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Quarterly Management Document FY19, 4th Quarter, Physics-based Creep Simulations of Thick Section Welds in High Temperature and Pressure Applications

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WBS Element	Project Title	Contract Number	Contract Start	Contract End
C.B.10.02.02.40	Physics-based Creep Simulations of Thick Section Welds in High Temperature and Pressure Applications	FEAA90	10/01/17	09/30/2020

Performer Name and Address	Principal Investigator(s)
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BUDGET AND COST REPORT

Prior Year Funds ($K)				46.3								
Total Current Year Commitment ($K)				46.3								
Projected Current Year Costs ($K)				46.3								
	O	N	D	J	F	M	A	M	J	J	A	S
Monthly Planned Costs	4	4	2	3	5	7	6	5	10.3	0	0	0
Actual Monthly Costs	3	2	2	2	1	3	15	0	0	2.6	1.2	0.6
Monthly Variance	-1	-2	0	-1	-4	-4	9	-5	-10.3	-2.6	-1.2	-0.6
Total costs – planned	4	8	10	13	18	25	31	36	46.3	46.3	46.3	46.3
Total costs - actual	3	4.6	8.6	10.5	11.9	15.3	31	31	31	33.6	34.8	35.4

MILESTONE REPORT

Milestone Designation	Milestone Description	Due Date	Revised Due Date	Completion Date
A	Evaluate current MOOSE capabilities	09/30/2015		09/30/2015
B	Complete Alloy 617 weld characterization	10/30/2015		11/18/2015
C	Receipt of Alloy 740H plates	10/30/2015		11/05/2015
D	Complete welds in Alloy 740H	11/16/2015	7/31/2016	7/31/2016

E	Characterize Alloy 740H welds	02/01/2016	09/30/2016	9/02/2016
F	Creep model development – Stage 1	09/30/2016		9/30/2016
G	Creep Model Development – Stage 2	8/29/2017	2/28/2019	1/15/2019
H	Calibration of Secondary creep – Alloy 617	9/30/2017	3/31/2019	Eliminated
I	Stress Drop Tests	2/01/2017	5/31/2018	6/28/2018
J	Characterization of creep failure mechanisms	4/01/2017	04/30/2018	5/04/2018
K	Secondary creep calibration for welds – Alloy 617	5/30/2018	4/15/2019	Eliminated
L	Creep model development – Completion of Stage 3	8/30/2018	8/16/2019	9/9/2019
M	Creep simulation of a welded joint in Alloy 740H	9/30/2018	11/30/2019	
N	Validation of creep simulation model via an Alloy 740H weld consisting of refined microstructure	9/15/2018	12/20/2019	

TECHNICAL HIGHLIGHTS

Milestone L, "Creep model development – Completion of Stage 3"

The tensor implementation of Shen's (2015) scalar approach to diffusion creep was completed during the 4th quarter of FY19. (Details of the tensor implementation of Shen's scalar approach to diffusional creep can be found in the previous quarter report.) Preliminary/demonstration results were obtained for a simple 4x4x4, equiaxed grain structure (most closely representing the base metal). The figure below compares the results with and without diffusional creep in the model. The blue line, representing only dislocation creep (no diffusional creep), exhibits a linearly increasing creep strain with time – as indicated by the straight, orange dashed line. However, when diffusional creep is incorporated into the model – using the same starting grain structure – the creep strain quickly deviates from linearity (compare with the straight, dashed black line), simulating the transition to tertiary creep. Calibration of model parameters (to be performed for Milestone M) is still needed to accurately simulate the "strength" of diffusional creep versus that of dislocation creep. Calibration will affect the tertiary transition behavior – the timing/onset of the transition and the apparent duration of secondary creep. Calibration of diffusional creep in the weld metal will be performed using creep data for all-weld-metal creep specimens. Base metal-only creep data will be used to calibrate diffusional creep in the base metal. Calibration will be performed for temperatures between 700-800°C. Synthetic microstructures for base metal and weld metal, constructed from the EBSD data, collected under Milestone E, will be used in the calibration process.

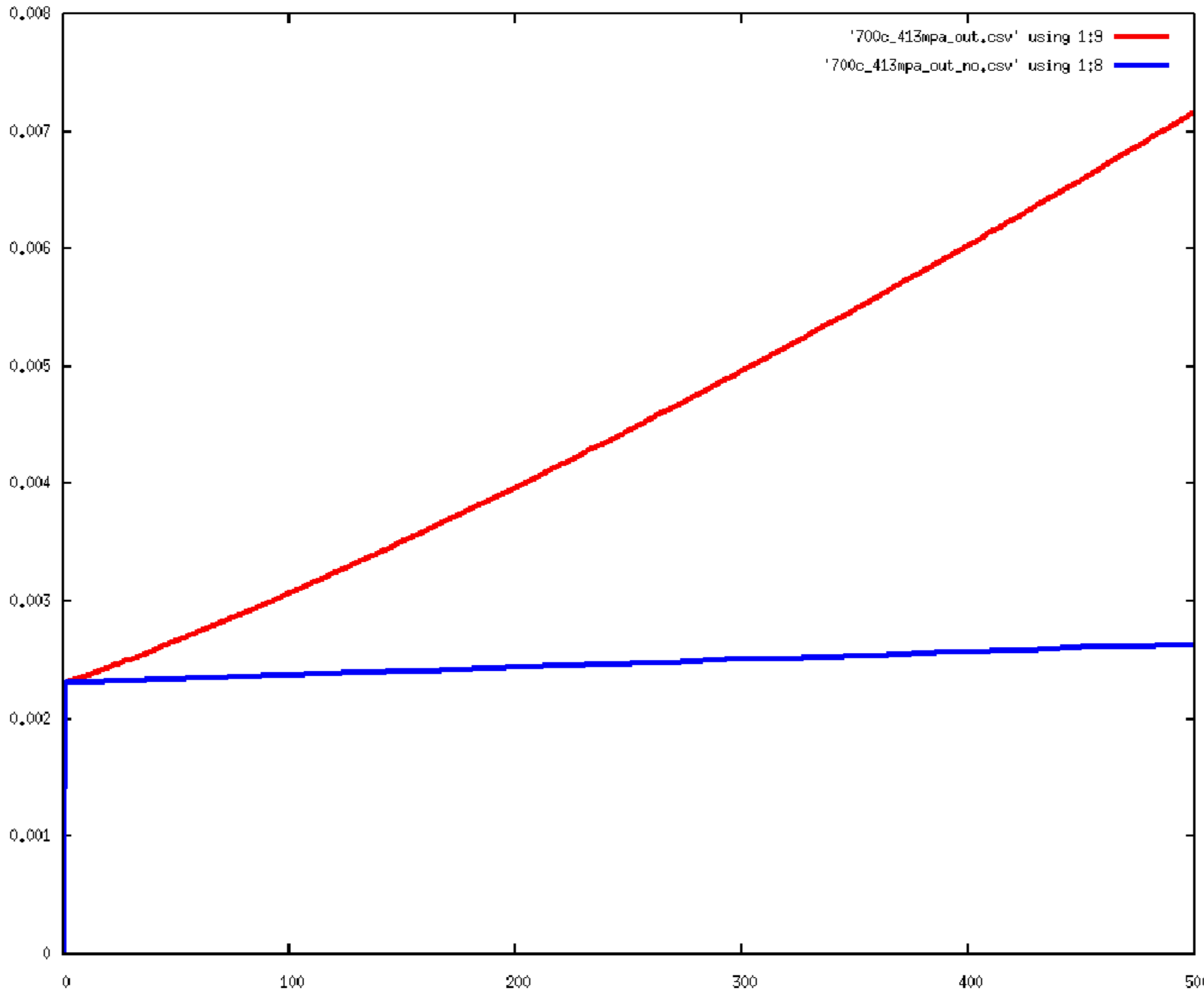

Figure 1. Comparison of the simulated creep behavior without (blue) and with (red) diffusional creep incorporated into the creep model. Diffusional creep induces the transition to tertiary creep behavior.

Reference:

C. Shen, "Modeling Long-term Creep Performance for Welded Nickel-base Superalloy Structures for Power Generation Systems", Topical Report: Constitutive Creep Model for Alloy 282, DOE/NETL Cooperative Agreement DE-FE0024027, 2015.

Milestone M, "Creep simulation of a welded joint in Alloy 740H"

This task will start immediately in the first quarter of FY20. The model will be fully calibrated (dislocation creep and diffusional creep in the base and weld metal) with 500 hr, creep tests on all-weld-metal, base metal only, and cross weld creep specimens from 740H welds, using synthetic microstructures. Simulations will then be performed for other conditions – temperature and initial stress – in the experimental creep dataset on cross weld specimens, including the long-term creep tests at 750 and 800°C.

Completion of this task is now targeted for 11/30/2019.

Milestone N, "Validation of creep simulation model via an Alloy 740H weld consisting of refined microstructure"

No progress on this task during the 4th quarter of FY19.

The completion date of this task is now targeted for 12/20/2019

ISSUES

Report Prepared By	Date
Thomas M. Lillo and Wen Jiang	10/22/2019