CANFSA

Center for Advanced Non-Ferrous Structural Alloys
An Industry/University Cooperative Research Center

Project 40-L: Evaluation of Processing Path Effects on Microstructure and Properties of Powder-Based Al-TM alloy.

Summer 2020 Videoconference

June 29 – July 1, July 8 – 10 2020

Student: Stuart Shirley (Mines)

Faculty: Kester Clarke (Mines)

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IOWA STATE UNIVERSITY

Project 40-L: Evaluation of Processing Path Effects on Microstructure and Properties of Powder Al-TM alloy.

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- Student: Stuart Shirley (Mines)
- Advisor(s): Kester Clarke (Mines)

Project Duration
Masters: August 2019 to December 2021

- Problem: Al-TM alloys have excellent performance, but can be challenging to process via conventional processing pathways
- Objective: Evaluate the effect of processing path on the microstructure and mechanical properties of Al-TM alloy.
- Benefit: Improved understanding of processing path effects on microstructure and properties Al-TM powders.

Recent Progress
- Polishing of Al-TM samples
- Literature review
- Thermal stability testing

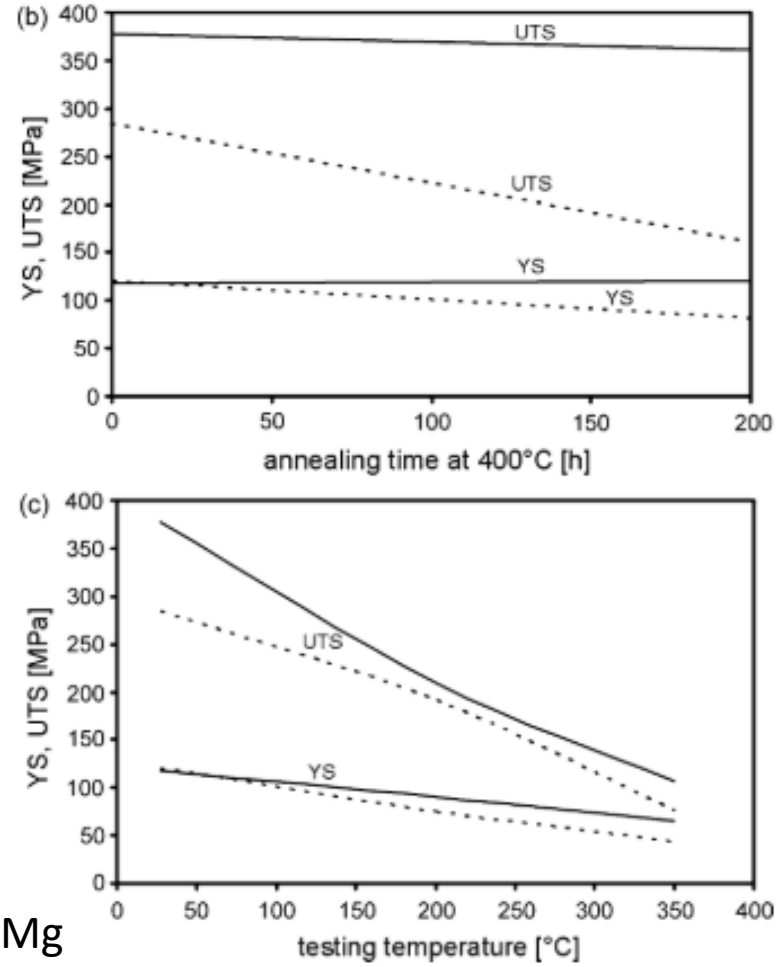
Metrics		
Description	% Complete	Status
1. Literature review	45	●
2. Microstructure Characterization of Forged Al-TM	10	●
3. Microstructure Characterization of Additive Friction Stir Deposition (AFSD)	0	●
4. Microstructure Characterization of ShAPE Al-TM alloy	10	●
5. Thermal Stability Testing	65	●

Outline

- Alloy background
- Material of interest
- ShAPE process
- Recent work

Al-TM background

- Produced as a powder via melting and atomization
- Aluminum alloyed with Fe, Cr and Ti
  - Other alloys are Al-Fe-Cr-X
  - X; Ti, Nb, Ta, V [2]
- High temperature thermal stability



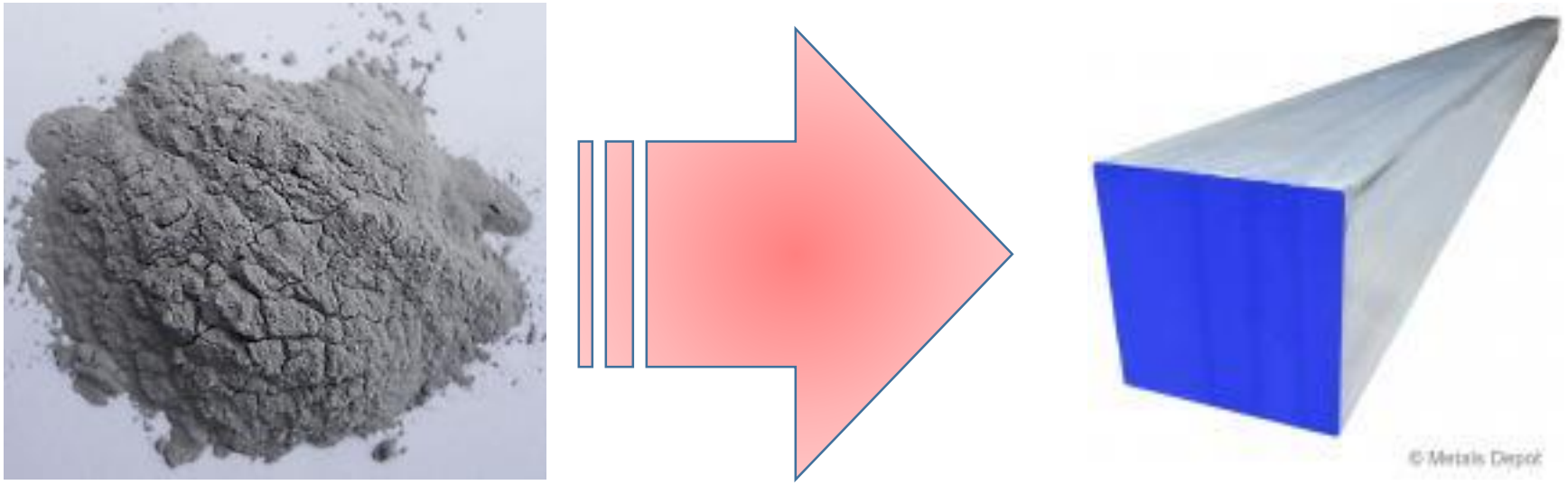
Al–12Si–1Ni–1Cu–1Mg casting alloy dashed lines
Sourced: Adapted from [1]

Al-TM background cont.

Test Temperature (°C)	Al-Fe-Cr-Ti* (MPa) [2]	8009 (MPa) [3]	2618-T61 (MPa) [4]	Al-Fe-Cr-Ti** (MPa) [5]
200			221	330
300	554			
315	528	230	52	
330	450			
350	420			
370			34	

*Al-TM results from melt spun ribbons
**Hot Extrusion post 200°C 100hr aging
All values are UTS

Motivation



Adapted [6,7]

Material of Interest

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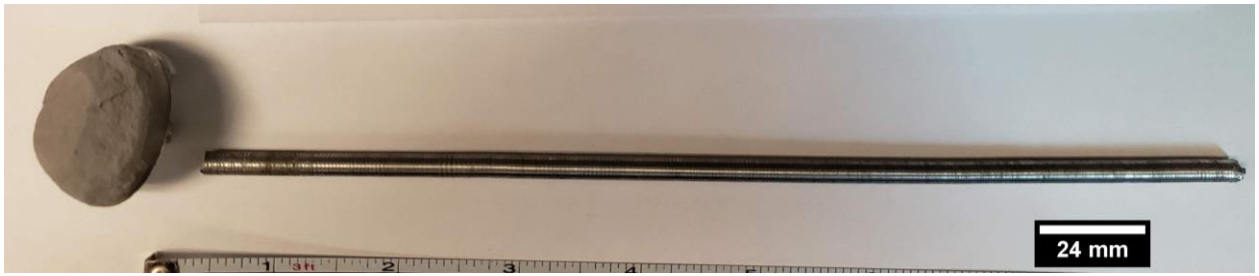
Received Material

- Extruded
  - Al- TM
  - Material from two extrusion ratios. 17.4:1 and 25:1
- Forgings
  - Al-TM

Material of Interest Cont.

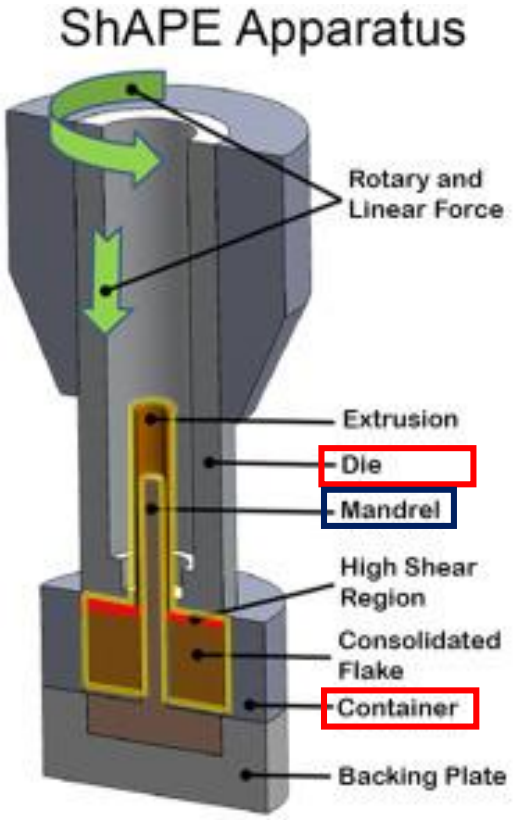
- Shear Assisted Processing and Extrusion
  - Two powder sizes
  - Same processing conditions



Anticipated Material

- Additive Friction Stir Deposition
  - Supplied by MELD
  - Possible subsequent forging

ShAPE



Source [8]

- Shear assisted processing and extrusion (ShAPE)
- Friction stir extrusion
- Friction stir back extrusion is a related process [9]
- Aluminum, Copper, Magnesium [8-10]

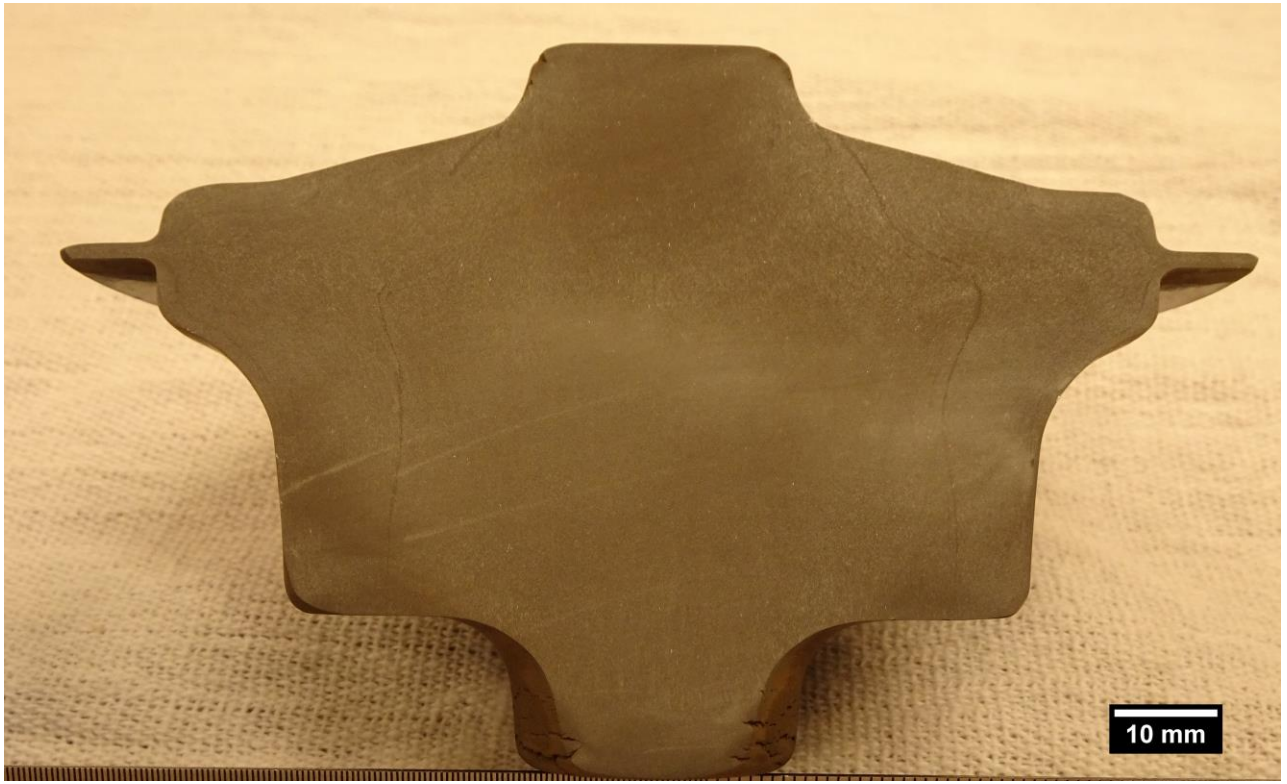
ShAPE Al-TM

- Homogenization and refinement of second phase particles [11]
- Powder 4-5 µm refined to 400-500nm [11]
- Second phase particles present after 450°C processing temperature[11]

- Evaluate thermal stability of the processed material
- Influence of powder size on final microstructure

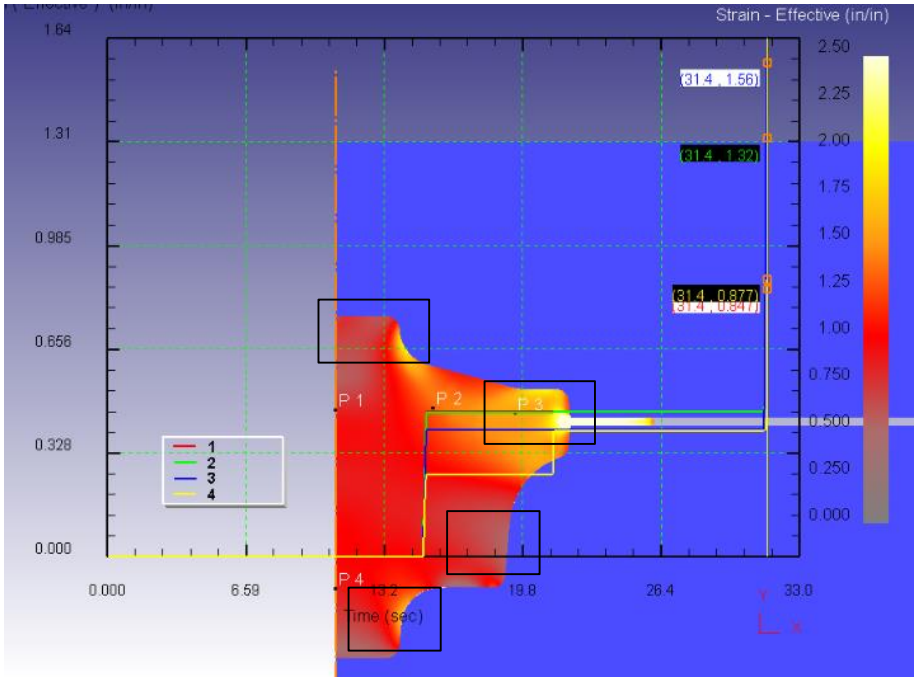
Recent work

- Forging macro etching
- Polishing process
- Thermal stability testing

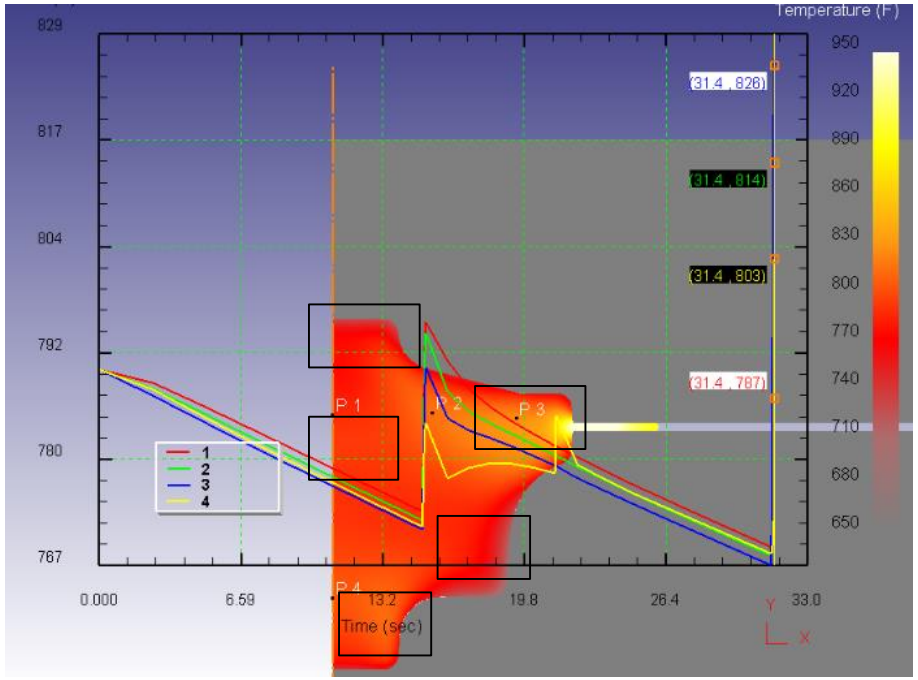


Forgings

Strain

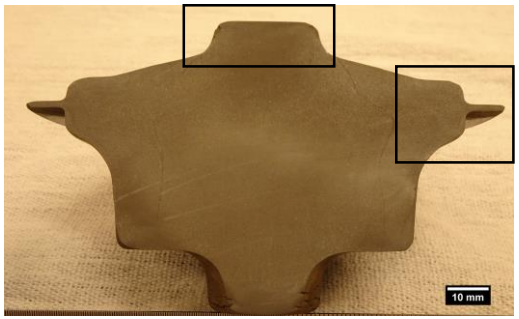


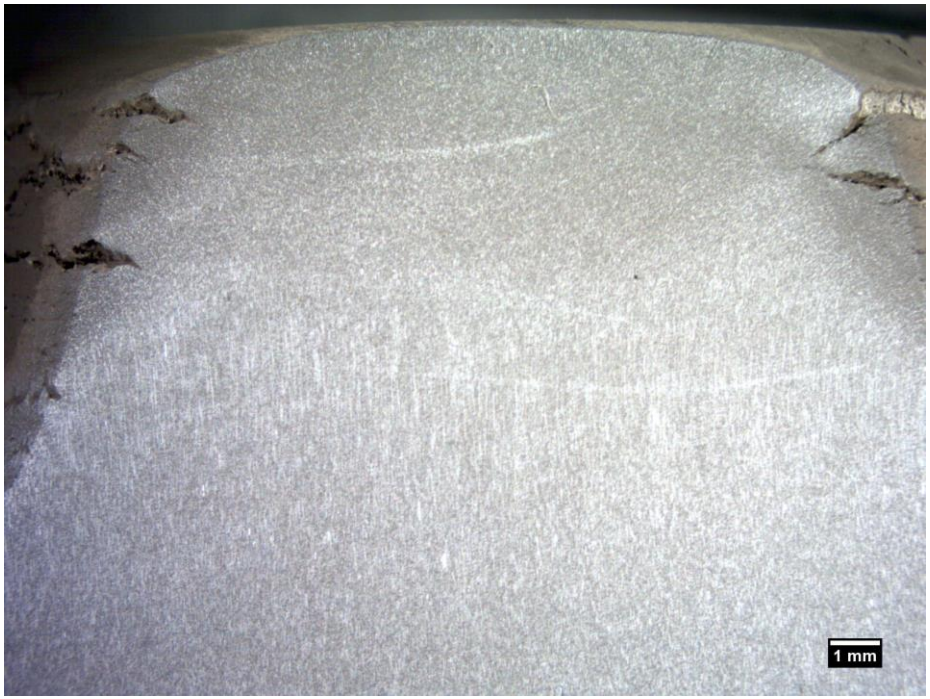
Temperature

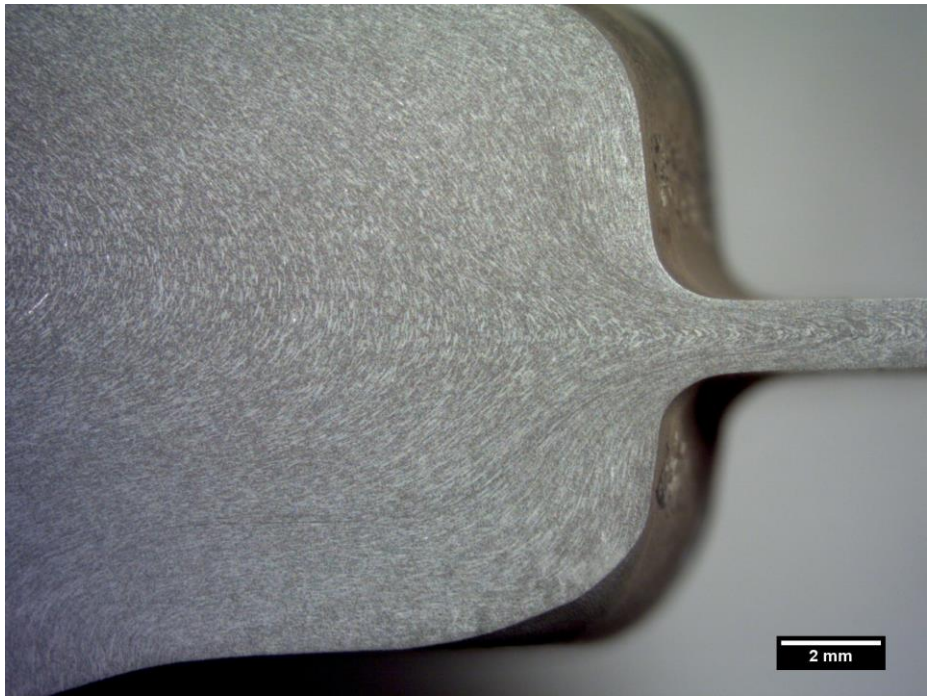


Simulation of 2618 forging provided by Tkach Consulting

Forgings

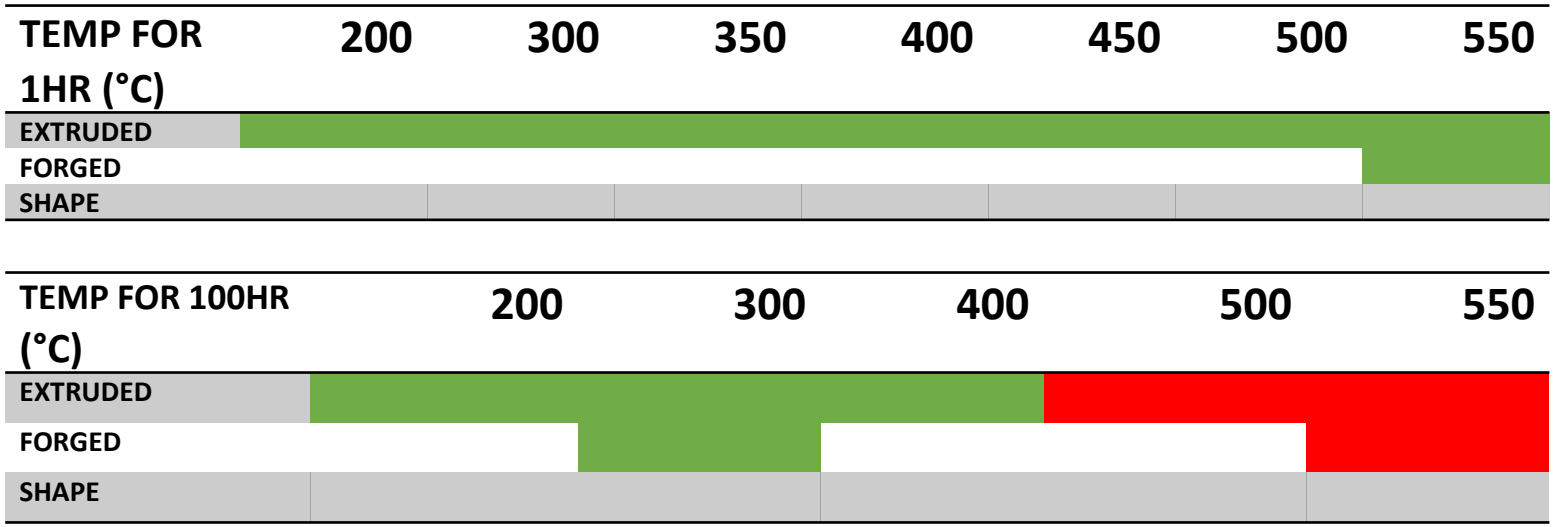




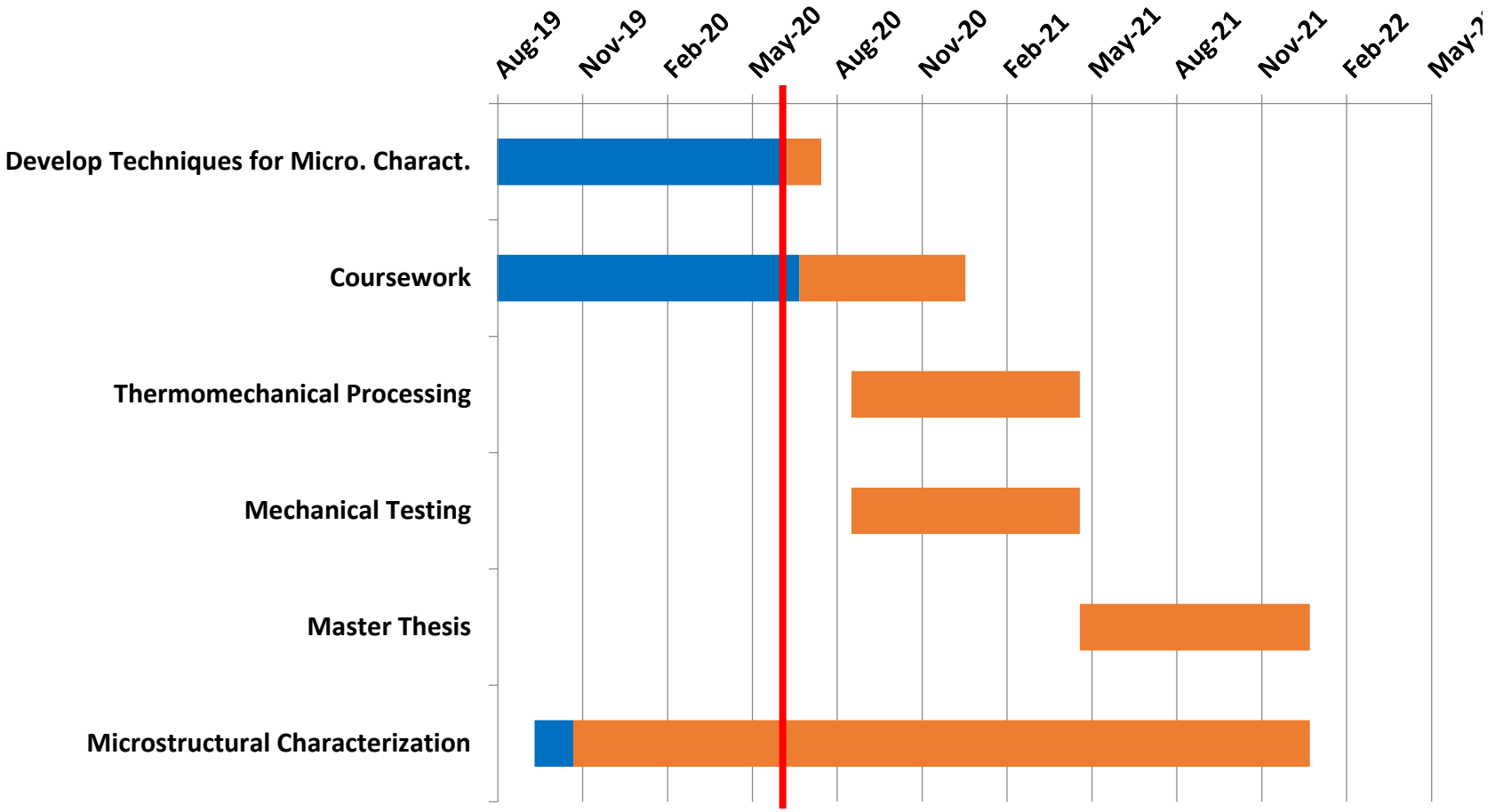


Thermal Stability

- 1 hour thermal stability test to determine temperatures of interest
- 100 hour long time treatment
  - Considering a high temperature short time simulation to reduce heat treat times



Progress



Challenges & Opportunities

Opportunities

- Understanding of thermal stability from extrusion and forging samples
- Thermal stability test of ShAPE material
- Mechanical testing
  - Hardness- as a function of temperature
  - Tensile
- Thermomechanical processing
- EBSD

Challenges

- Many samples to prepare for metallography

Thank you!

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[1]D. Vojtěch, A. Michalcová, J. Pilch, P. Šittner, J. Šerák, and P. Novák, "Structural characteristics and thermal stability of Al-5.7Cr-2.5Fe-1.3Ti alloy produced by powder metallurgy," *J. Alloys Compd.*, vol. 475, no. 1–2, pp. 151–156, 2009, doi: 10.1016/j.jallcom.2008.07.019.

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[11]S. Whalen *et al.*, “High ductility aluminum alloy made from powder by friction extrusion,” *Materialia*, vol. 6, no. December 2018, 2019, doi: 10.1016/j.mtla.2019.100260.

Forging

- Possible friction influence on the top spud
  - Conduct ring upset tests to determine friction coefficient and influence on the process