CONFLUENT

The Effect of Low Temperature Aging on Ni-Rich Ti-Ni

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Outline:

- Annealed Ni-rich Ti-Ni

  Aging temperatures: 100°C - 200°C & exposure times up to 720 hours (one month)

  — Thermal properties (DSC results)
  — Microstructural changes

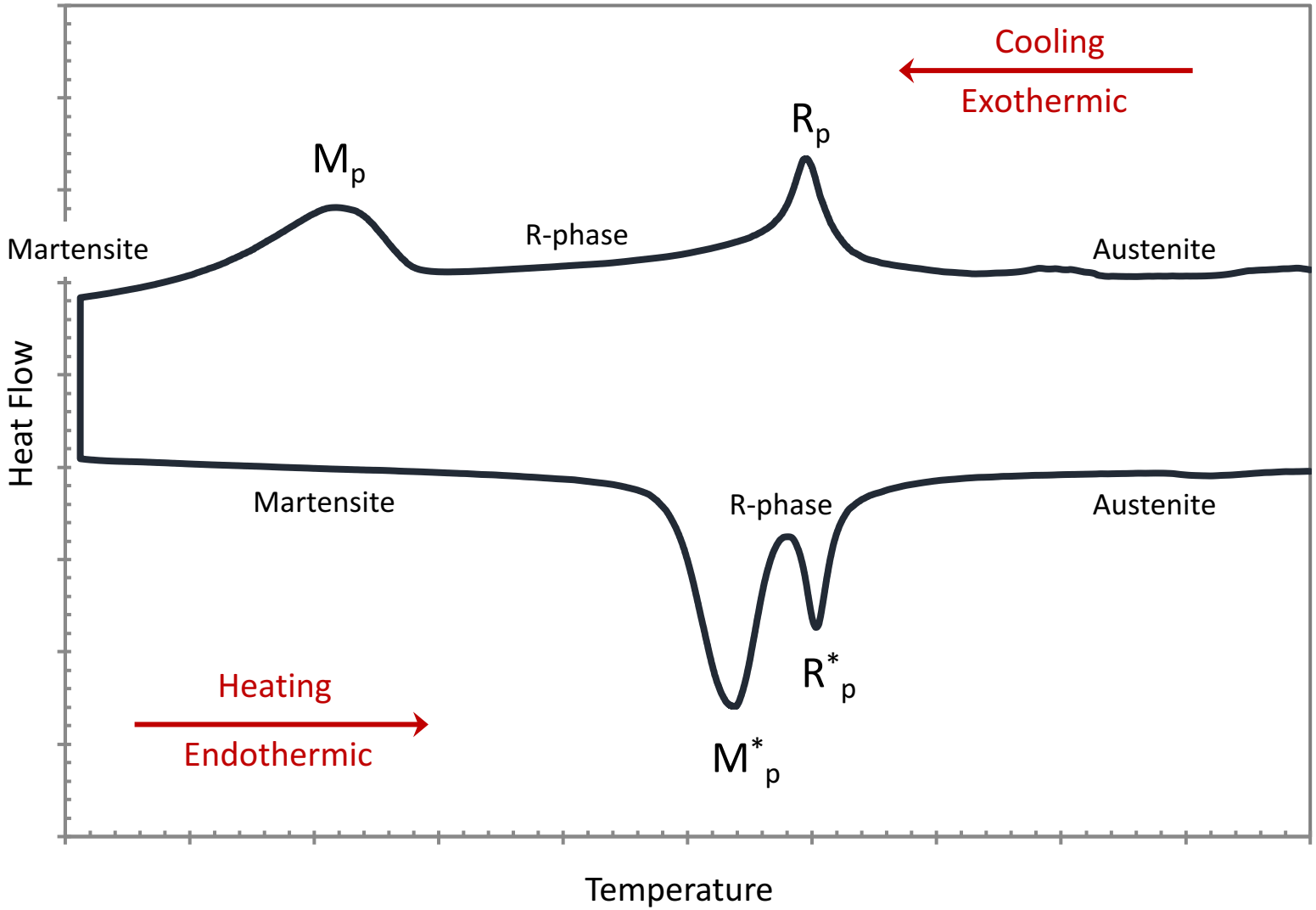
- Cold-Worked and Heat Treated Ni-rich Ti-Ni

  Aging temperatures: 100°C - 250°C & exposure times up to 720 hours (one month)

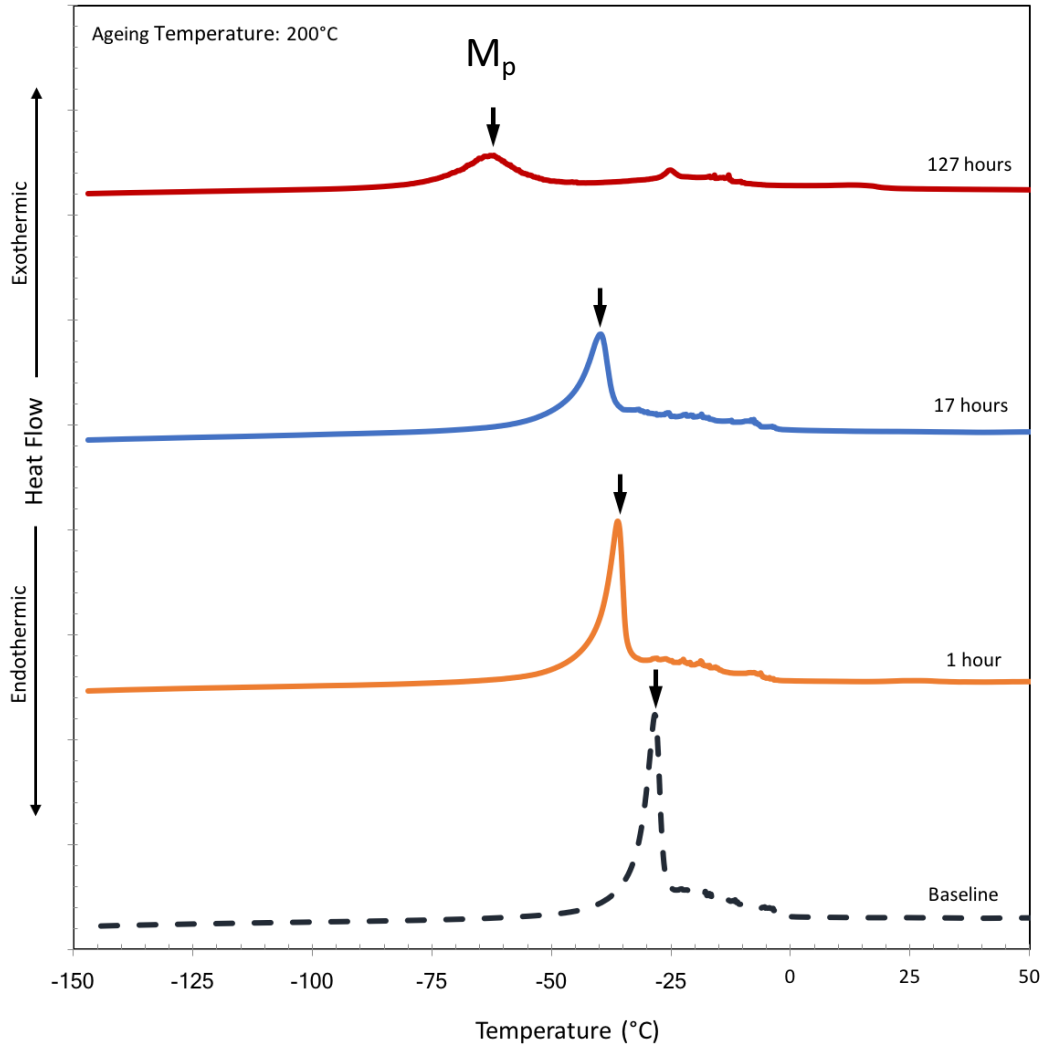
  — Thermal properties (DSC results)
  — Influence on mechanical properties

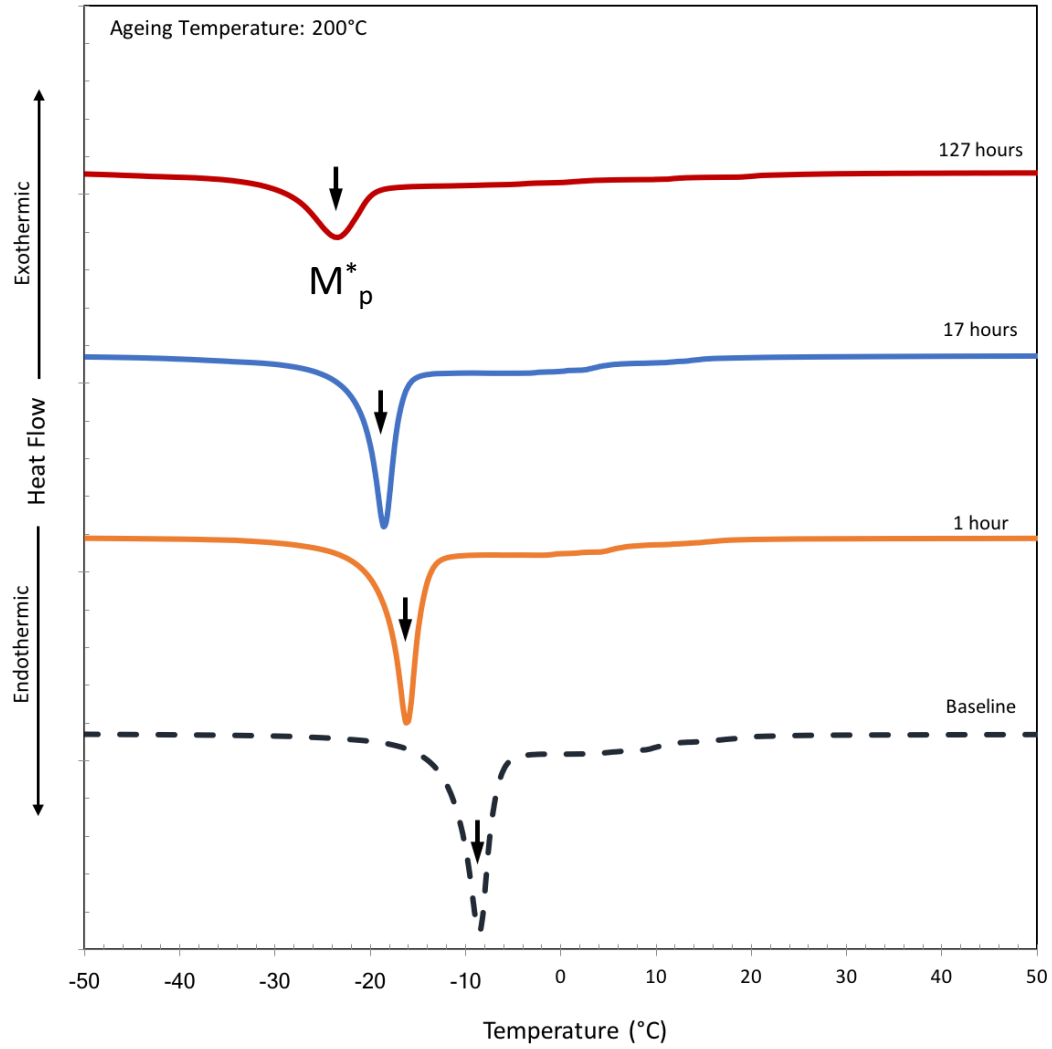
- Remarks & Conclusions

DSC Graph – Terminology

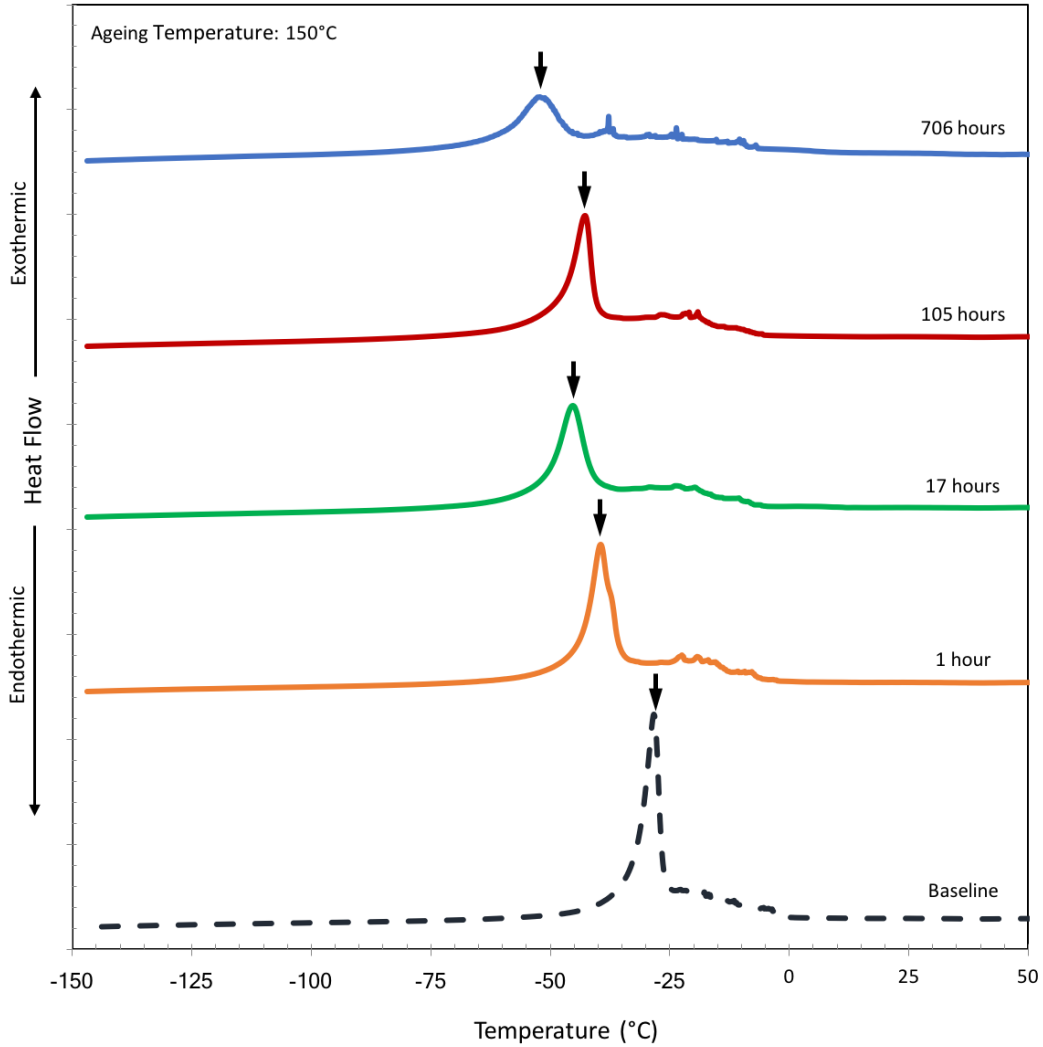


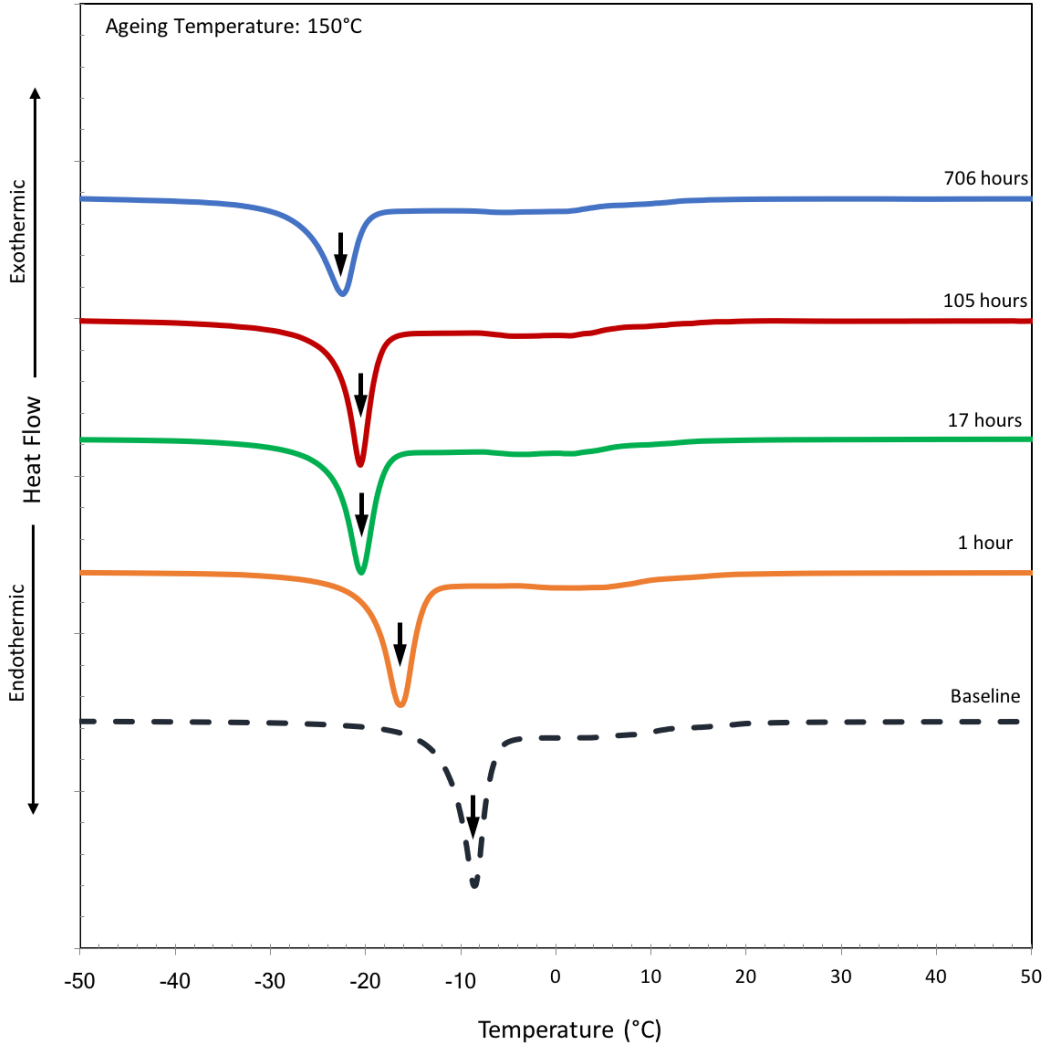
Fully Annealed Sample – Aged at 200°C



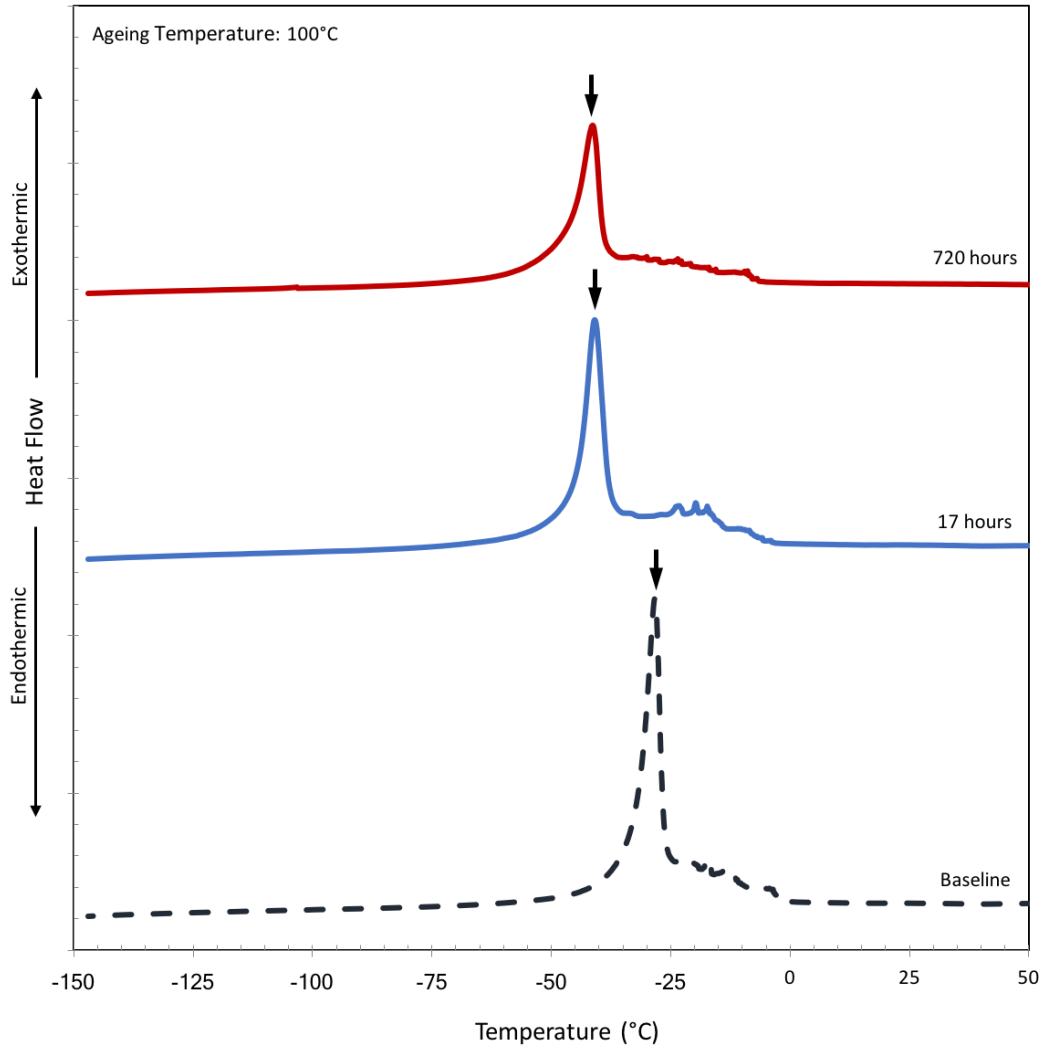


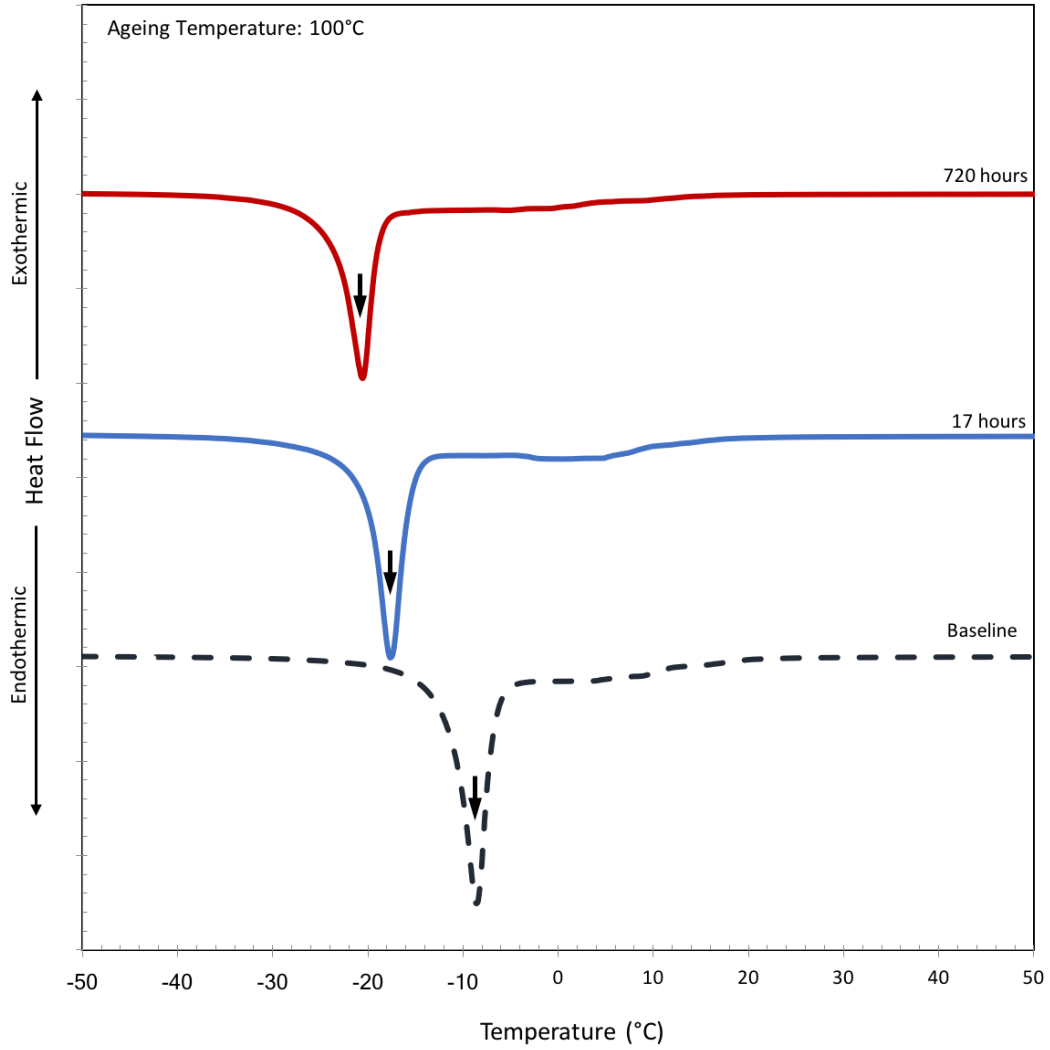
Fully Annealed Sample – Aged at 150°C



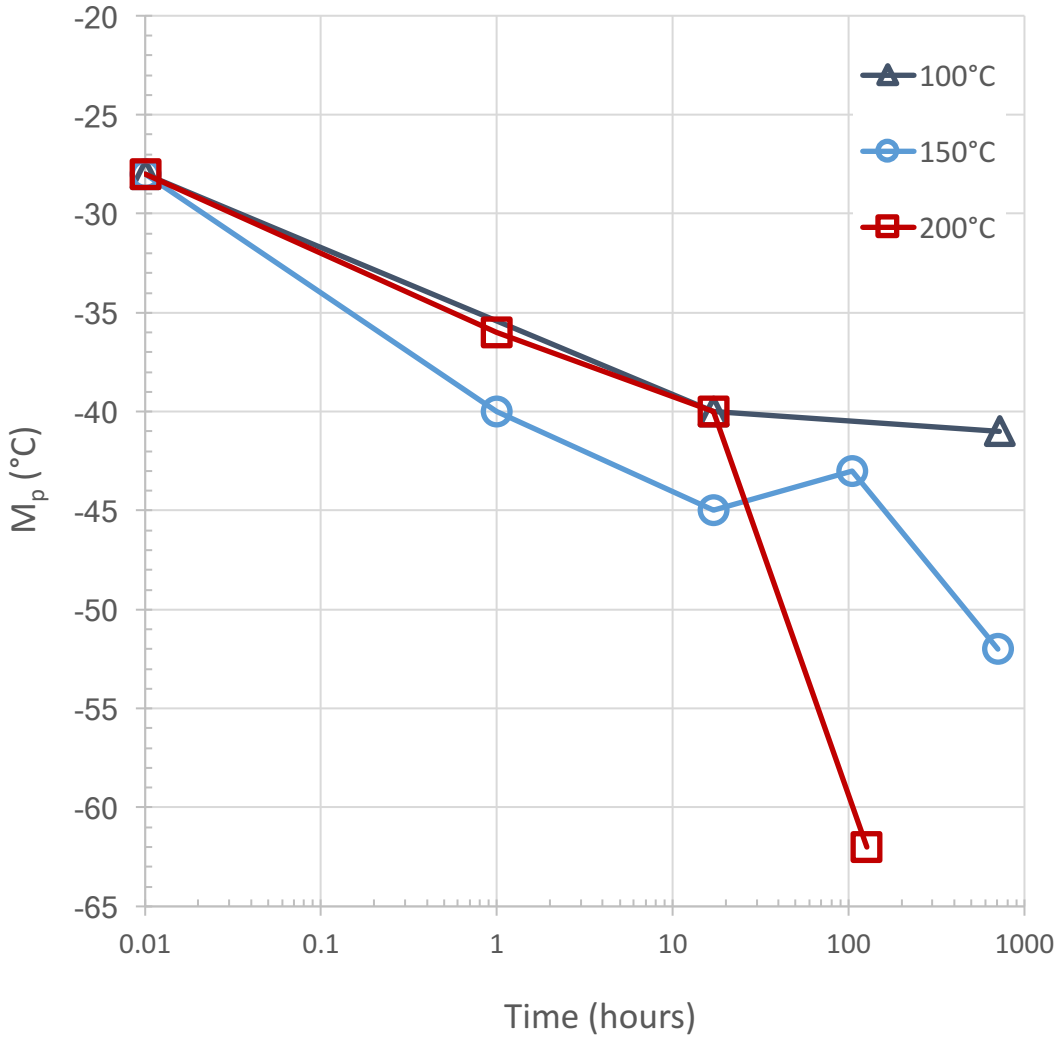


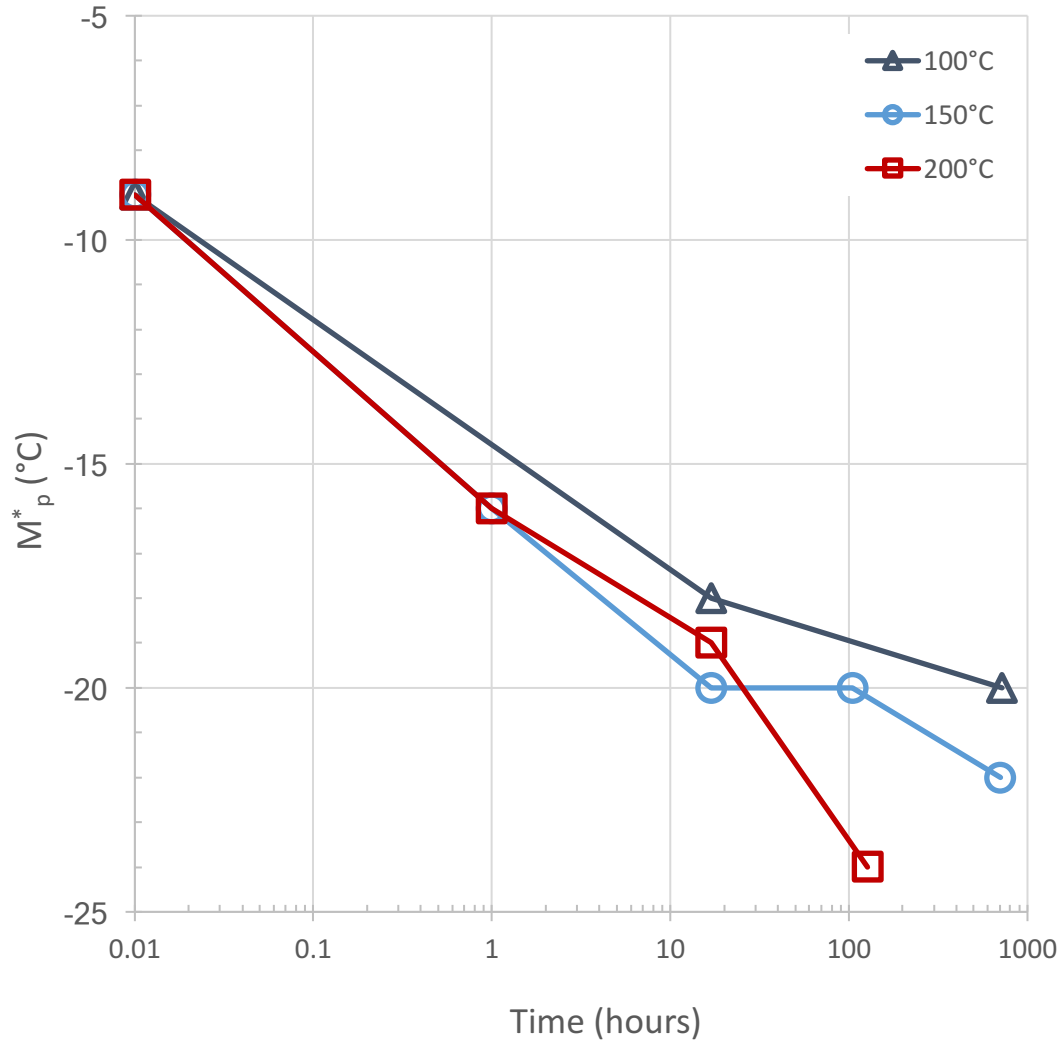
Fully Annealed Sample – Aged at 100°C



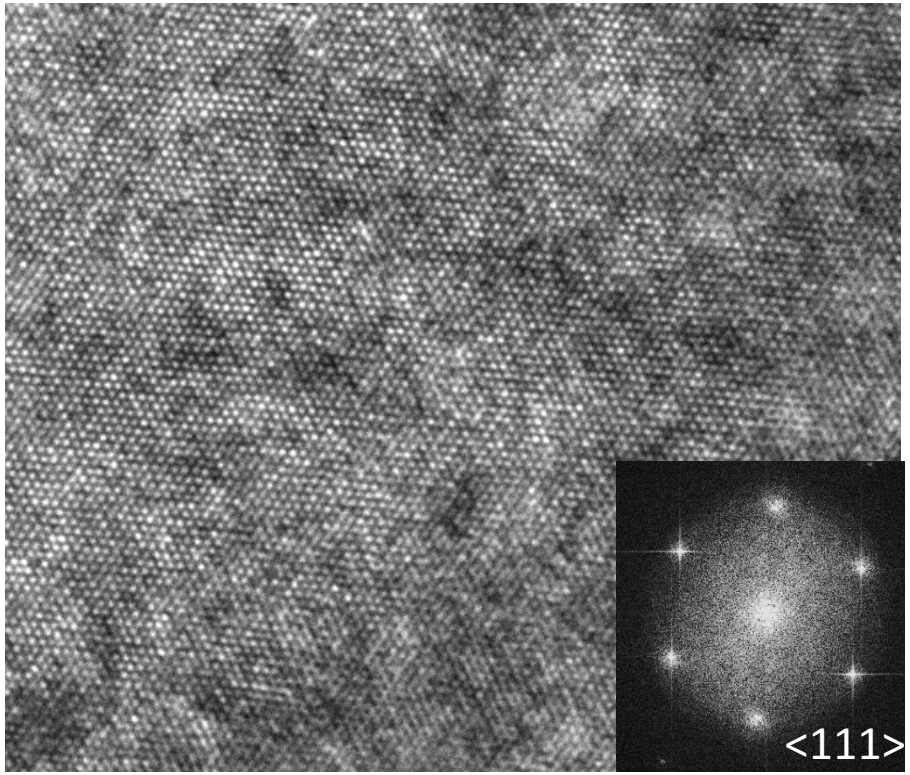


Suppression of Martensite Formation (M_p) and Reversion (M^*_p)

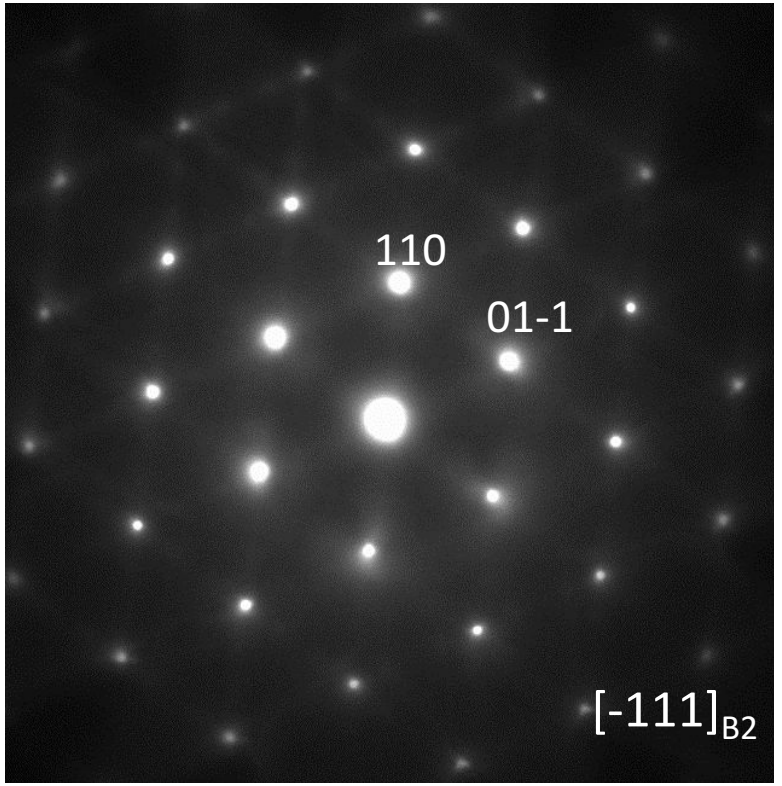




Fully Annealed Sample – Baseline



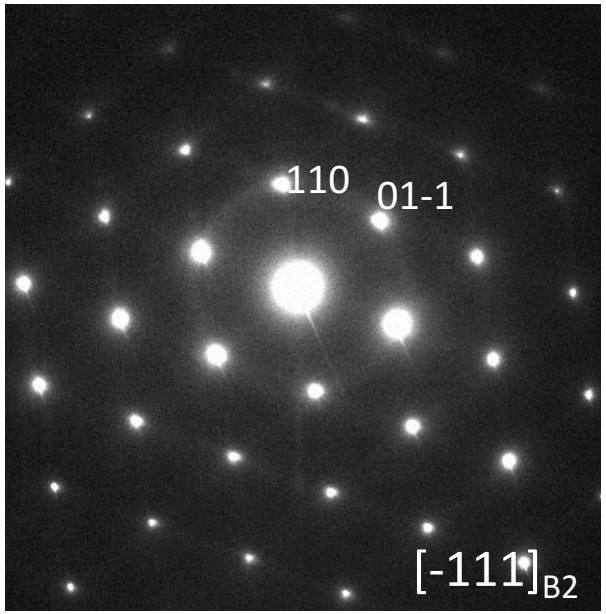
High resolution TEM micrograph along <111> direction

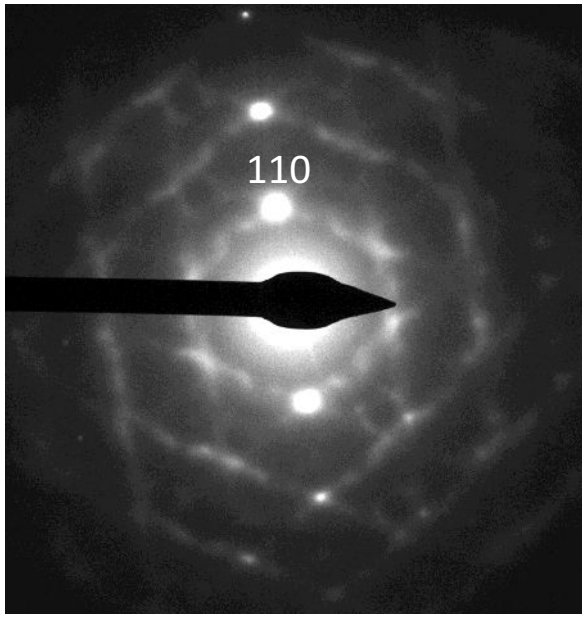


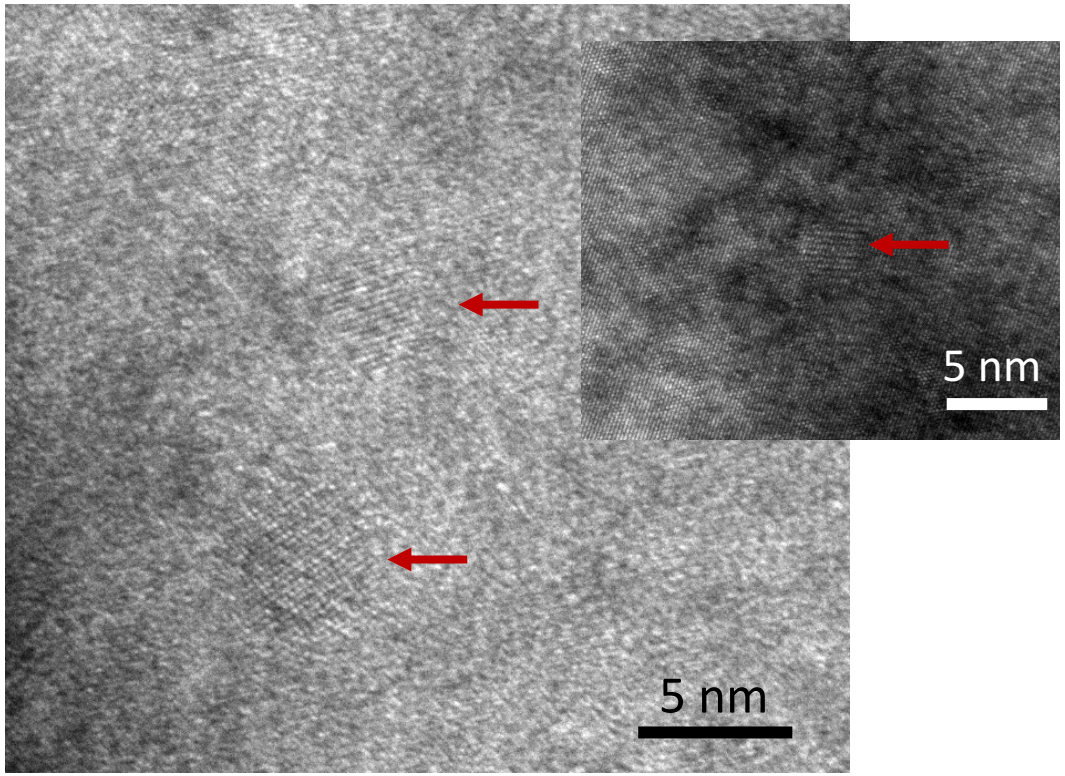
Selected area diffraction pattern

- No Evidence of Precipitation

Fully Annealed Sample – Aged at 100°C for 105 hours







Tilting the sample around [110] direction and diffuse intensities (evidence of Ni clustering) are appeared in diffraction pattern.

- Evidence of Ni Clustering (Precursor to Precipitation)*
- Evidence of Precipitation

* S. Pourbabak *et al.*, *Functional Materials Letters*, **10**, No. 1 (2017) 1740005

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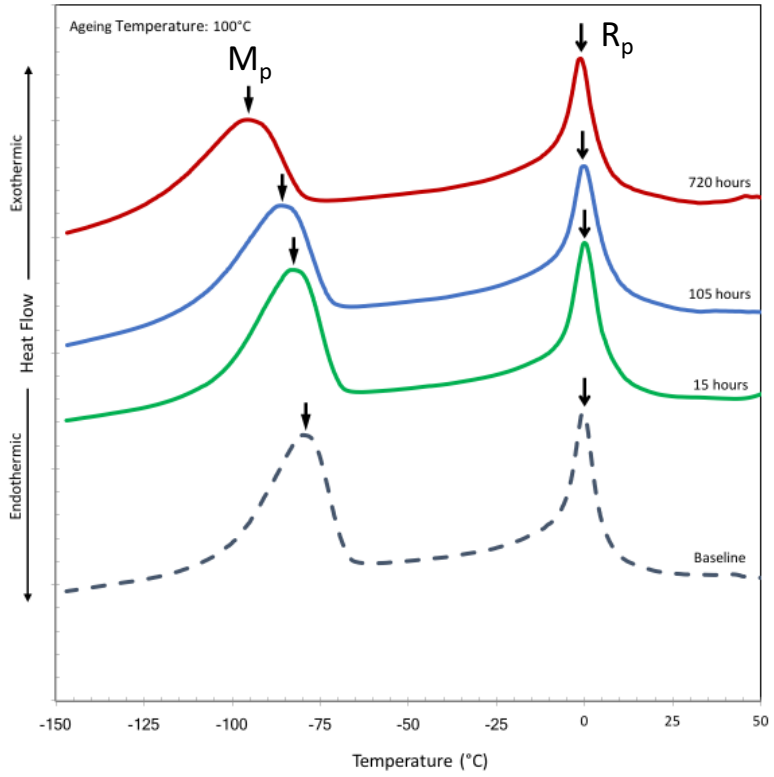
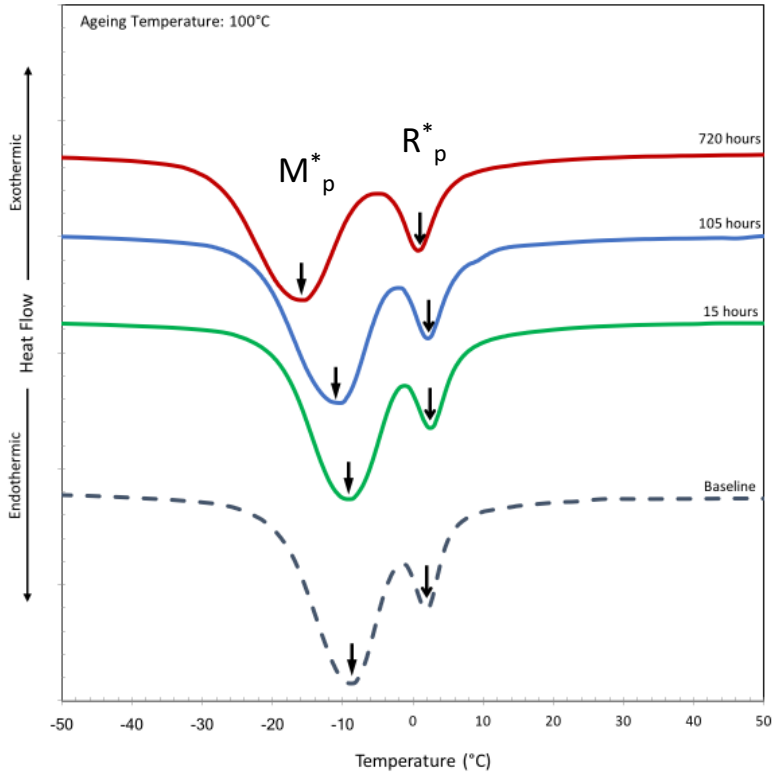
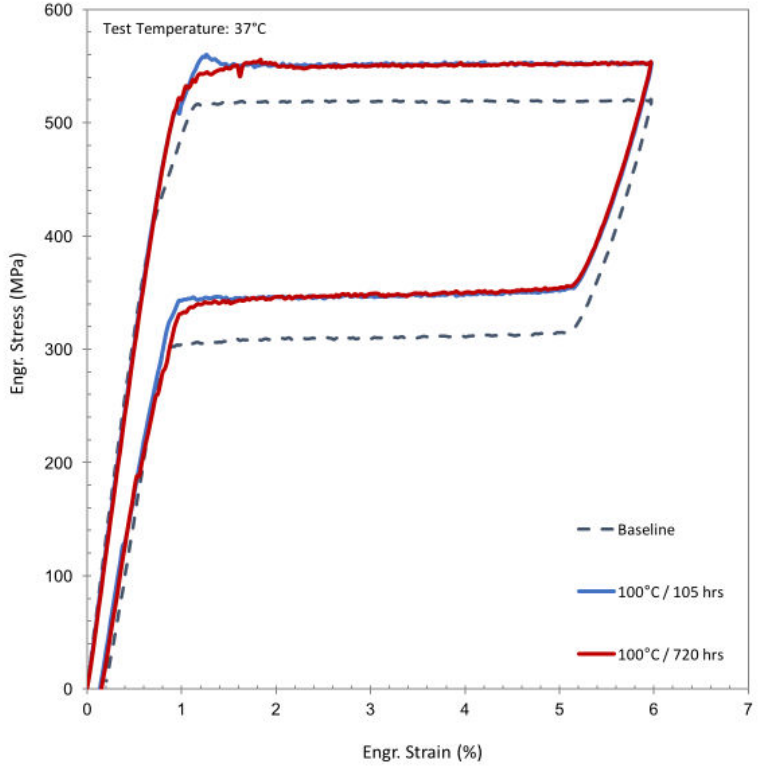
  — Influence on mechanical properties

- Remarks & Conclusions

Sample with Retained CW & Precipitates – Aged at 100°C







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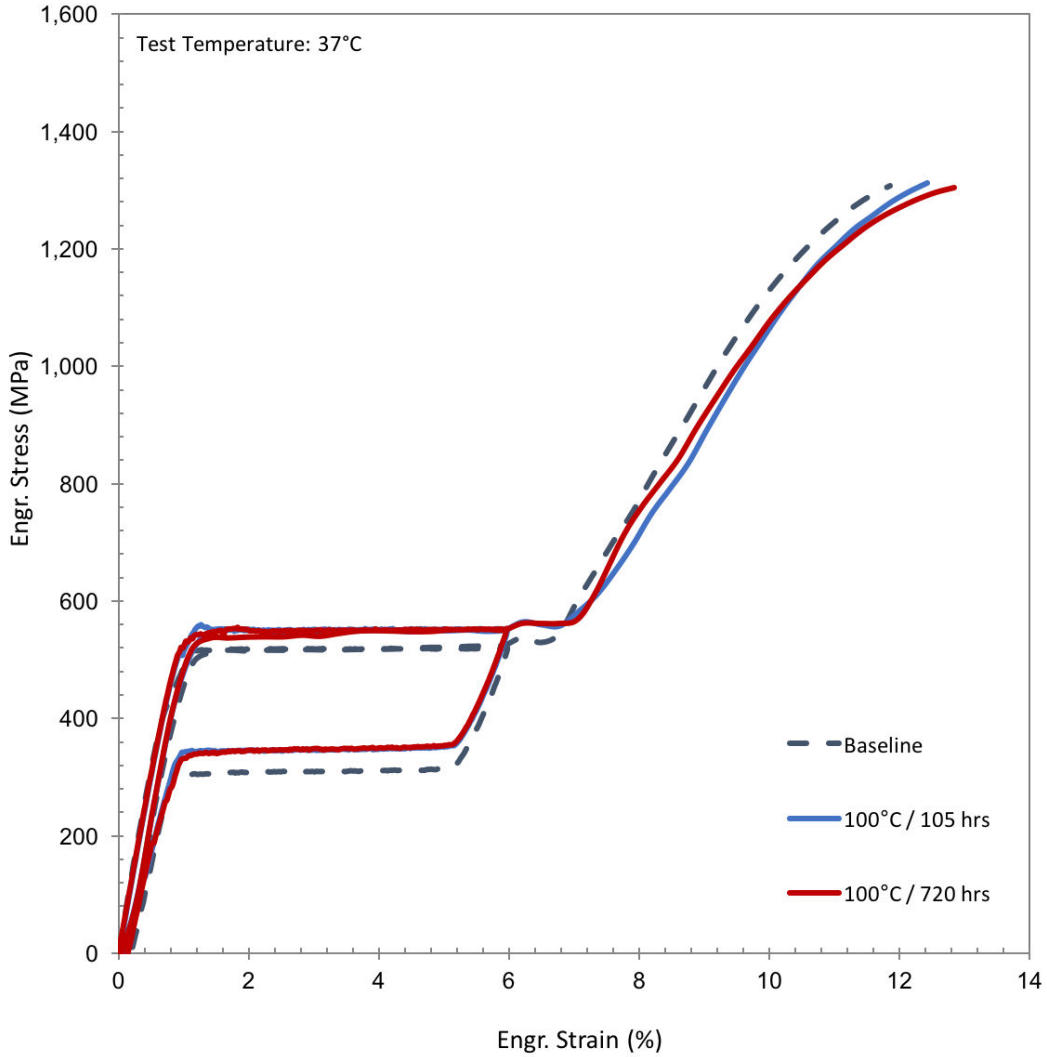
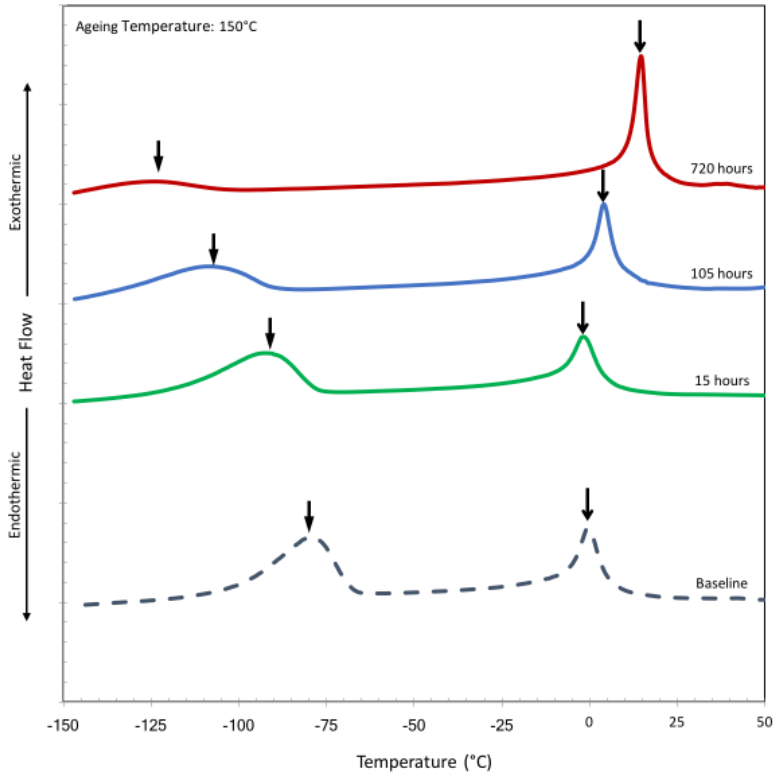
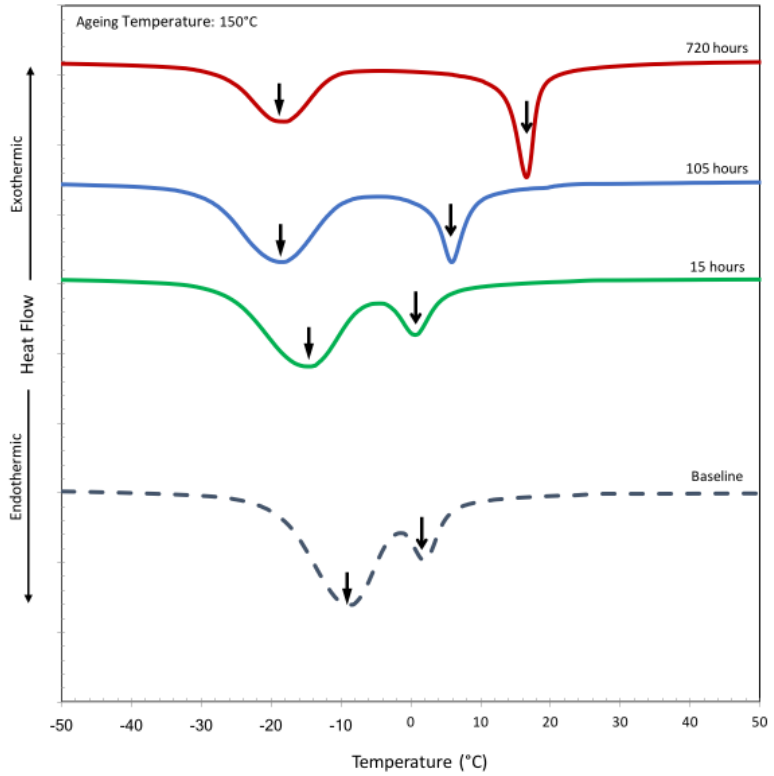
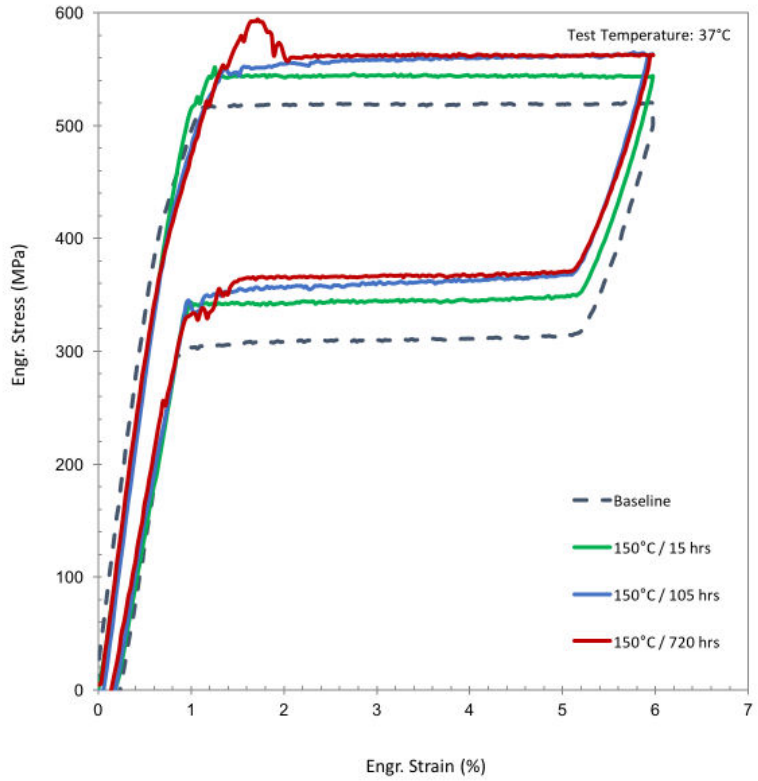


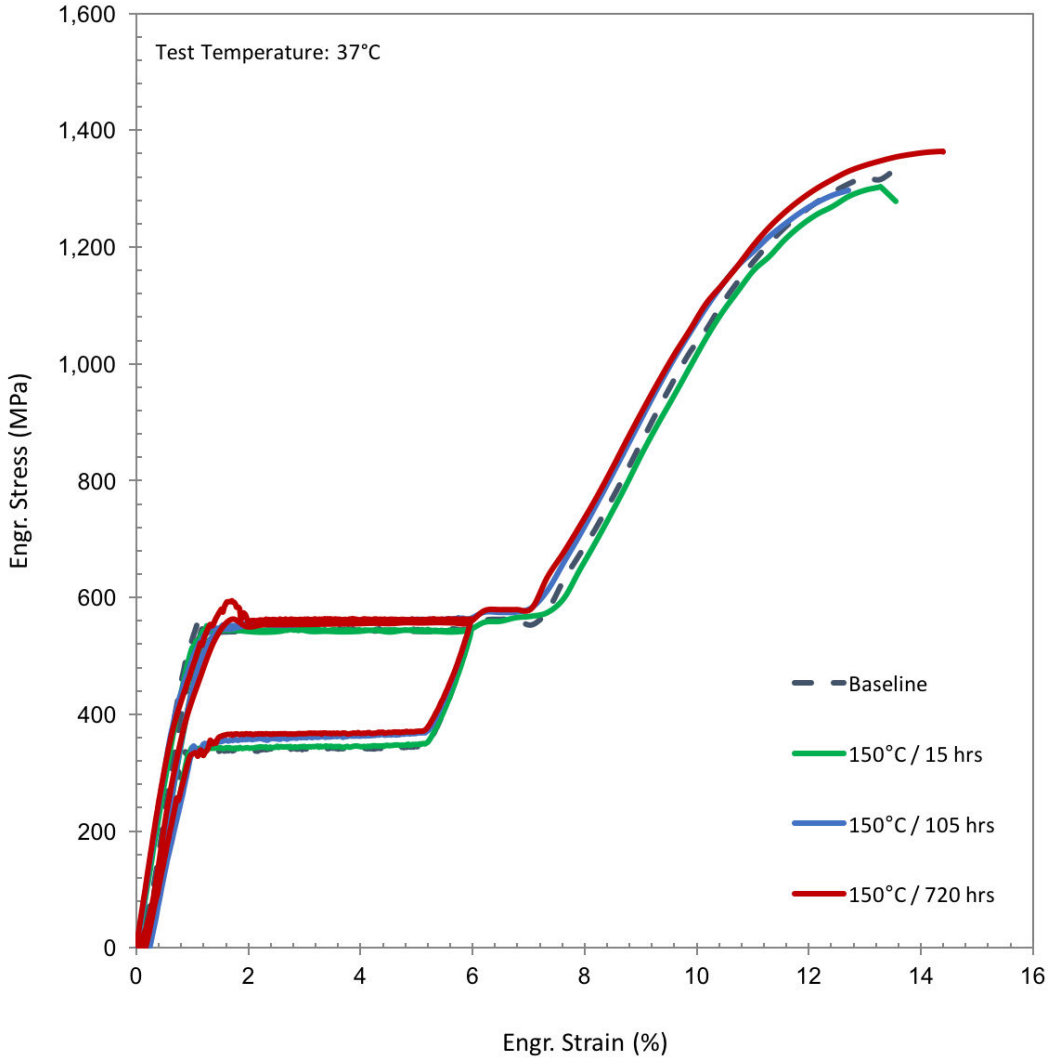
Sample with Retained CW & Precipitates – Aged at 150°C



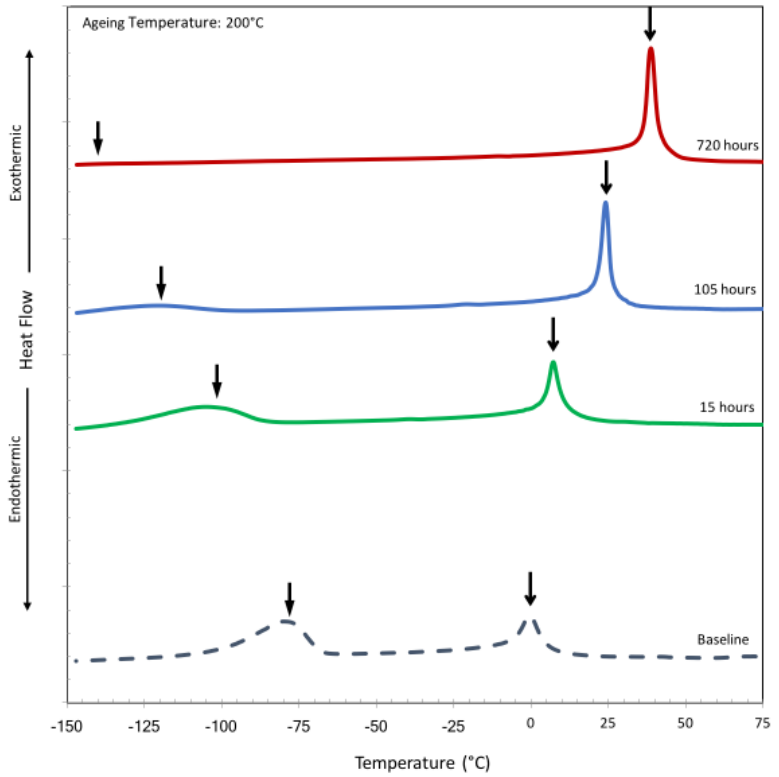


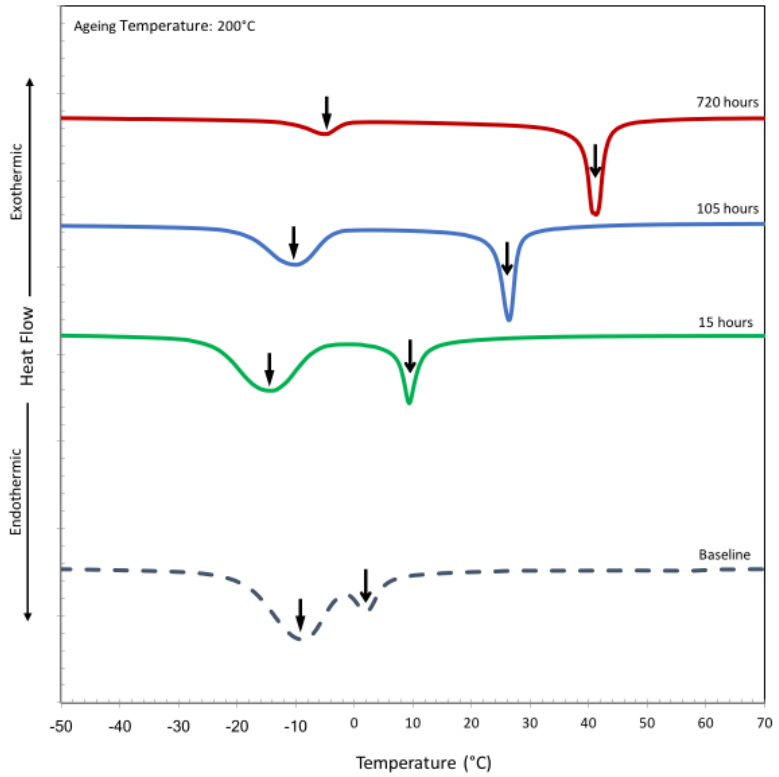


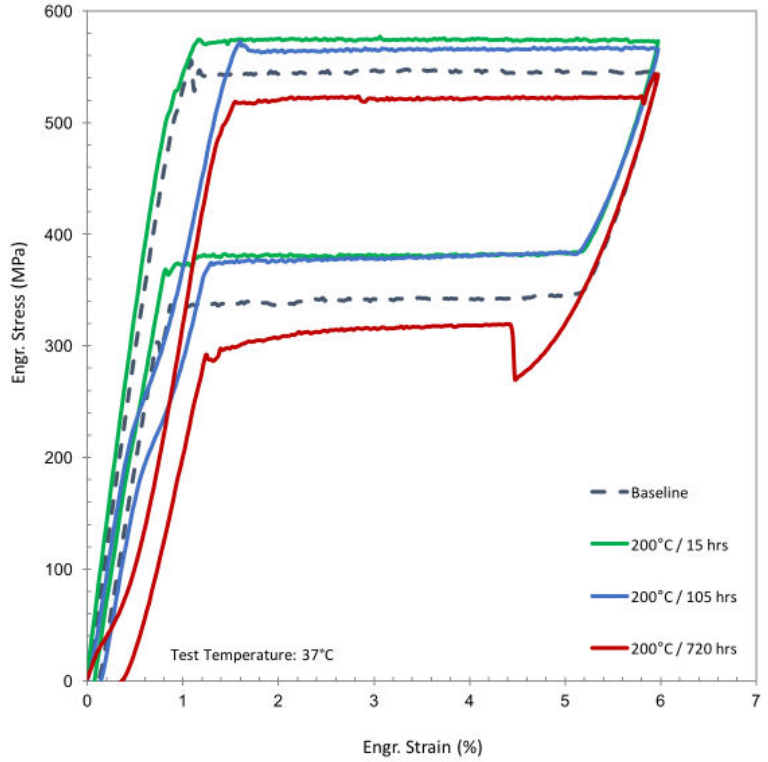
Sample with Retained CW & Precipitates – Aged at 150°C



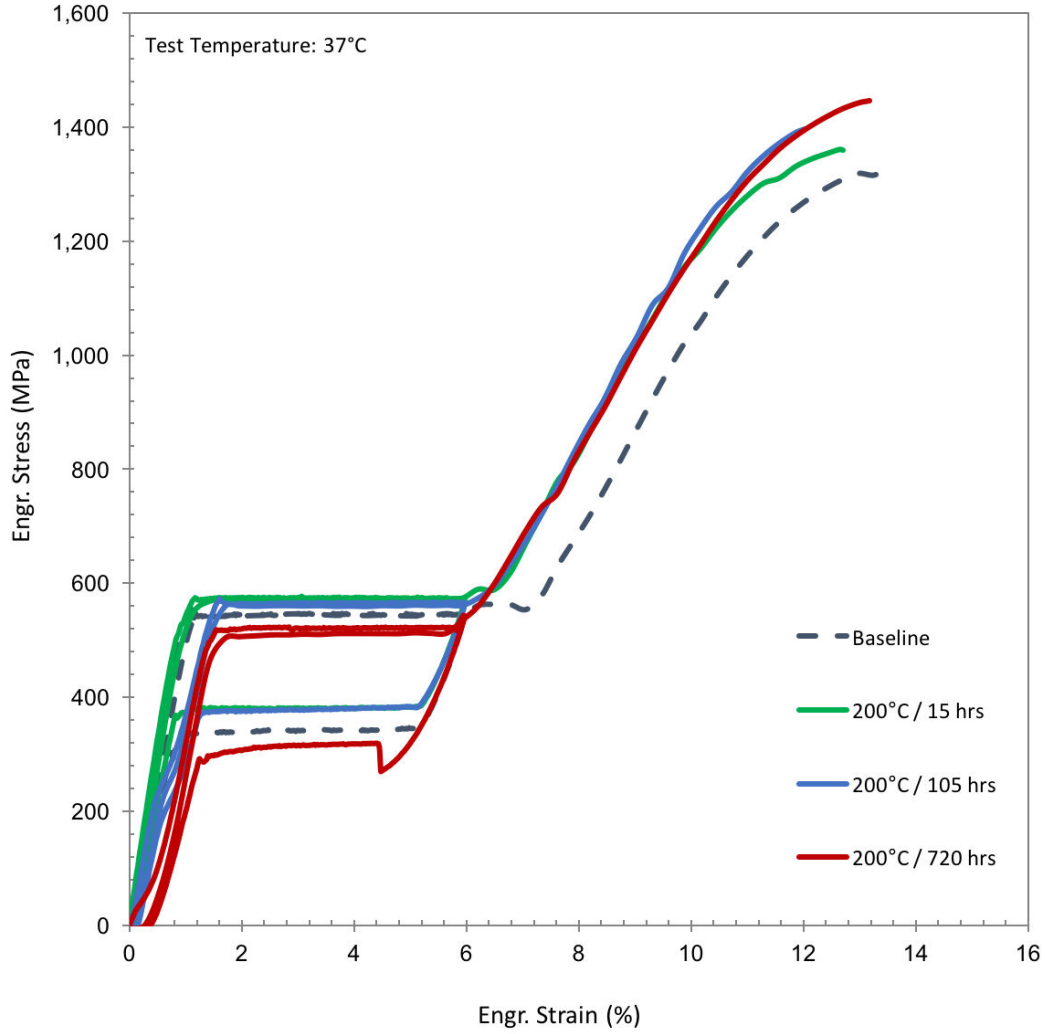
Sample with Retained CW & Precipitates – Aged at 200°C



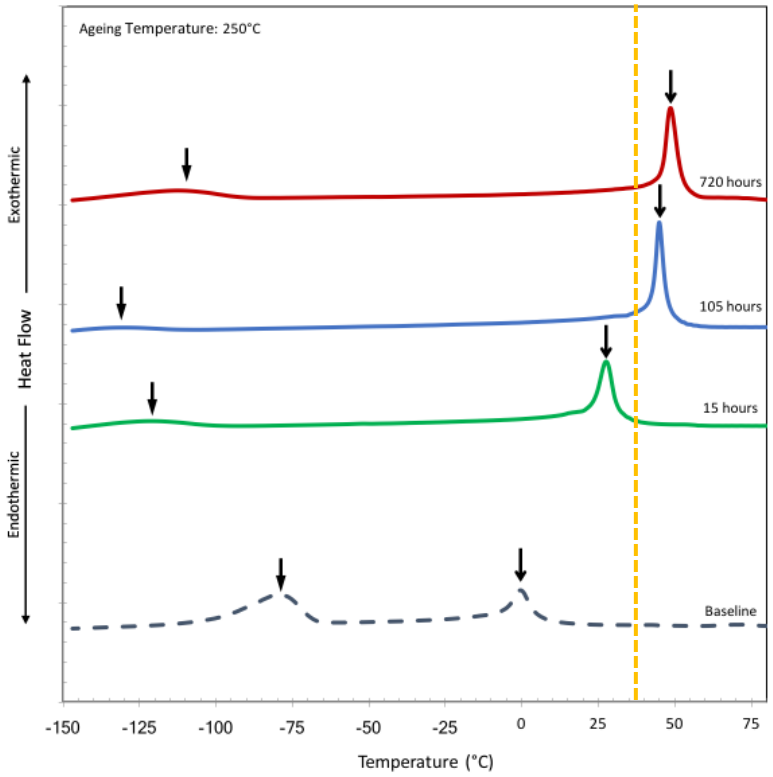


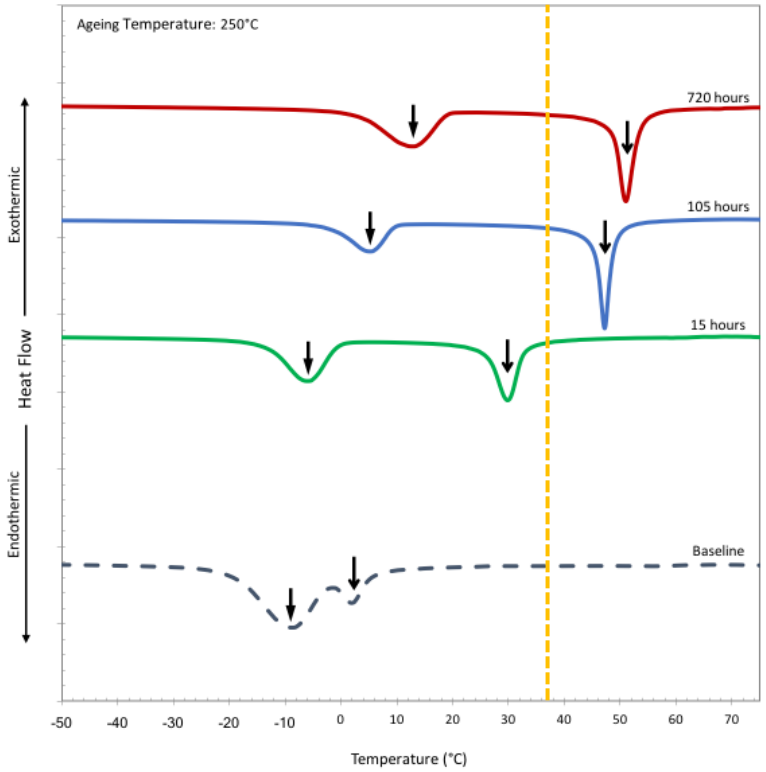


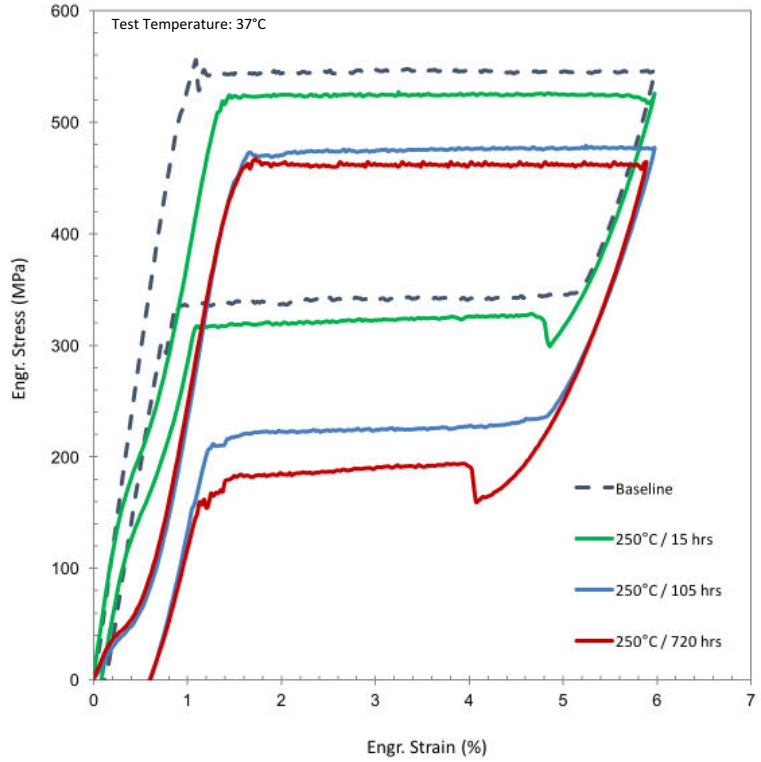
Sample with Retained CW & Precipitates – Aged at 200°C



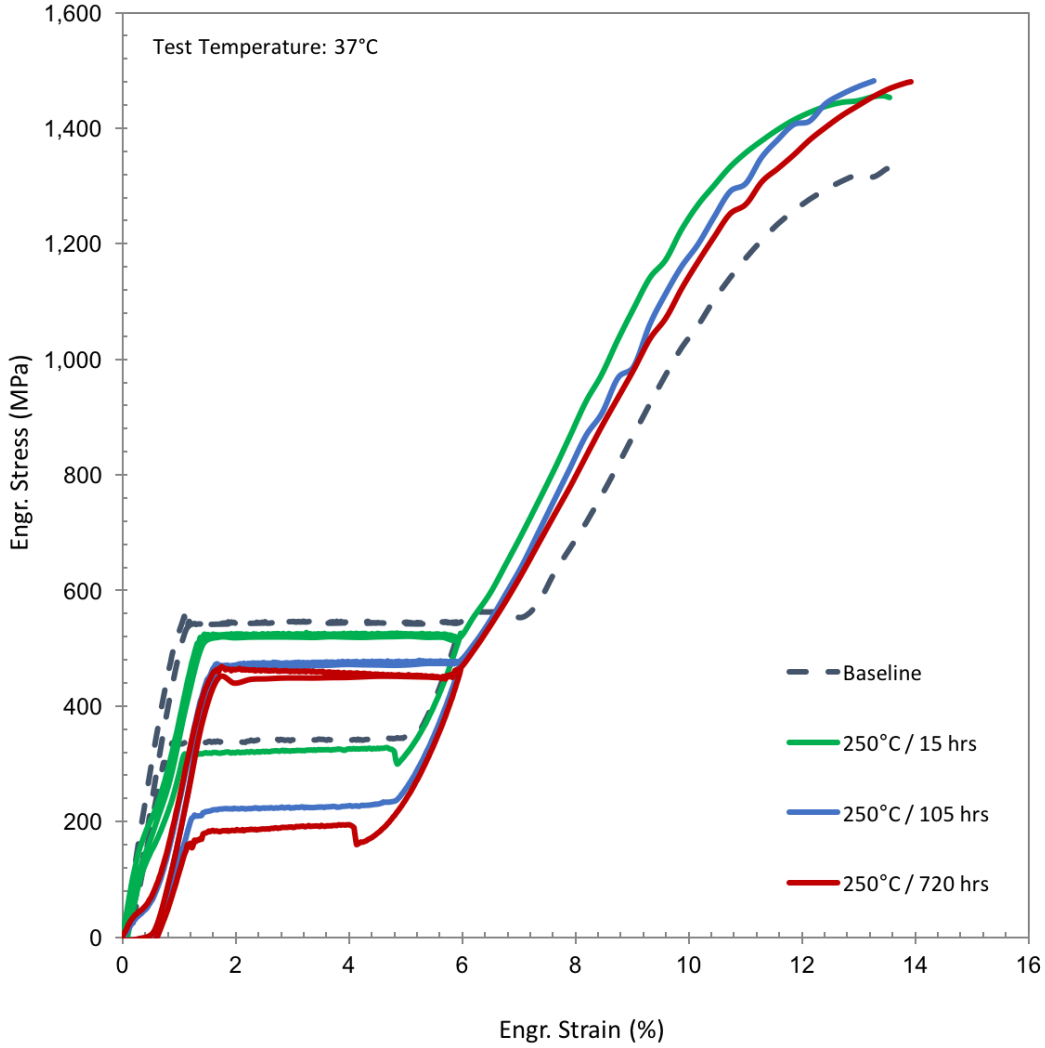
Sample with Retained CW & Precipitates – Aged at 250°C



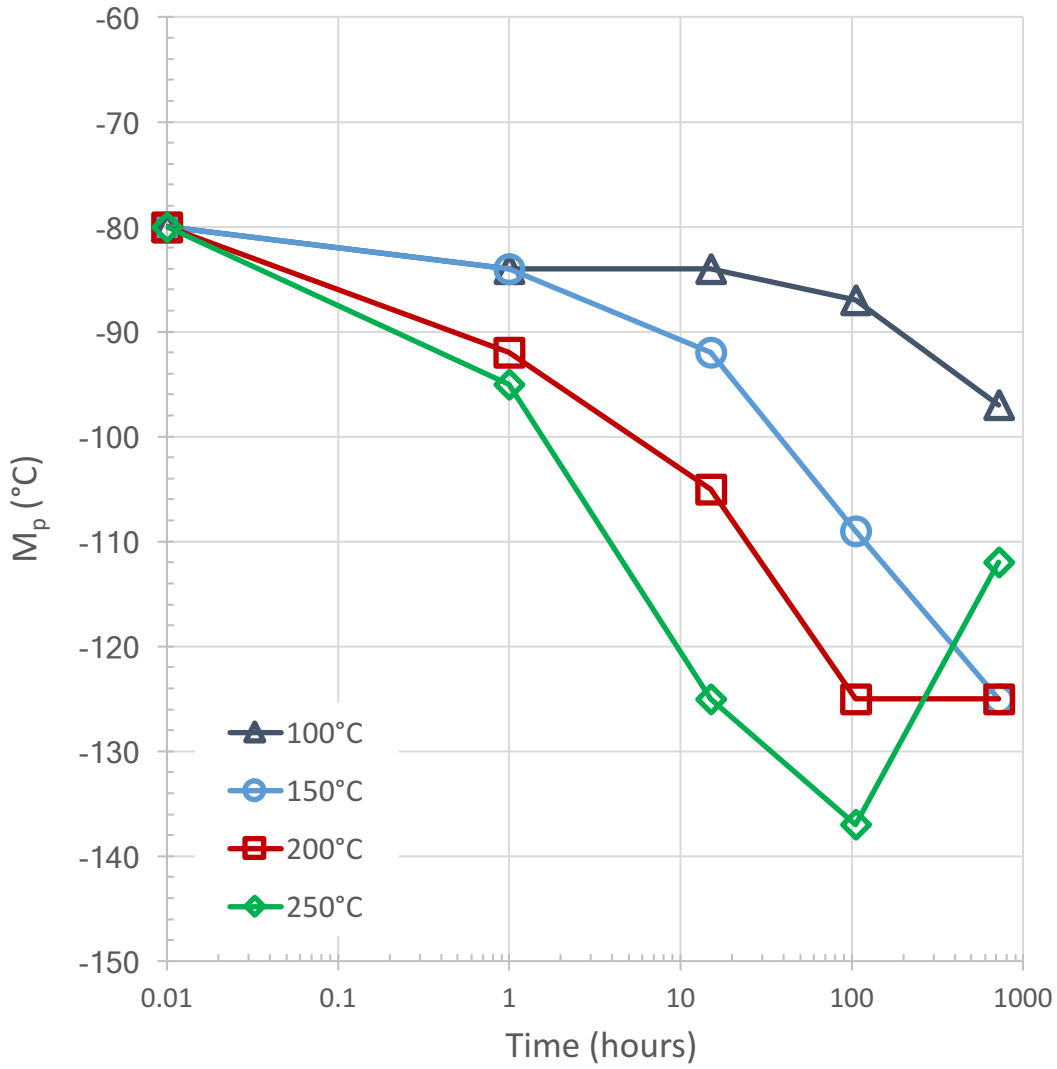


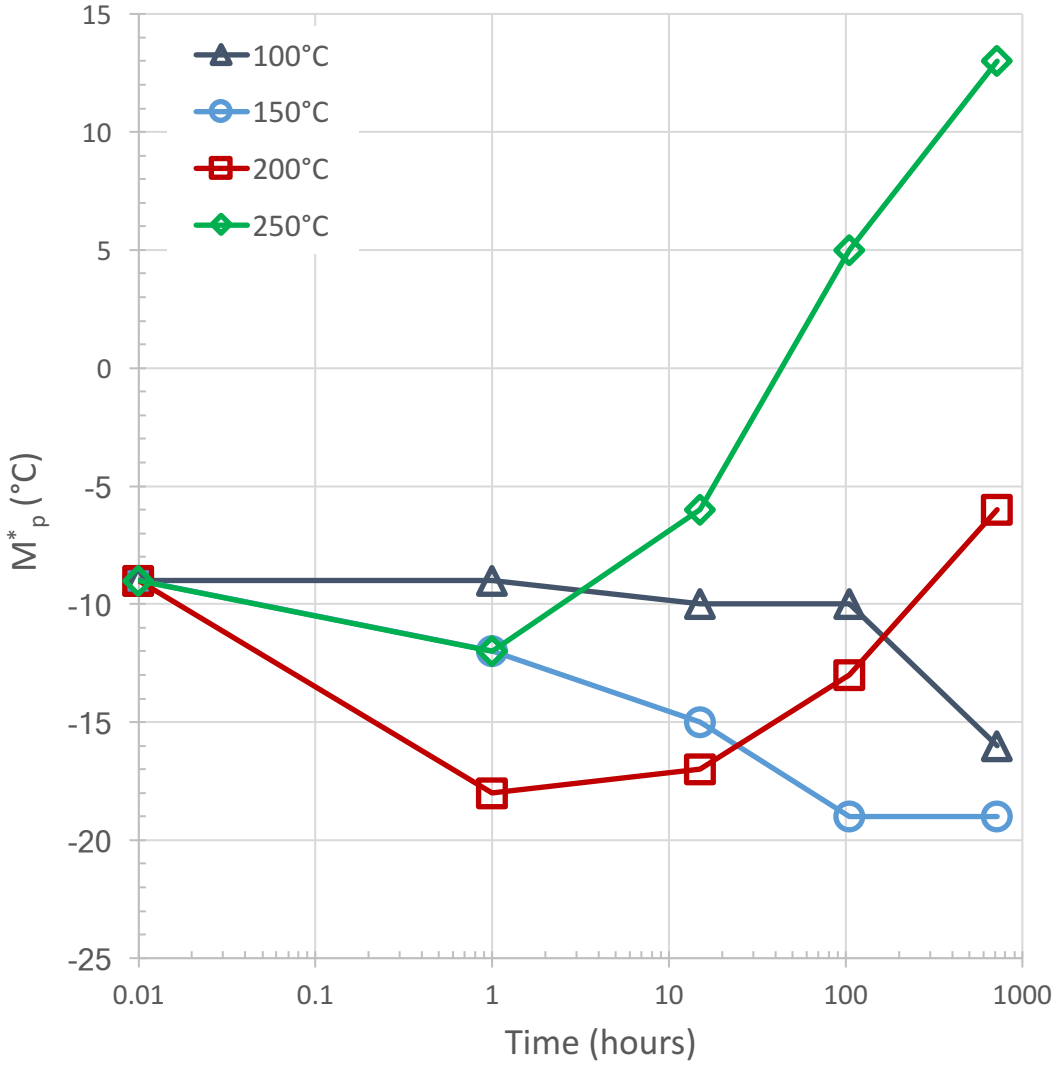


Sample with Retained CW & Precipitates – Aged at 250°C

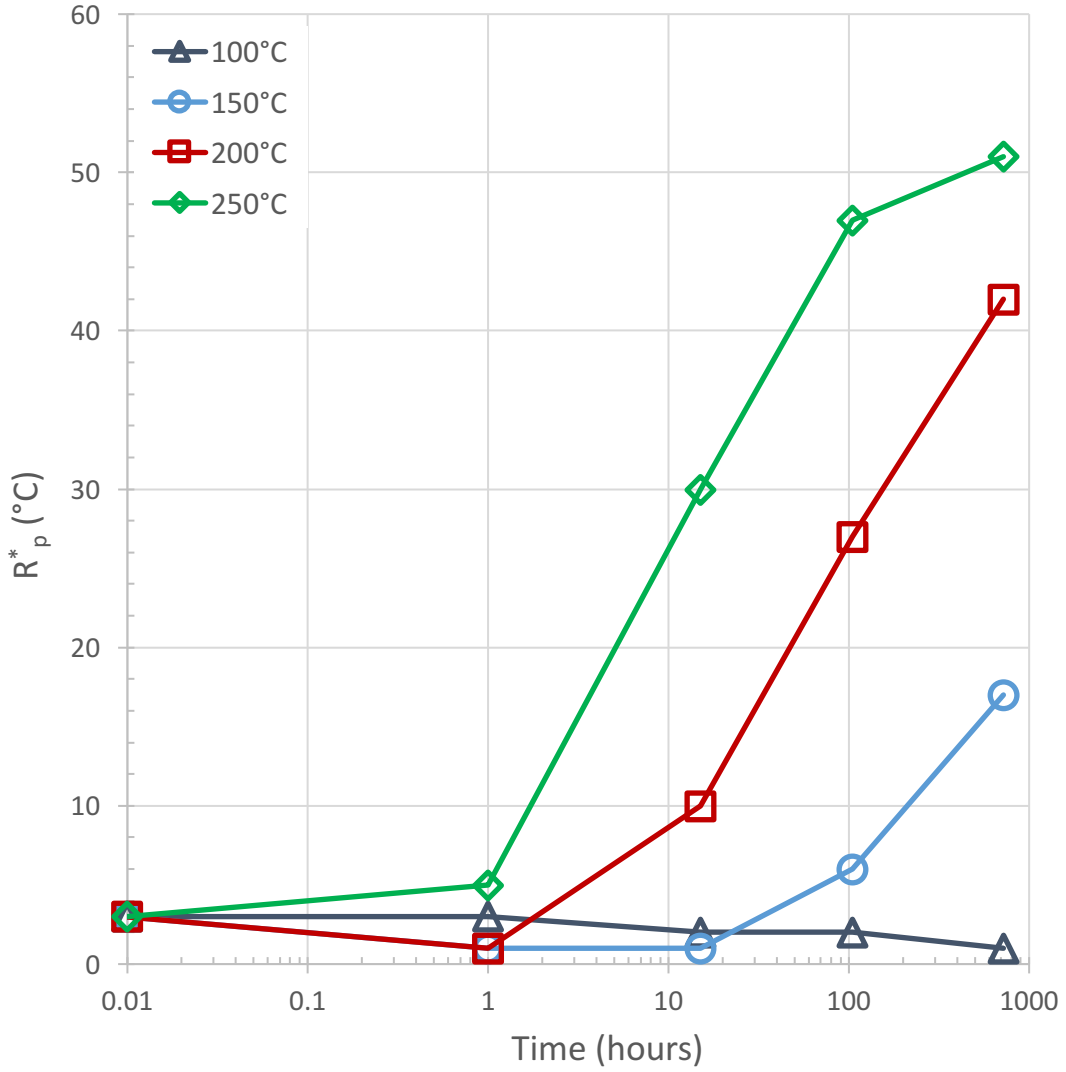


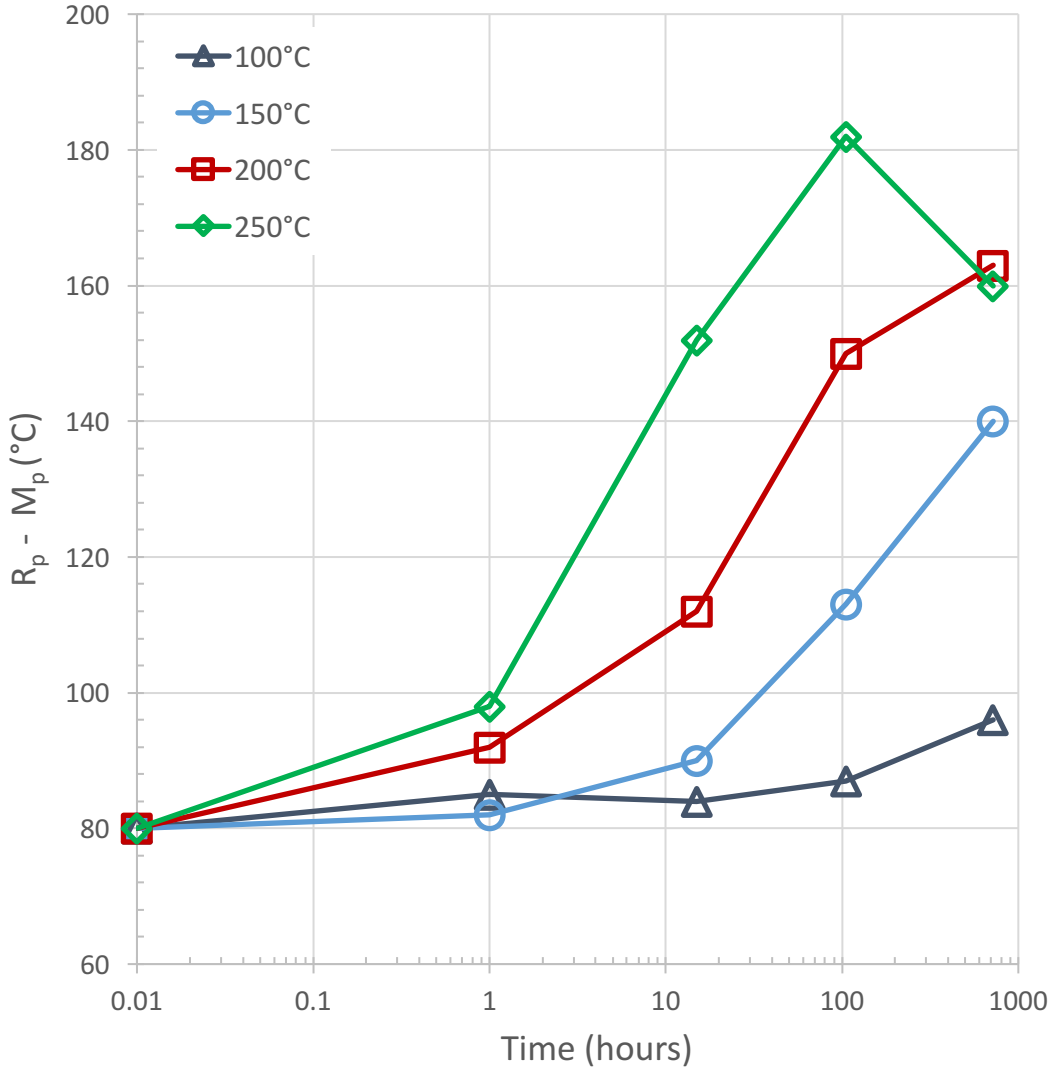
Evolution of Martensite Formation (M_p) and Reversion (M^*_p)



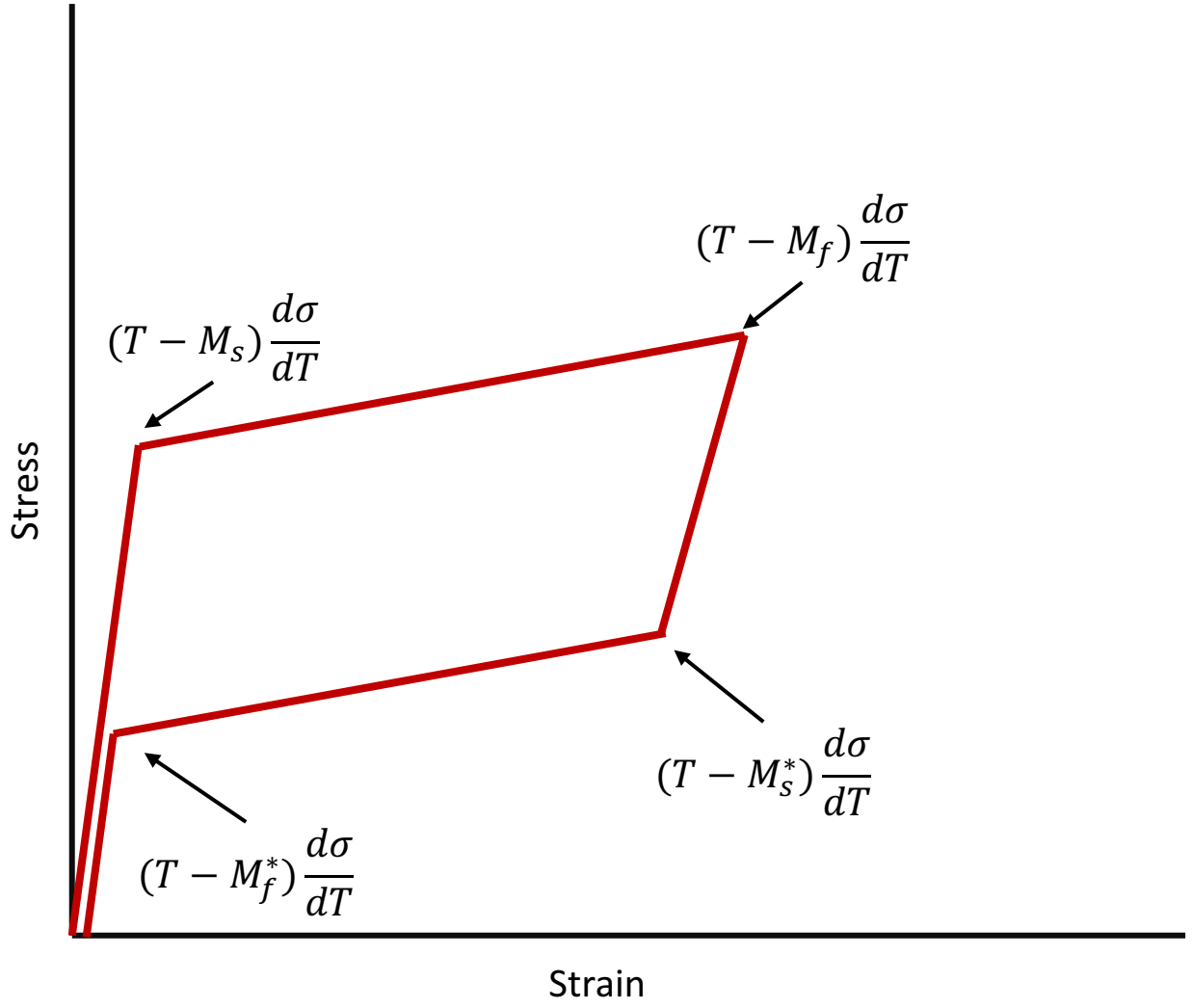


Evolution of R-Phase (R^*_p) and Peak Separation ($R_p - M_p$)

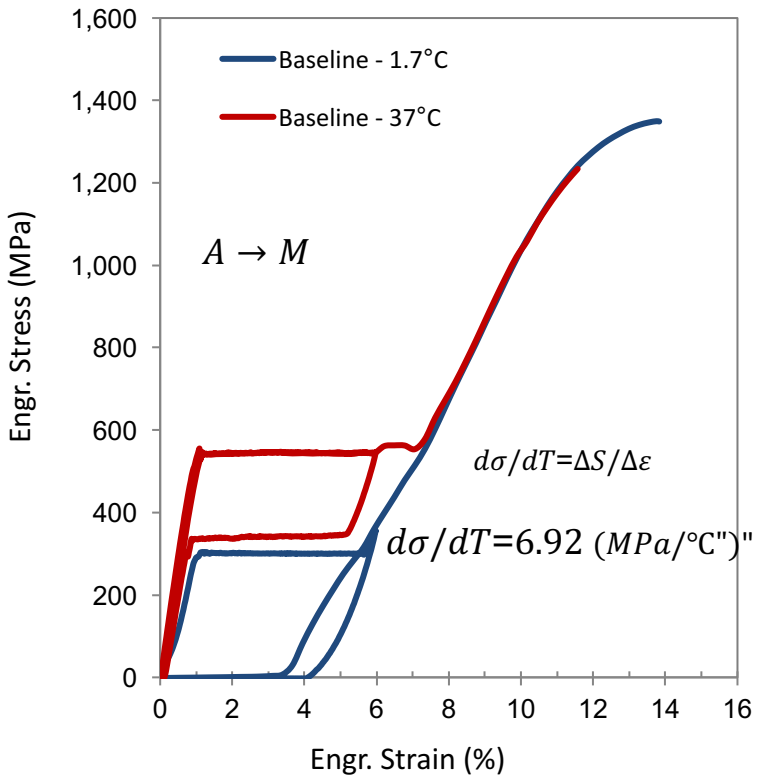


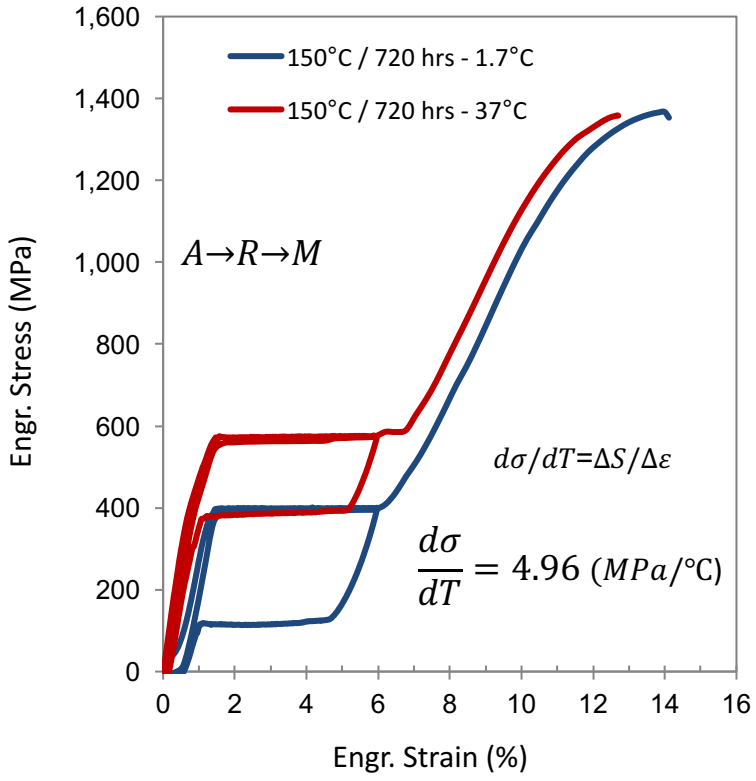


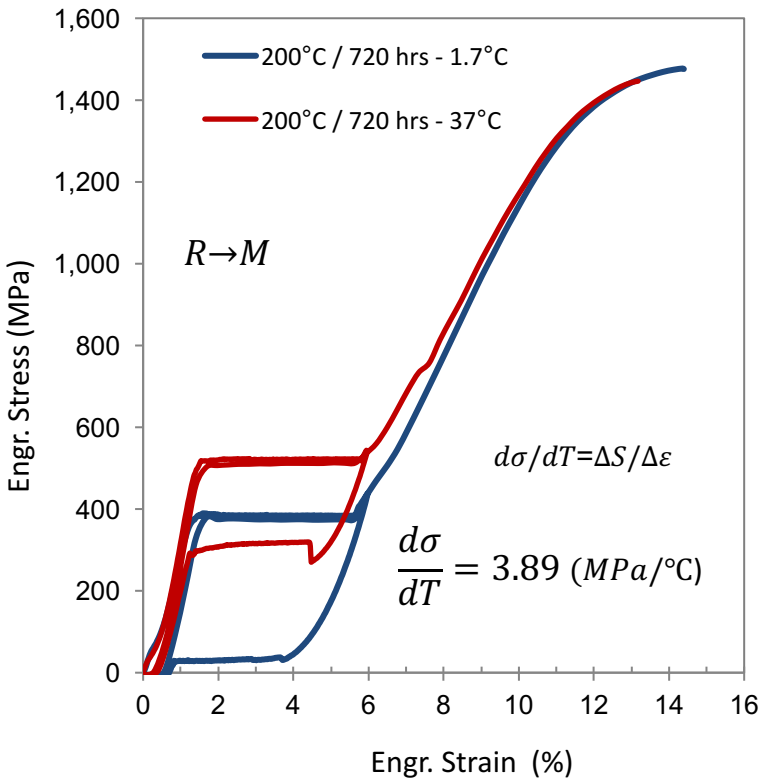
Clausius-Clapeyron – Relation between Stress and Temperature



Stabilization of “R-Phase” and its effect on “Stress”







Remarks & Conclusions:

- Ni-rich Ti-Ni is metastable even at temperatures as low as 100°C
- Exposures at temperatures ≤150°C resulted in stiffening of the material due to the suppression of Martensite formation (M_p) & reversion (M^*_p)
- Suppression of Martensite could be attributed to Ni clustering, precipitation, or the coherency of the precipitates OR a combination of all
- Exposures at temperatures >150°C resulted in loss of stiffness
- Loss of stiffness is attributed to the decrease in $d\sigma/d\mathrm{T}$ due to stabilization of the R-phase
- Stabilization of the R-phase at higher temperatures can also result in materials with an A_f well above body temperature (i.e. 48°C) with pseudoelasticity!
- Caution must be taken when exposing NiTi to temperatures <200°C (e.g. when applying coatings)

bit.ly/smst17ndc

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