ICME for Creep of Ni-Base Superalloys in Advanced Ultra-Supercritical Steam Turbines

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AIMS

- Critical assessment of existing experimental data and datamining to find **processing-microstructure-property** (PMP) relationships.
- Assessment of predictive accuracy of current creep models.
- Development of new modeling capabilities to predict long-term creep behavior of Ni-base superalloys used in A-USC applications. This include **integration of phase-field and FFT-based crystal plasticity** to develop a multi-scale, physics-based, microstructure-sensitive creep model.

RESULTS AND DISCUSSION

A. Physics-based creep model :

- A phase field model has been developed for large scale simulation of γ/γ' two-phase microstructure evolution in the single crystal level.
- Elastic energy has been formulated using inhomogeneous phase-field microelasticity theory developed by Wang, et al [5].
- Coupling of plastic strain energy using crystal plasticity is currently in progress

Simulation results for γ' precipitation and coarsening:

- γ' volume fraction 60%
- Though A-USC Ni base superalloys have lower amount of γ' but the coarsening behavior should be same.

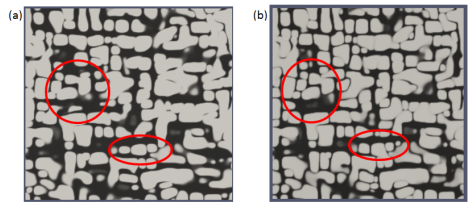

Figure 2: Comparison of precipitation and coarsening without external stress for two cases (a) no modulus mismatch (b) with modulus mismatch.

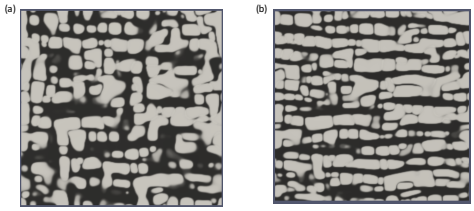

Figure 3: Comparison of precipitation and coarsening with external stress (150 MPa) for two cases (a) no modulus mismatch (b) with modulus mismatch.

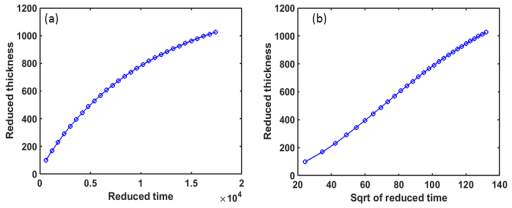

Figure 4: Relationship between precipitate size and time

ACKNOWLEDGEMENTS

This project is funded by DOE-NETL under DOE/NETL Cooperative Agreement DE-FE0027776. We wish to thank **Dr. Chen Shen** and **Dr. Bryce Meredig**, CTO Citrine Informatics, for technical discussions and support. The simulations presented in this report are supported by an allocation of computing time from the **Ohio Supercomputer Center**.

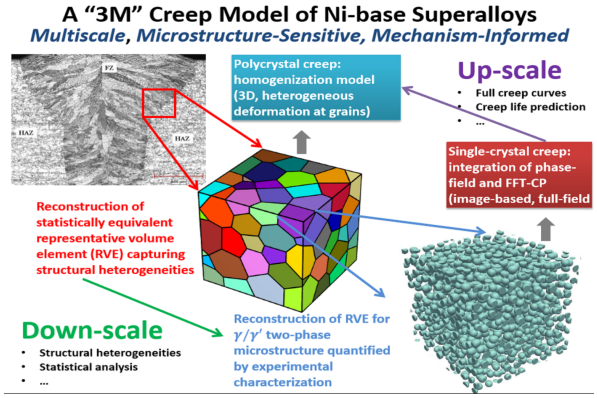

Figure 1: ICME Approach

B. Data Assessment and Datamining :

- Experimental data for creep and stress rupture is being collected from various sources.
- **Dr. Chen Shen** from GE Global Research has reaffirmed his commitment to share data and OSU will be receiving data this coming quarter.
- **Dr. Bryce Meredig**, CTO Citrine Informatics, is coming to OSU in the end of this month begin implementation of the machine learning framework and the integration of collected creep data into **Citrination.** The **Citrination** platform will be used to find PMP linkages from the collected data.

C. Assessment of Existing Creep Models :

- Existing creep models is currently being assessed **including GE GRC model of Dr. Chen Shen developed under NETL support.**
- Creep models which are microstructure-informed will be matched with the experimental data.
- Based on the results the best model will be chosen for the long time creep life prediction of these A-USC based superalloys.

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