Development of a Highly Reliable Hot Isostatic Press Can Weld

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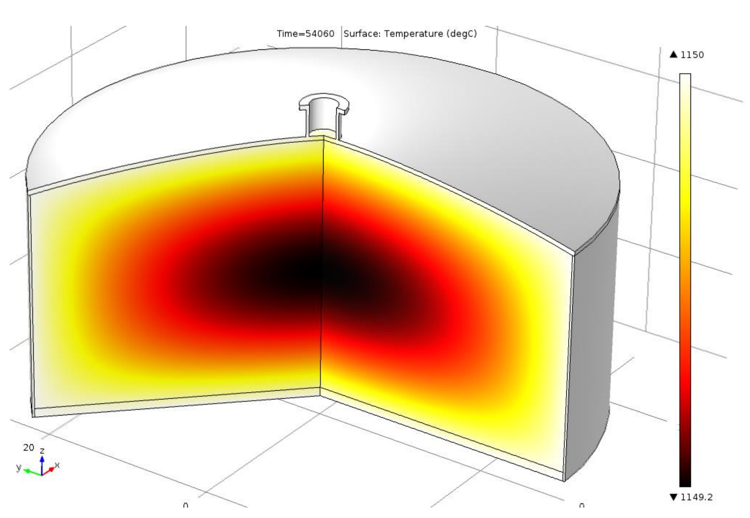
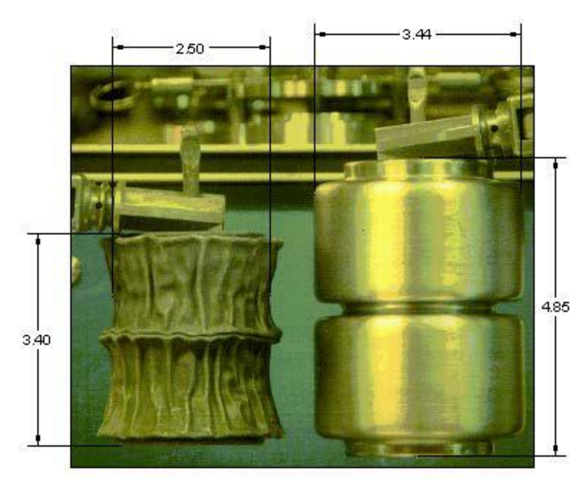
Introduction

- Hot isotactic press (HIP) technology is a reliable way to treat and dispose of nuclear waste with the HIP Can subsystem being used as primary containment
- This container will be used as a boundary in order to apply high temperature and pressure to the waste it contains to produce the desired glass ceramic final form.
- To have a HIP can with 99.99% reliability it is important to establish weld metal integrity throughout the duration of the process
- Grade 316L stainless steel was chosen due to its high temperature and corrosion resistant properties

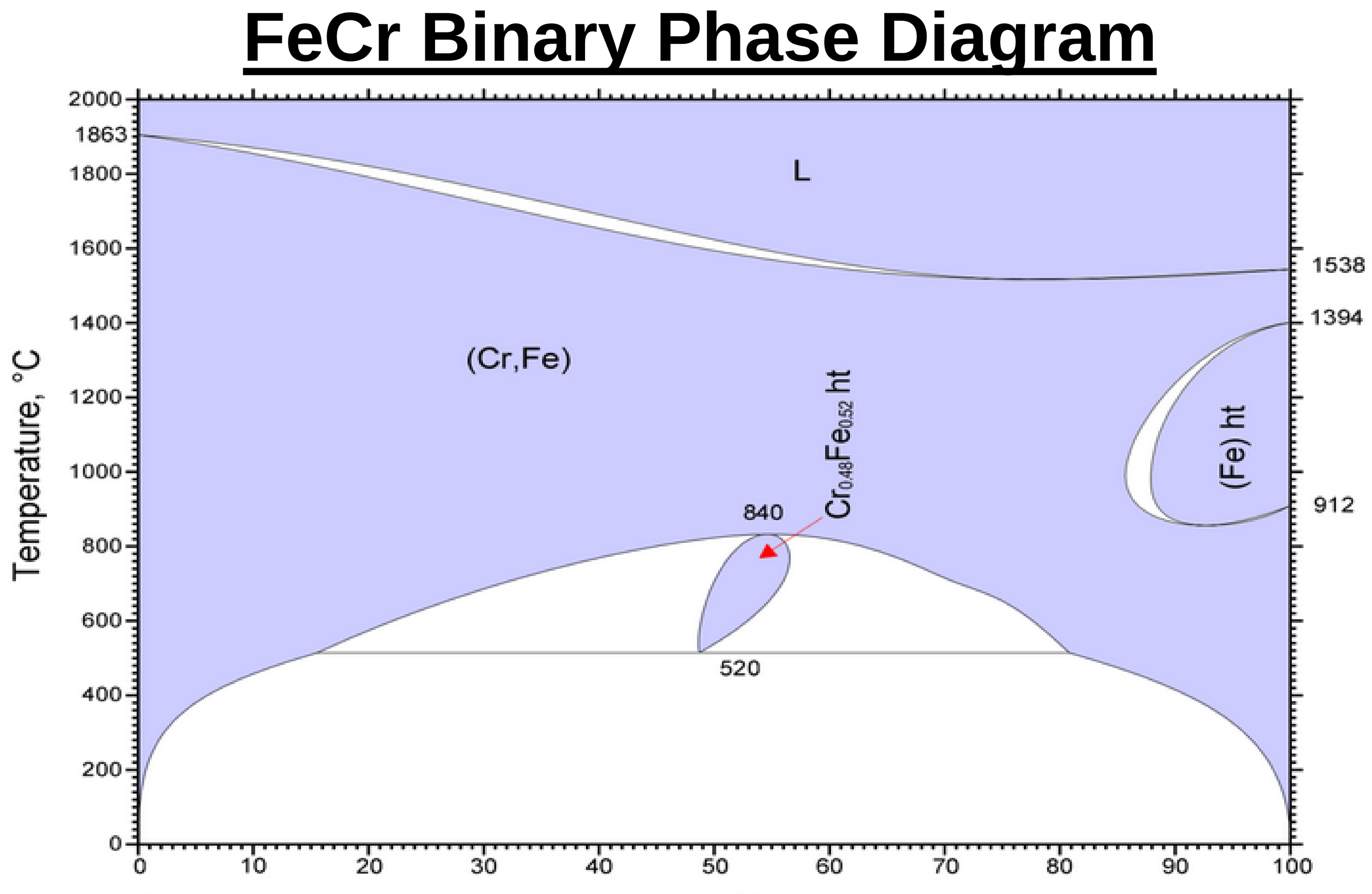




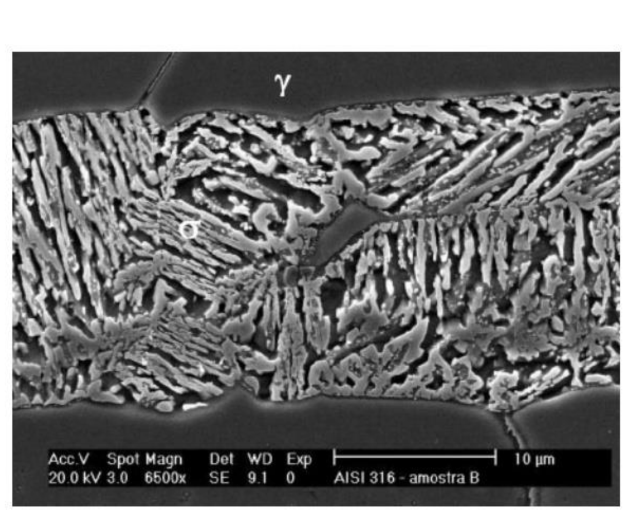
Background

- In order to maintain strength and ductility it is necessary to control the precipitation of an embrittling phase known as sigma phase
- The presence of ferrite in the microstructure accelerates the formation of this phase
- Using filler metals to control the ferrite content of the weld metal is one way of combatting this problem
- Sigma phase characteristics:
  - It is an equilibrium FeCr phase
  - The precipitation range is roughly 600 to 900°C
  - May form in post-weld heat treatment of large structures
  - Reduces corrosion resistance, ductility, and toughness

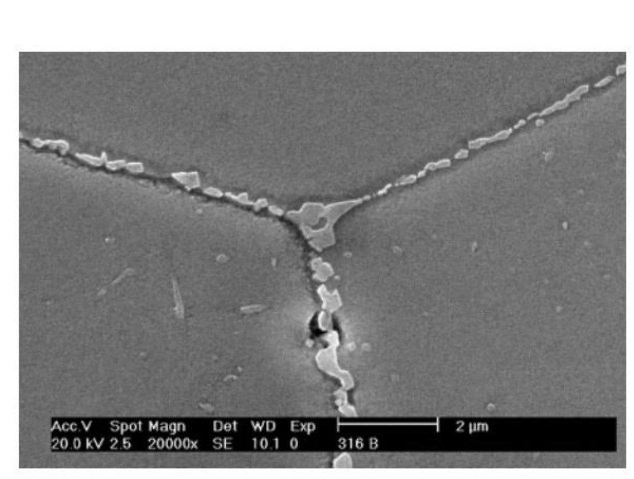
FeCr Binary Phase Diagram



In the phase diagram above, the sigma phase formation range is indicated its molecular formula ($Cr_{0.48}Fe_{0.52}$)



2 Sigma phase precipitation inside ferrite on gauge length of creep sample of 316L steel tested at 550°C for 85 000 h with load of 150 MPa: etchant – V2A Beize, SEM



3 Sigma phase precipitation at grain boundaries on gauge length of creep samples of 316L steel tested at 550°C for 85 000 h with load of 150 MPa (SEM): etchant – V2A Beize

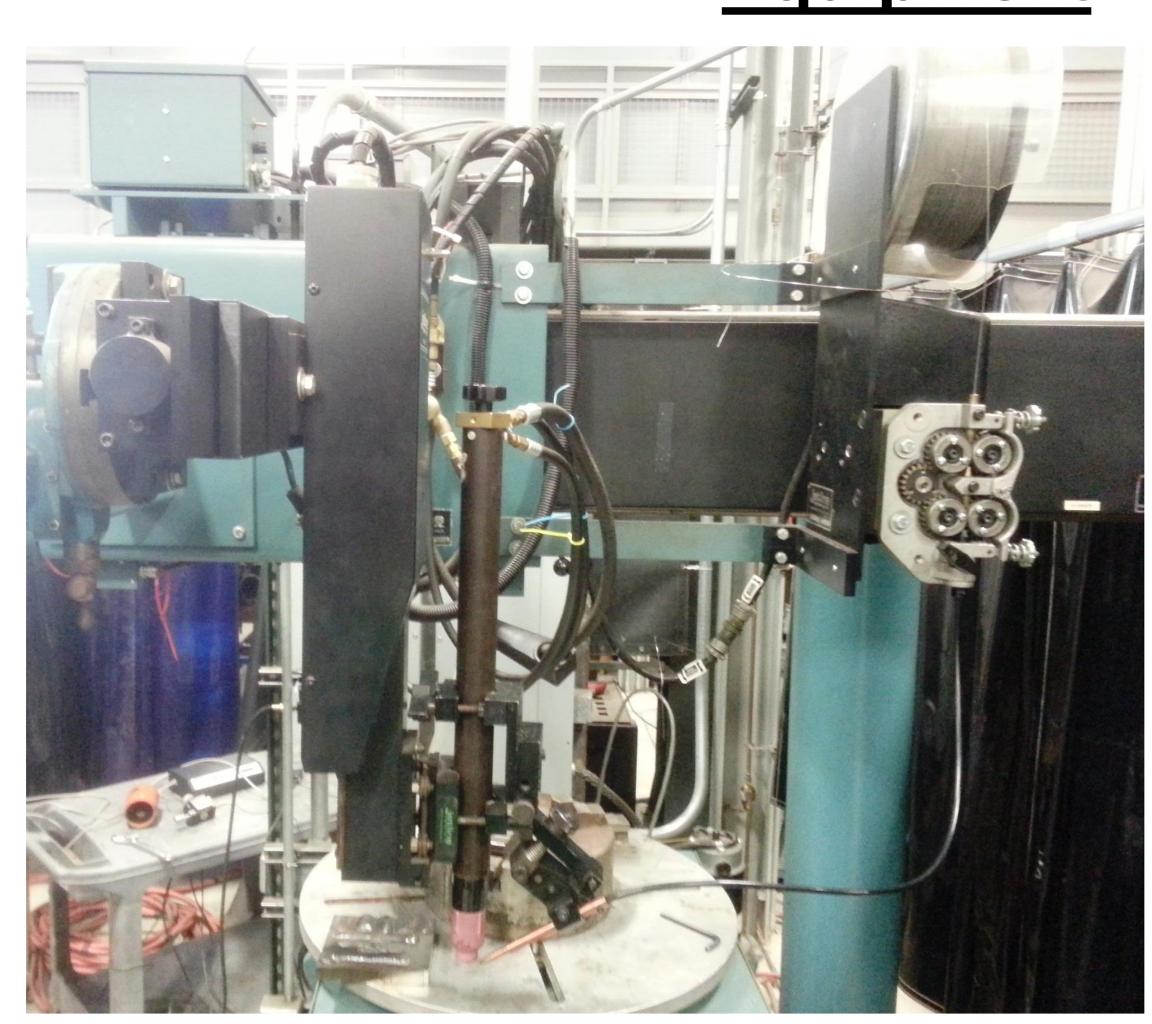
Objective

- Research the HIP thermal cycle and its effect on material properties
- Show the affects of time at elevated temperature on sigma phase formation

Proposed Experiment

- In order to create a worst case scenario which is ideal for the formation of sigma phase we will use a filler metal with a relatively high ferrite number.
- Cooling time to be controlled in an attempt to not only replicate actual times used by the HIP process but to gauge the amount of sigma phase present based on slower/faster times as well.
- Bead-on-plate welds will be made on 0.25″ plate using 0.035″ diameter wire. These welds will be sectioned and taken up to temperature (1150°C). These sections will be analyzed in three different groups based on cooling time:
  - Quench
  - 8-10 hours
  - 24-25 hours

Equipment



Jetline cold wire TIG machine (left) and controller (right)

Results

- Sigma phase precipitates from residual chromium rich δ-ferrite
- Ferrite content can help control final microstructure to get preferred mechanical and corrosions resistant properties
- It is necessary to maintain a high enough ferrite content to prevent problems like WSC while keeping it low enough to avoid excess sigma phase precipitation
- Cooling rate can be controlled in order to adequately avoid the sigma precipitation region within the HIP thermal cycle

Acknowledgements

We would like to thank the CH2M and the Idaho National labs for giving up this opportunity to study this crucial issue in nuclear waste. As well as, Dr. Farson, Dr. Lippold and Dr. Phillips for their guidance.