Study on the microstructure influence in ultrasonic test in duplex forged components

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Project overview

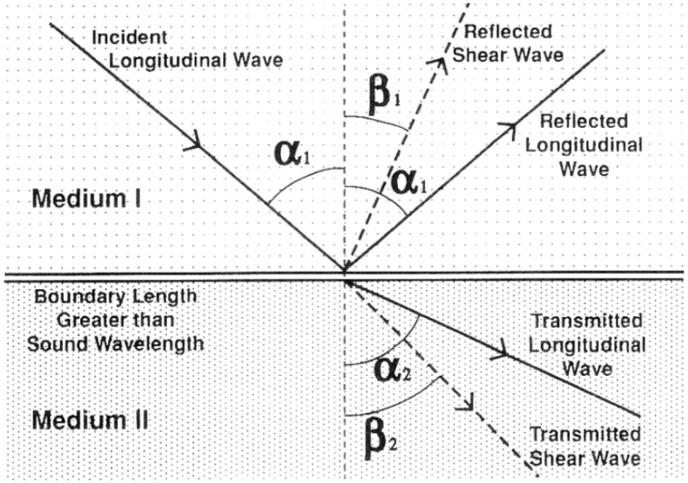
- Study the response of DSS with controlled INTERMETALLIC PHASES PRECIPITATION when inspected by UTS

- Understand the role of MICROSTRUCTURAL FEATURES on UTS attenuation

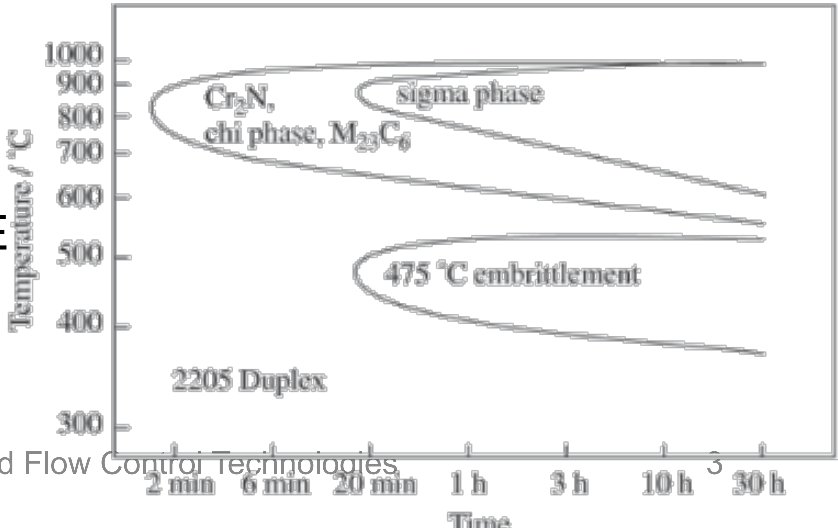
- Evaluate the possibility to use UTS as a method to characterize the **INTERMETALLICS** fraction in **DSS**

Introduction

- DSS are difficult to inspect by ULTRASOUND
  - AUSTENITE (FCC cell)
  - CRYSTALLOGRAPHIC TEXTURE
  - DIFFRACTION, SCATTERING, ABSORPTION



- Precipitation of INTERMETALLIC PHASES affects the sound wave propagation
  - EMBRITTLMENT
  - REDUCTION of CORROSION RESISTENCE



Experimental procedure

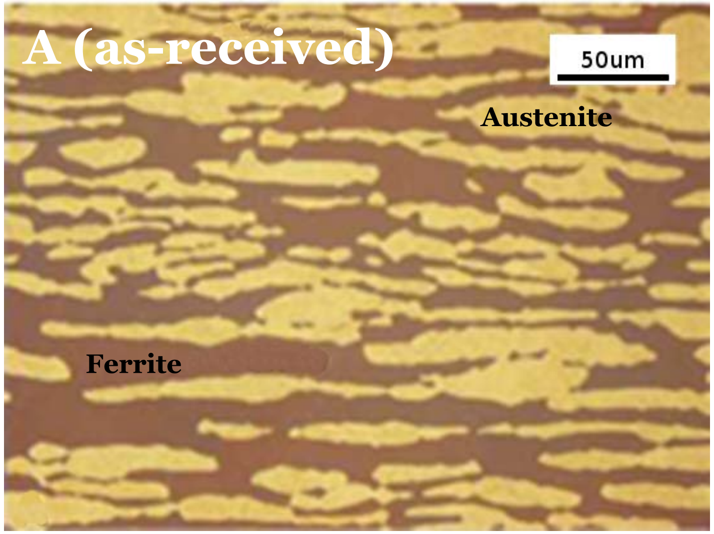
- Material: UNS S31803 Forged and solubilized (size 45x45x15 mm)

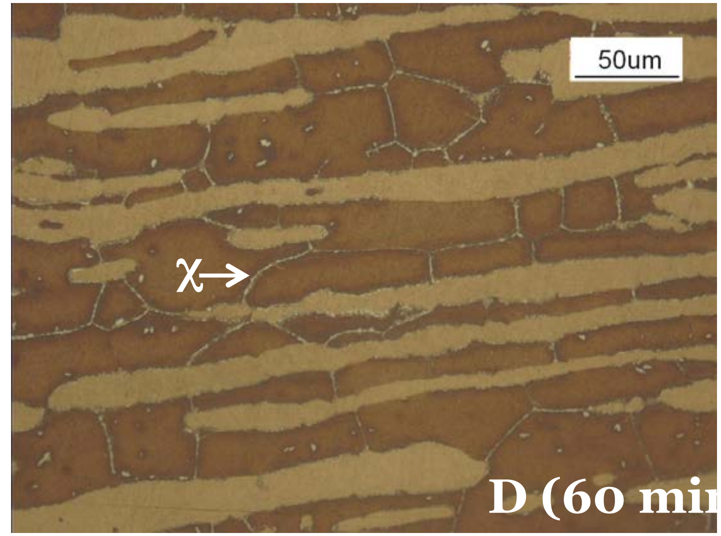
C	Cr	Mn	Mo	N	Ni	P	S	Si	Al
0.0240	22.14	1.79	3.38	0.17	5.11	0.02	0.0005	0.55	0.018

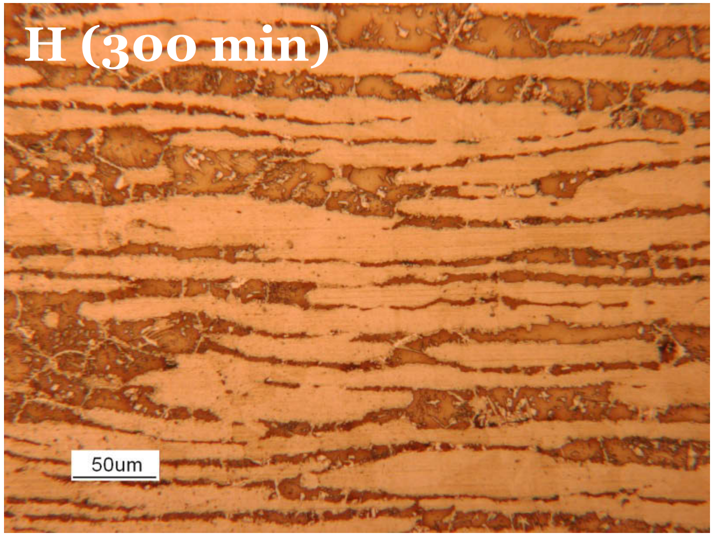
Sample	Treatment time (min) at 780 °C	
A	0	Water cooling
B	10	
C	30	
D	60	
E	120	
F	180	
G	240	
H	300	
I	390	
J	480	
K	600	

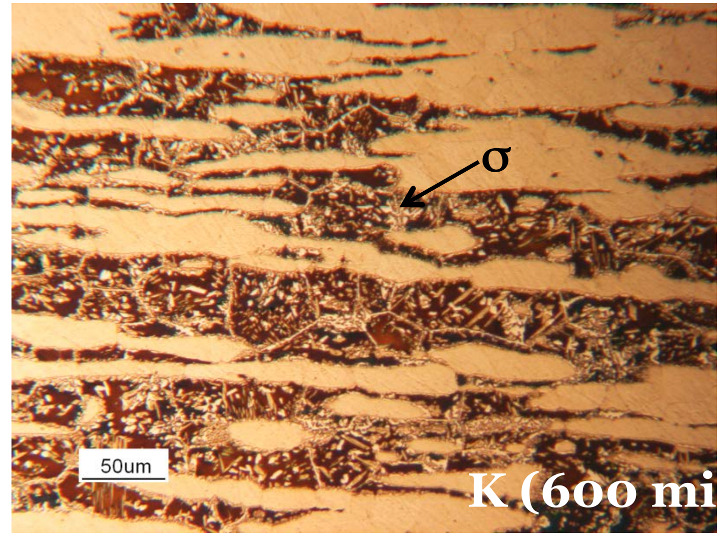
- Metallographic analysis
  - Phase fraction
  - Ferrite grains thickness
- SEM analysis
  - EDS
  - EBSD: misorientation and CLS
- Tensile test
- Ultrasonic velocity measurement
  - Longitudinal waves (4 MHz probe)

Metallographic analysis

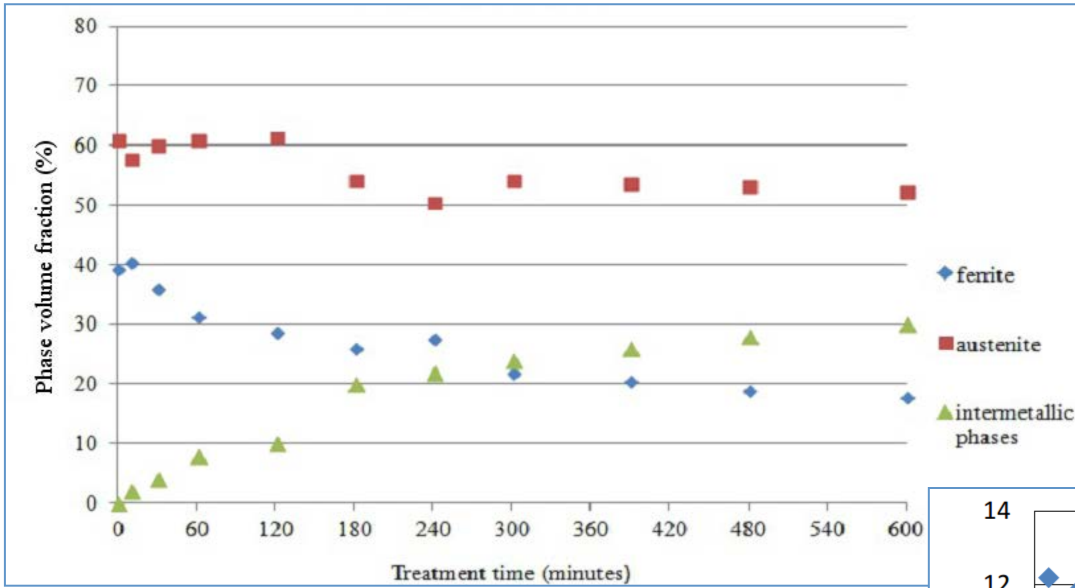






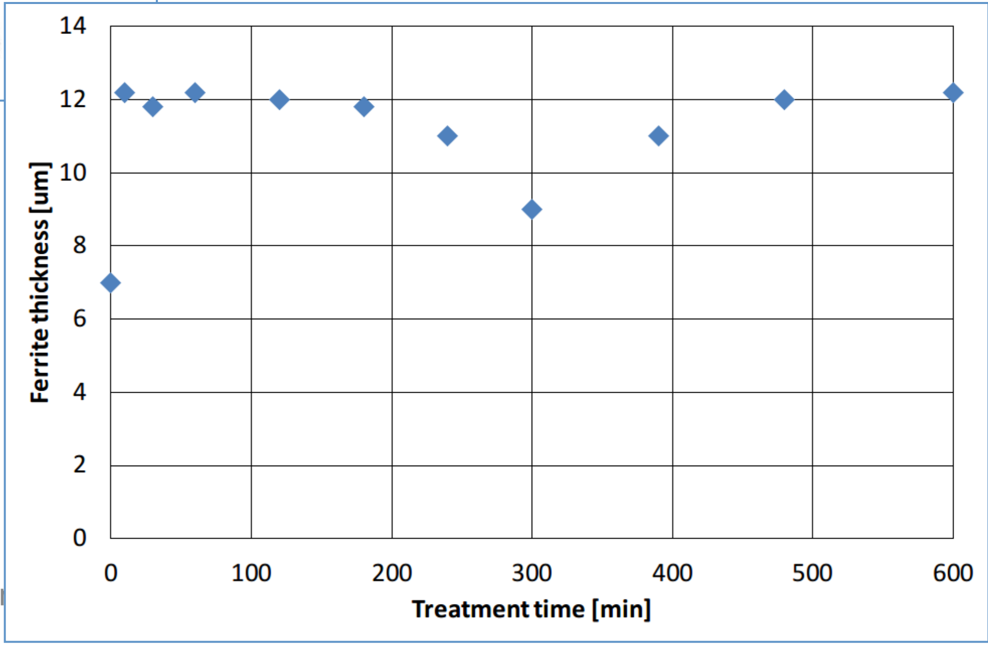


Metallographic analysis

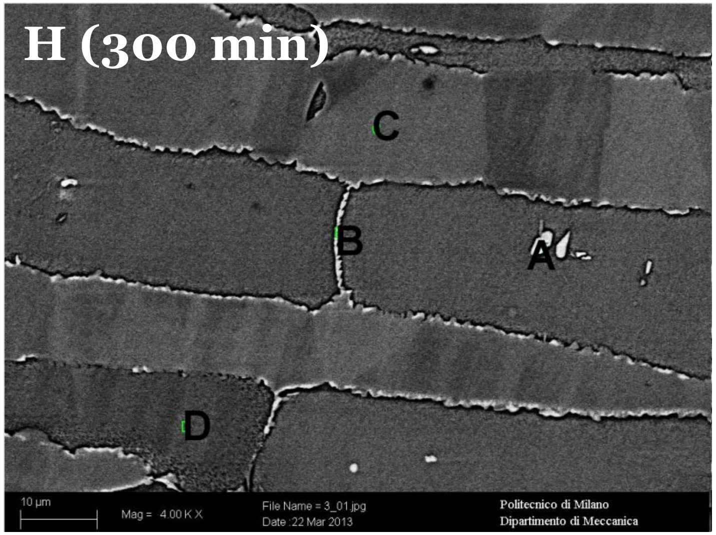


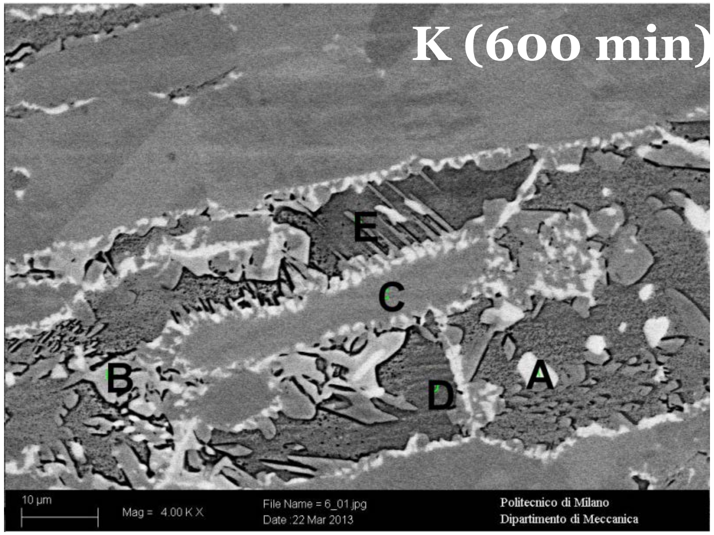
- Austenite fraction is ruled by diffusional phenomena
- σ and χ phase are enriched in Mo and Cr

- Decreasing in ferrite content
- χ and σ nucleate and grow at the interfaces of Fe-δ and Fe-γ grains



SEM analysis

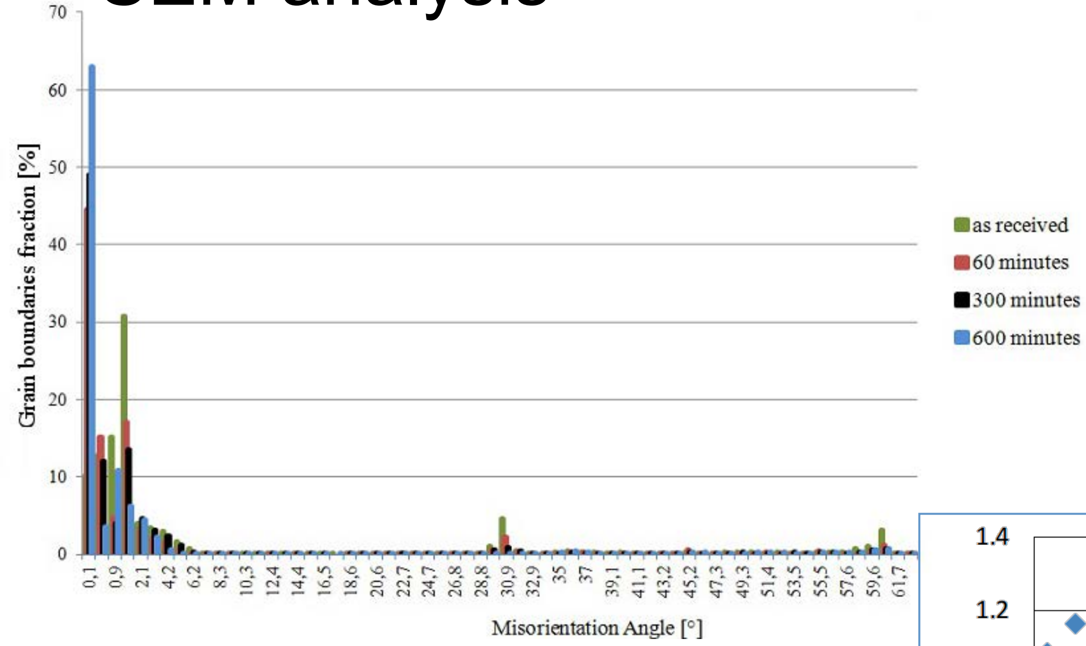


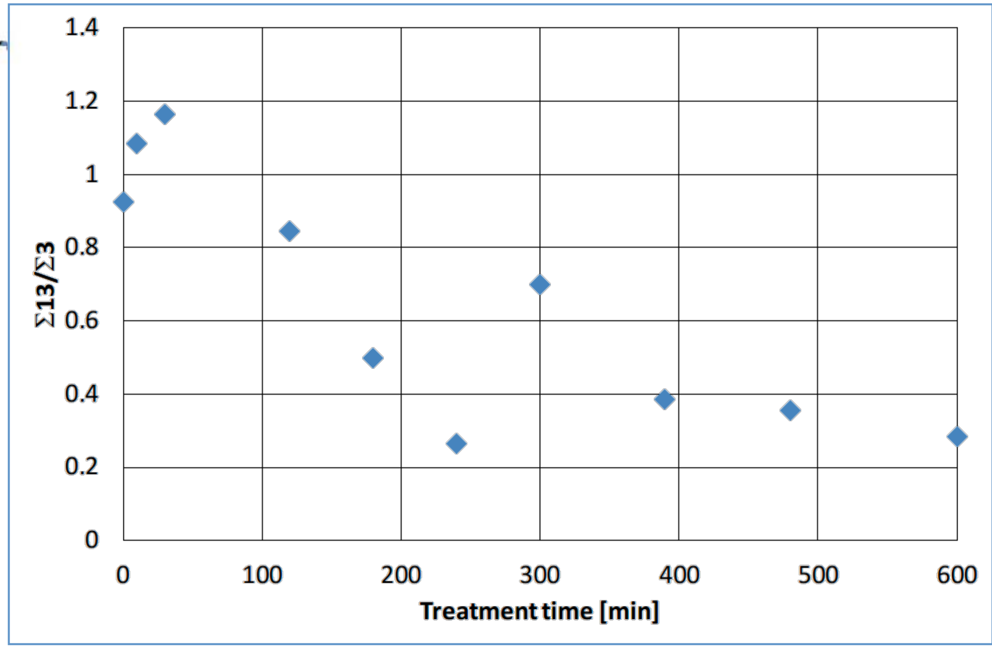


%wt.	Cr	Mn	Ni	Mo
A (σ)	29.60	1.89	4.80	8.10
B (χ)	26.74	1.95	3.74	13.04
C (Fe-γ)	21.68	2.16	6.26	2.01
D (Fe-δ)	24.52	1.97	6.20	4.10

%wt.	Cr	Mn	Ni	Mo
A (σ)	27.50	1.96	3.95	9.79
B (σ)	28.01	1.84	4.20	9.50
C (Fe-γ)	21.56	2.10	6.25	2.99
D (Fe-δ)	26.70	1.58	7.20	2.43
E (Fe-γ”)	22.40	2.57	5.20	1.75

SEM analysis

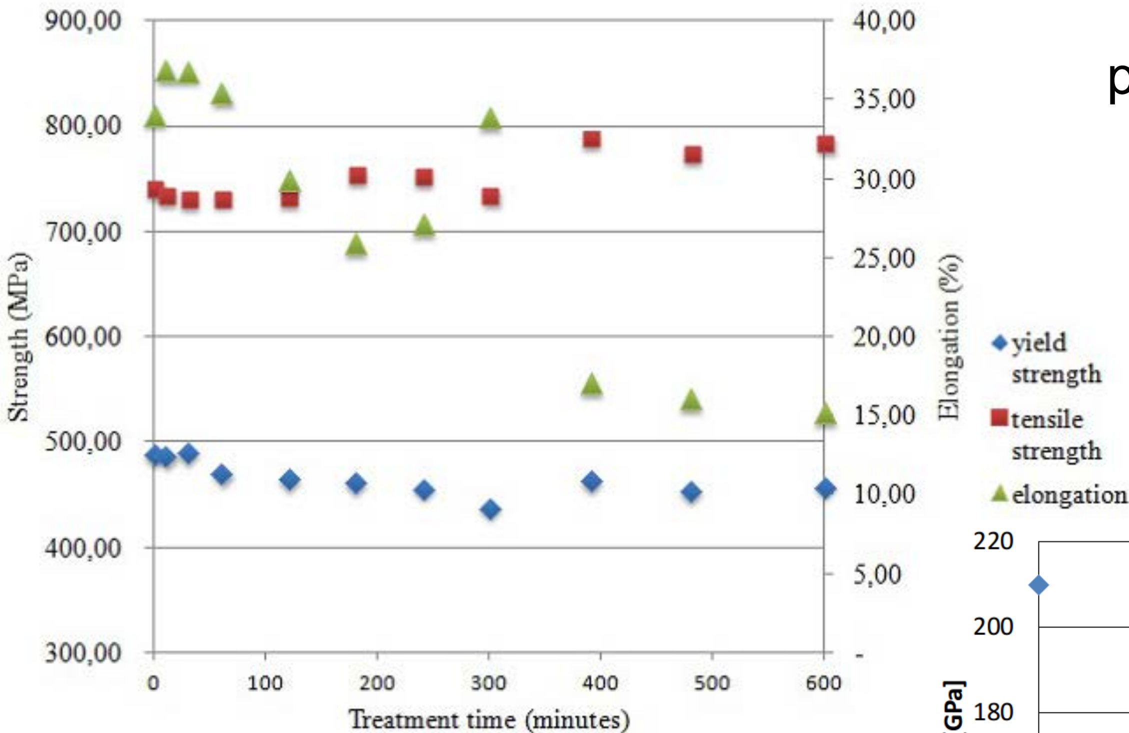


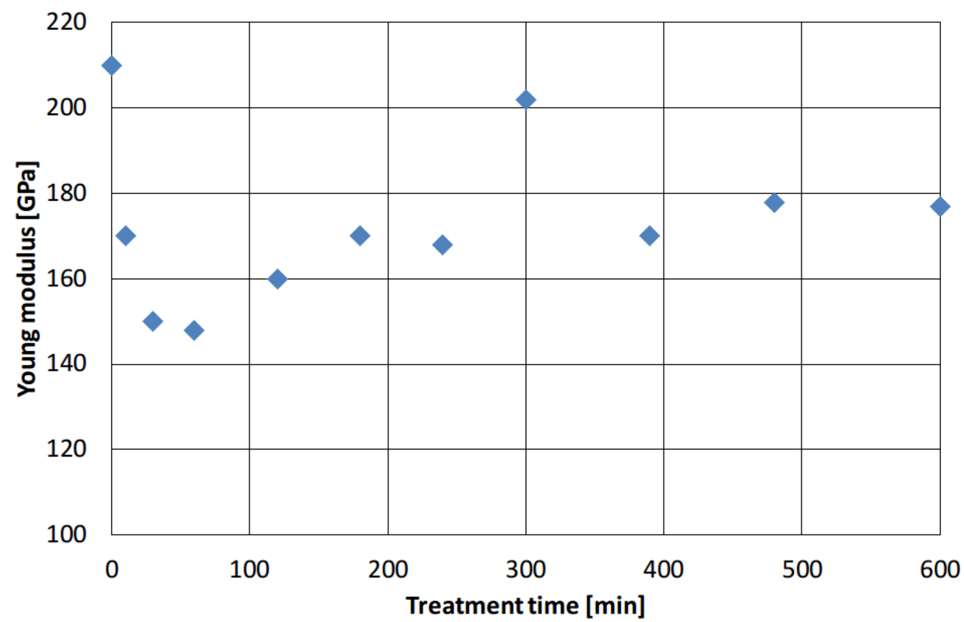


Σ13 = recrystallization
Σ3 = twinning

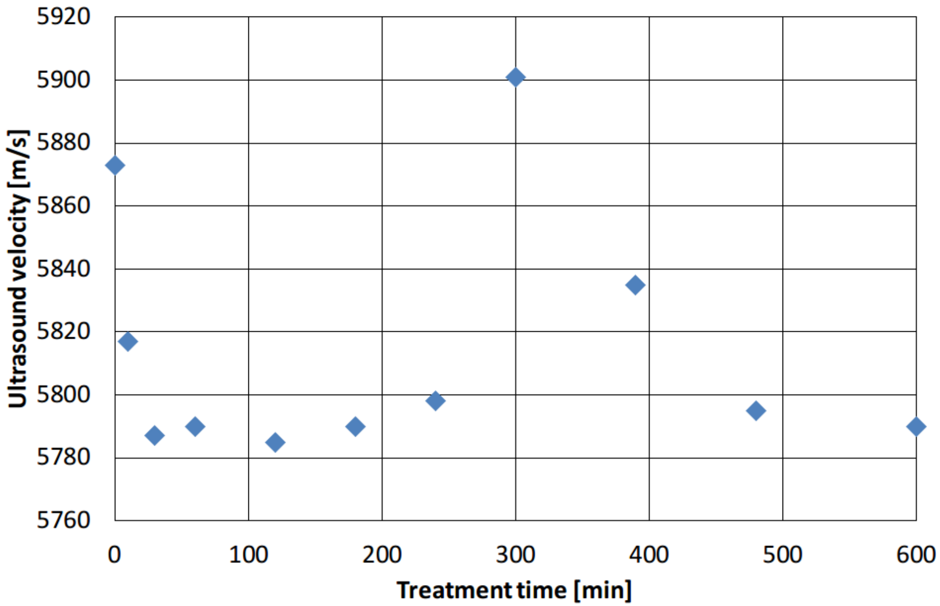
Tensile test

- E rose at 24% of intermetallic phases (300 min)



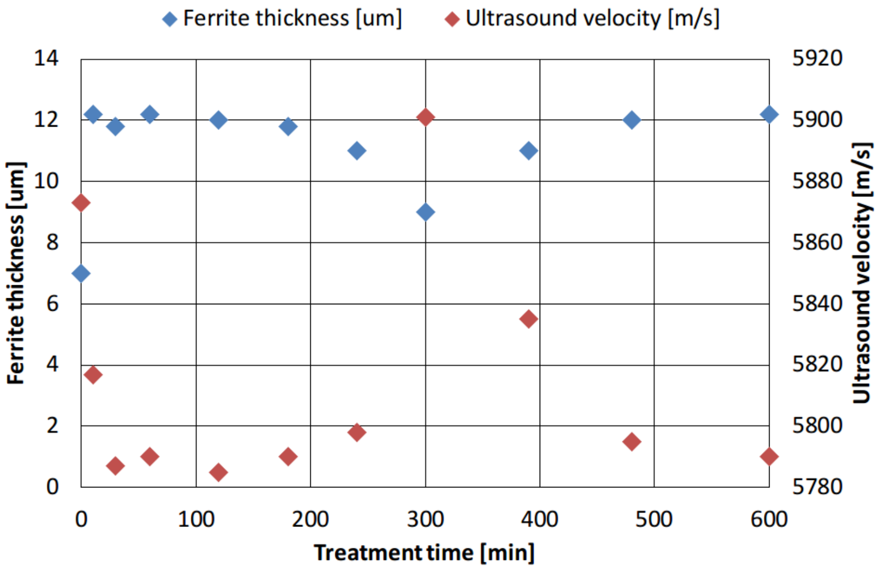


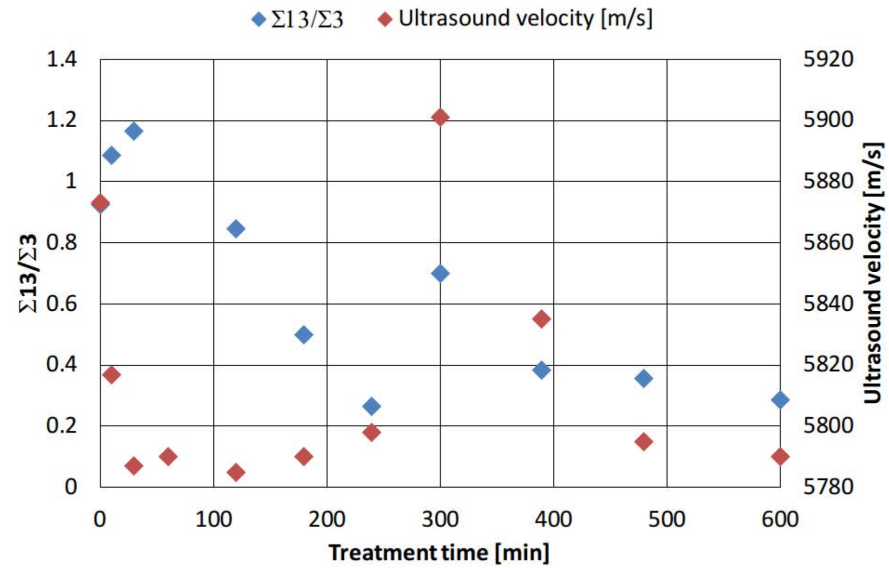
Ultrasound velocity



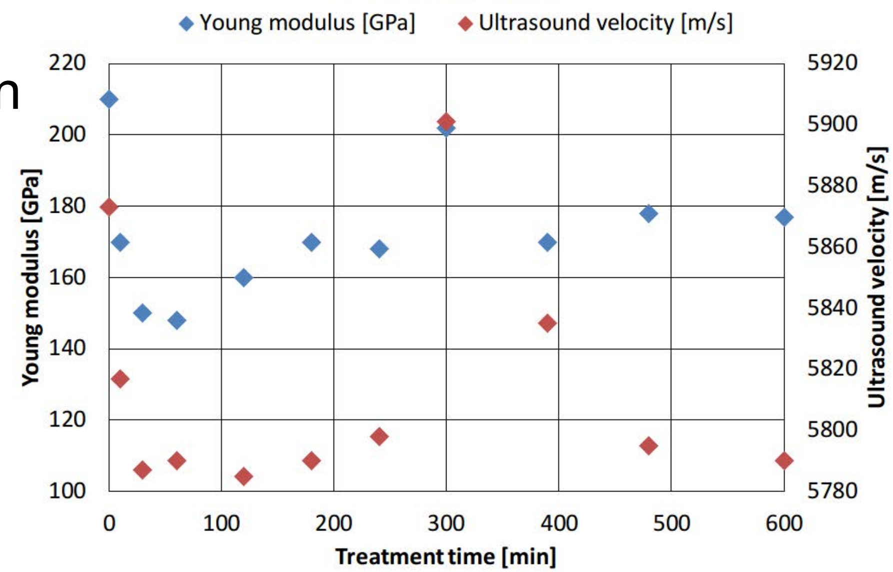
- The UTS velocity decrease for the samples treated up to 240 min --> 22% intermetallic
- Ultrasound velocity increased to 5900 m/s --> 300 min (24% intermetallic)
- Over 300 min, UTS velocity decreases again (from 26% to 30% intermetallic)

Discussion





- The ultrasound velocity variation coincides with the changes observed in the Fe-d thickness, S13/S3 and E
- At 300 min Σ13/Σ3 ratio is larger than for others conditions, indicating a strong recrystallization
- Recrystallized microstructure is known to reduce the ultrasound attenuation



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Conclusion

- The variation of mechanical and metallurgical parameters coincide to the ultrasound velocity variation
- Aging at 780°C for 300 min grants the lowest UTs attenuation

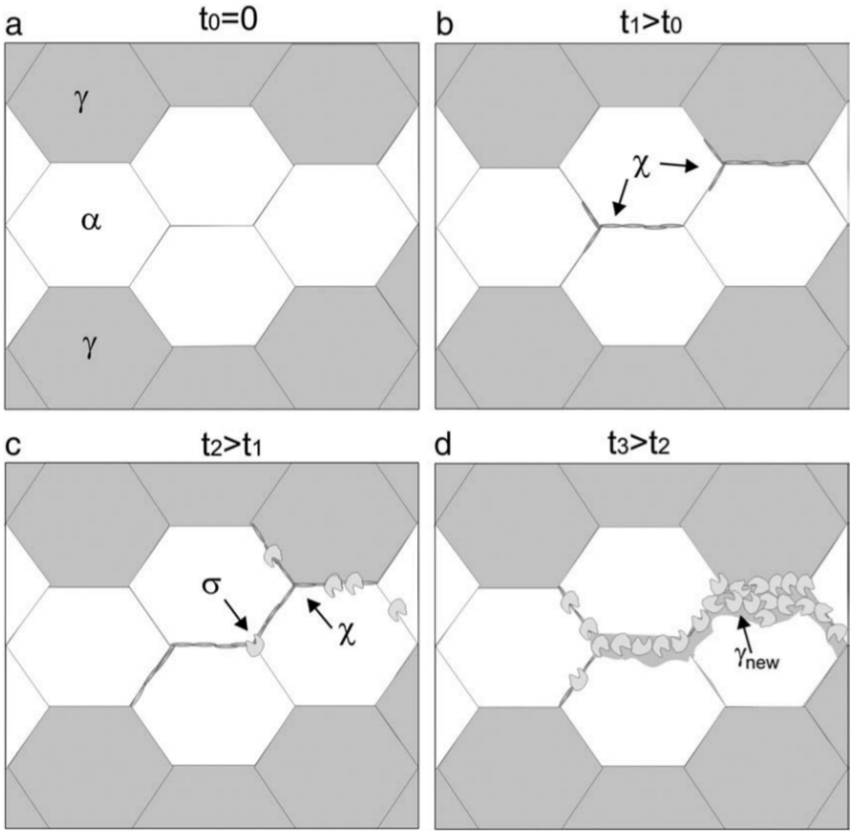
Industrial POV

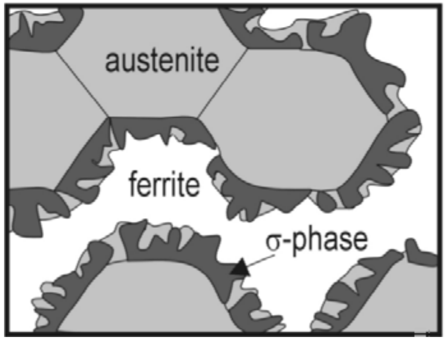
Use UTs to characterize the intermetallic phase content

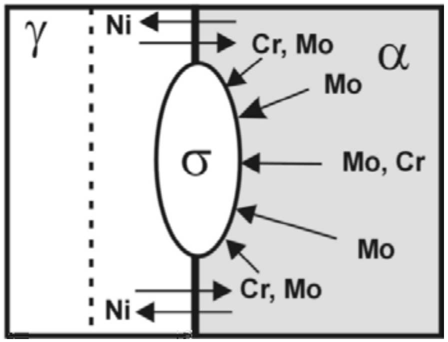
Controlled precipitation to allow UTs control

Solubilization and quality treatment

Addendum: σ and χ phase formation







Addendum: σ and χ phase formation