The Fundamental Creep Behavior Model of GR.91 Alloy by Integrated Computational Materials Engineering (ICME) Approach

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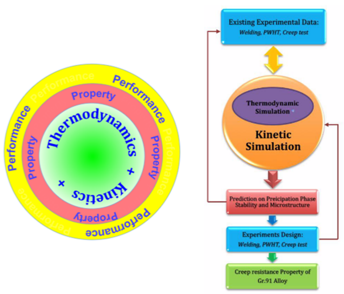
Project Objective & Scope

- Investigate the fundamental creep cracking mechanism of the Gr.91 alloy at advanced power generation operating conditions to establish a link between composition, processing parameters, phase stability, microstructure, and creep resistance using the ICME approach.

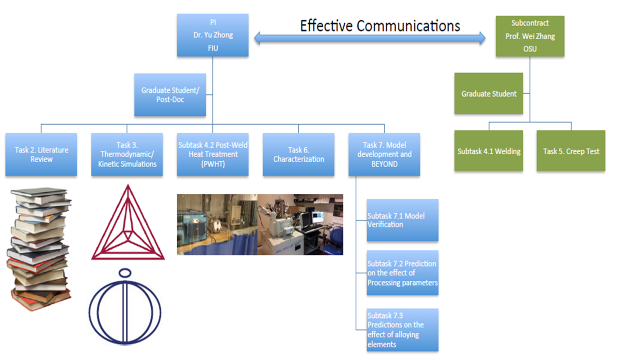
Anticipated Project Benefits

- Development of a model that will improve the creep resistance of Gr.91 alloys for use in advanced fossil-fueled power generation systems and other applications.
- Increase in fossil-fueled power generation efficiency and reduced emissions.



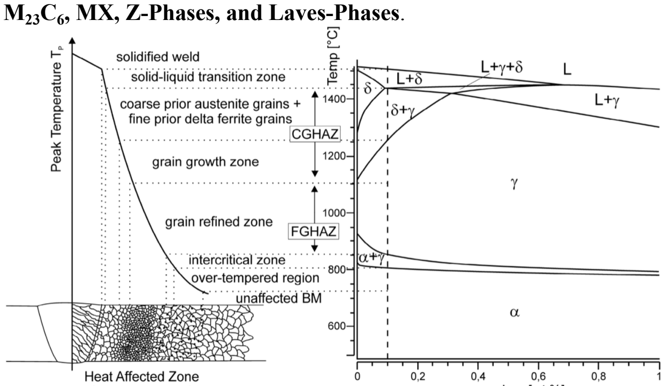
Materials Design Using ICME Approach

Team Description and Assignments



Introduction

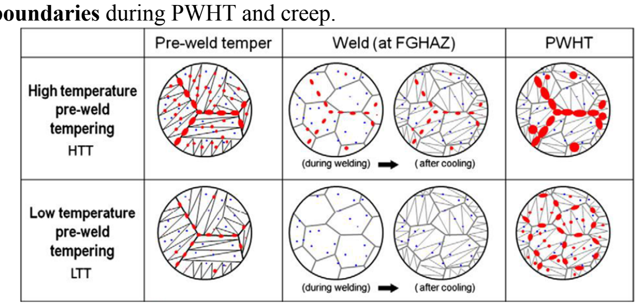
- Gr. 91 steel is primarily used in high-temperature facilities such as fossil-fired power plants, and steam generators of nuclear power plants due to high creep strength.
- The main creep strengths of this steel comes from its precipitates such as **$M_{23}C_6$, MX, Z-Phases, and Laves-Phases**.



Fe-Fe3C phase diagram with corresponding regions of a fusion weld

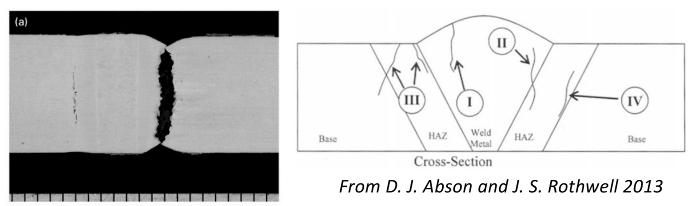
Coarsening of Precipitates

- **$M_{23}C_6$** (red) precipitates coarsen quickly after long periods of creep exposure. The fine **MX** phase (blue dots) has very low coarsening rate and is able to pin grain boundaries and dislocations
- **High Pre-Weld Tempering Temperature (HTT)** - $M_{23}C_6$ nucleate at grain boundaries. They "melt" during welding and then nucleate back within the grain matrix. They coarsen **within grain matrix** during PWHT and creep test.
- **Lower Pre-Weld Tempering Temperature (LTT)** - $M_{23}C_6$ precipitates nucleate at grain boundaries. They "melt" during welding but **do not** nucleate back within the grain matrix. They coarsen **within the grain boundaries** during PWHT and creep.



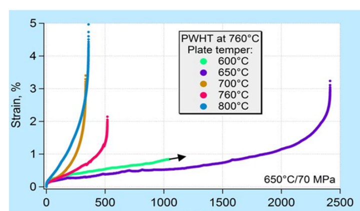
From Yu, X. *et al. Acta Materialia.* 61, 2013. pp. 2194-2206

Type IV Cracks

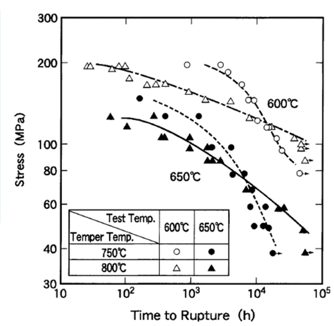


From D. J. Abson and J. S. Rothwell 2013

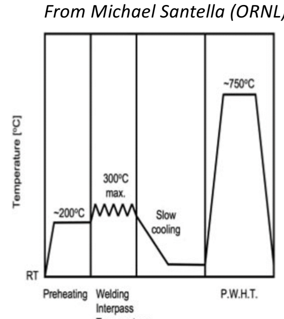
Literature Review of Tempering Effects of Grade 91



From Michael Santella (ORNL)



From Fujimitsu Masuyama 2000



From J. A. Francis, W. Mazur and H. K. D. H. Bhadeshia 2006

Heat Treatment

- The main problem is scattered data from different research groups.
- Since the Heat Treatment process is complex and involved, a lot of parameters can be set arbitrarily thus making the material act differently at different temperatures.

Acknowledgment

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