weld mechanics analysis that contributed to the successful repair of AECL's NRU reactor in 2009. GTI customers include leading multinationals in the agricultural machinery industry, the Canadian Navy on computational mechanics for weld repair of submarines and leading organizations in the Canadian and USA nuclear power industry.

INTRODUCTION

8:30 - 10:00 AM. 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 transient and 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 Computational Weld Mechanics (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.

10:30 - 12:00 WELD PROCEDURES

Armed with an understanding of how the fields fundamental to welding technology interact, 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 the hot weld pool to colder regions in the HAZ. As the liquid metal in the weld pool solidifies, the alloy components segregate as the liquid changes to crystals or grains. As the grains cool, they shrink because of thermal contraction but when grains change phase types, e.g., from austenite to ferrite, bainite or martensite, the specific volume expands. The thermal and mechanical properties depend on the crystal or grain type, composition, the size and shape of the grains and the presence of precipitates. The user does not have to be an expert on the 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, which takes only a few minutes, for a given weld procedure is the first step in CWM analysis. One must specify the width, depth and length of the weld pool, the net weld power, i.e., arc efficiency times voltage times current, the weld speed, the weld path, the start point on the weld path and the end point on the weld path to compute the transient temperature and microstructure. Given the transient temperature and microstructure at each point in the weld structure, now one can compute transient stress, strain and displacement at each point in the weld structure. This stress is computed exactly as it was in the simple tests in the first session of the seminar.

LUNCH 12:00-1:00 PM

1:00 - 1:40 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 toughness. Temper-bead welds use the thermal cycle of one pass to temper the zones that were hardened 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.

1:40- 2:20 PM DESIGNING AN OVERLAY WELD REPAIR FOR AECL'S NRU REACTOR IN 2009-2010

In May 2009, the NRU reactor was producing more than 80% of the world's 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. An optimal design of the overlay weld procedure for each weld patch was based on a CWM of the design done with VrWeld by Goldak Technologies Inc. before any mockup was done for that weld patch design.

2:20 - 3:00 PM HOT TAP WELDING PIPELINES WITH TEMPER - BEAD WELDS.

Hot tap connections of pipelines enable a new pipeline to be connected to an operating pipeline without shutting down the operating pipeline. Since a pipeline can cost hundreds of millions of dollars or more, avoiding the lost income that would be incurred by a shutdown is important. Although the technology to do this for connecting smaller diameter pipes to larger diameter pipes exists, CWM has the potential to optimize this technology. In particular CWM can predict the cooling rate based on the fluid type, pressure, flow rate and pipe size, wall thickness and alloy type. It can also compute the convection coefficient from cooling rate tests that measure the time to cool a 2" diameter spot heated to 300 C to 100 C and to near ambient temperature. With the computed convection coefficient and the weld procedure, VrWeld can compute the microstructure including the hardness, residual stress and distortion.

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 is 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

I am a founding member of the AWS committee that wrote this standard. 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 specific mockup tests should be designed for the specific decision to be made. In fact CWB WPDS would be excellent examples of mockup tests if sensors were added to gather experimental data. 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.



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LOCATION: CWB GROUP HEAD OFFICE

8260 Parkhill Drive, Milton ON L9T 5V7

DATE: JANUARY 31, 2018

Time 8:00 AM – 4:30 PM

REGISTRATION FEES:

CWA Members \$250

Non Members \$325

Educators \$150

Students: \$100

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