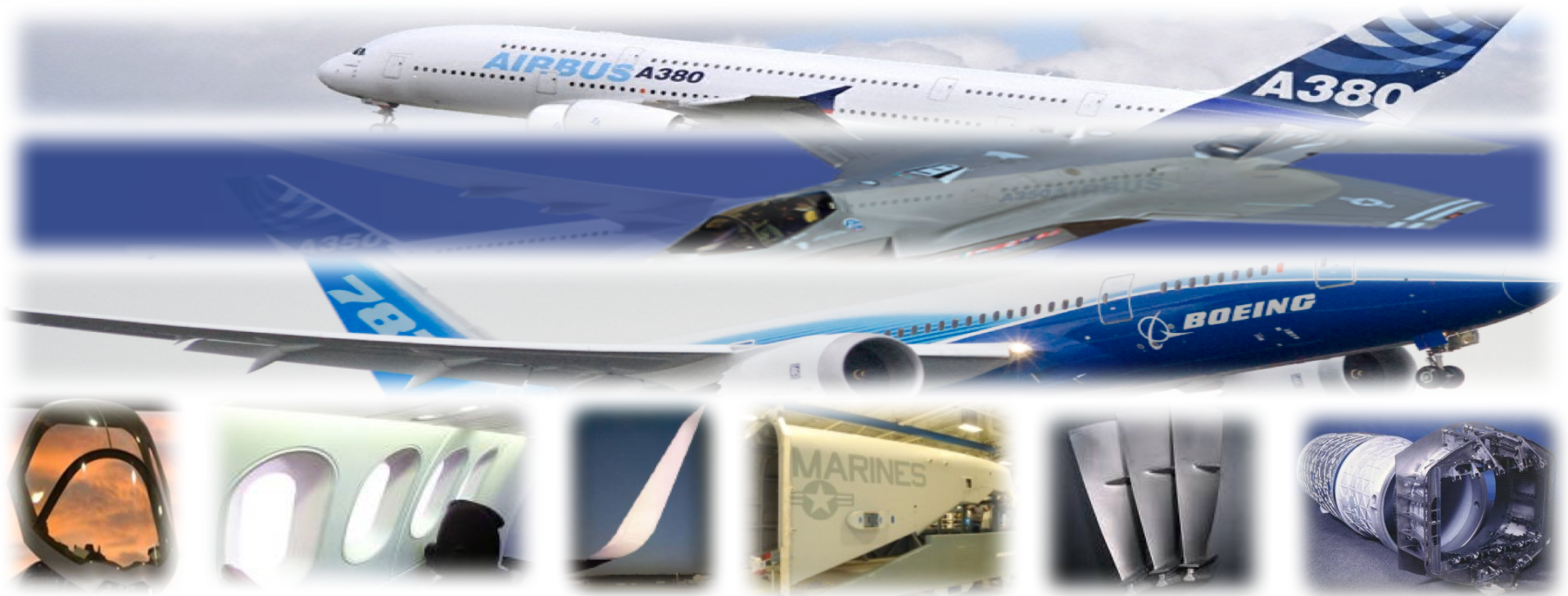




Weldability of nickel-base superalloys for energy applications (KME-706)

Development of weldability assessment and understanding of hot cracking in boiler and gas turbine materials (KME-719)



HTC/KME research symposium
March 15-16, 2016

Fabian Hanning, Sukhdeep Singh, Joel Andersson & Lars Nyborg

Drivers for Research

> Gas turbines and boiler plants?

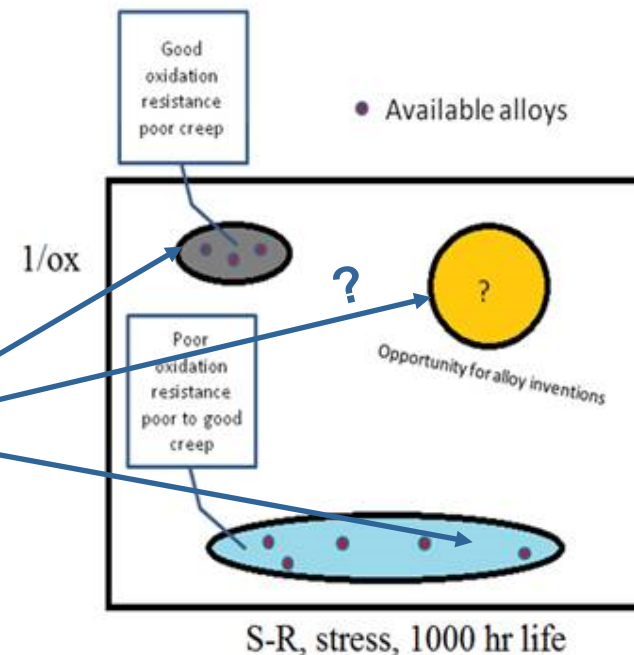
> Thermal energy processes

> Increased efficiency!

■ "New" materials

- Oxidation
- Creep

> Production problems (e.g. welding)



Weldability of nickel-base superalloys for energy applications

KME 706

Fabian Hanning, Joel Andersson & Lars Nyborg

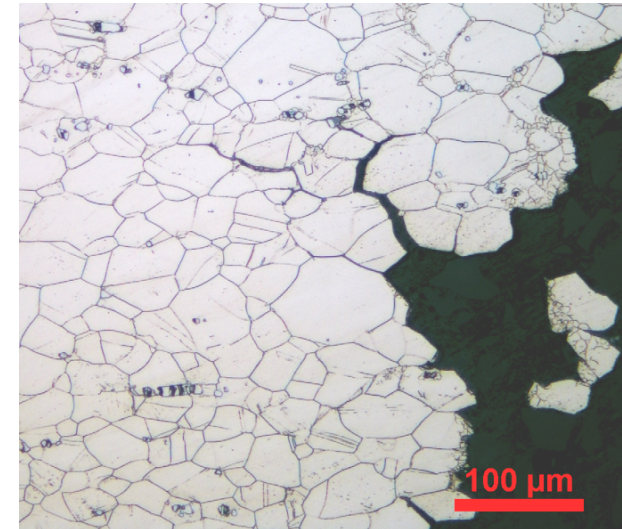
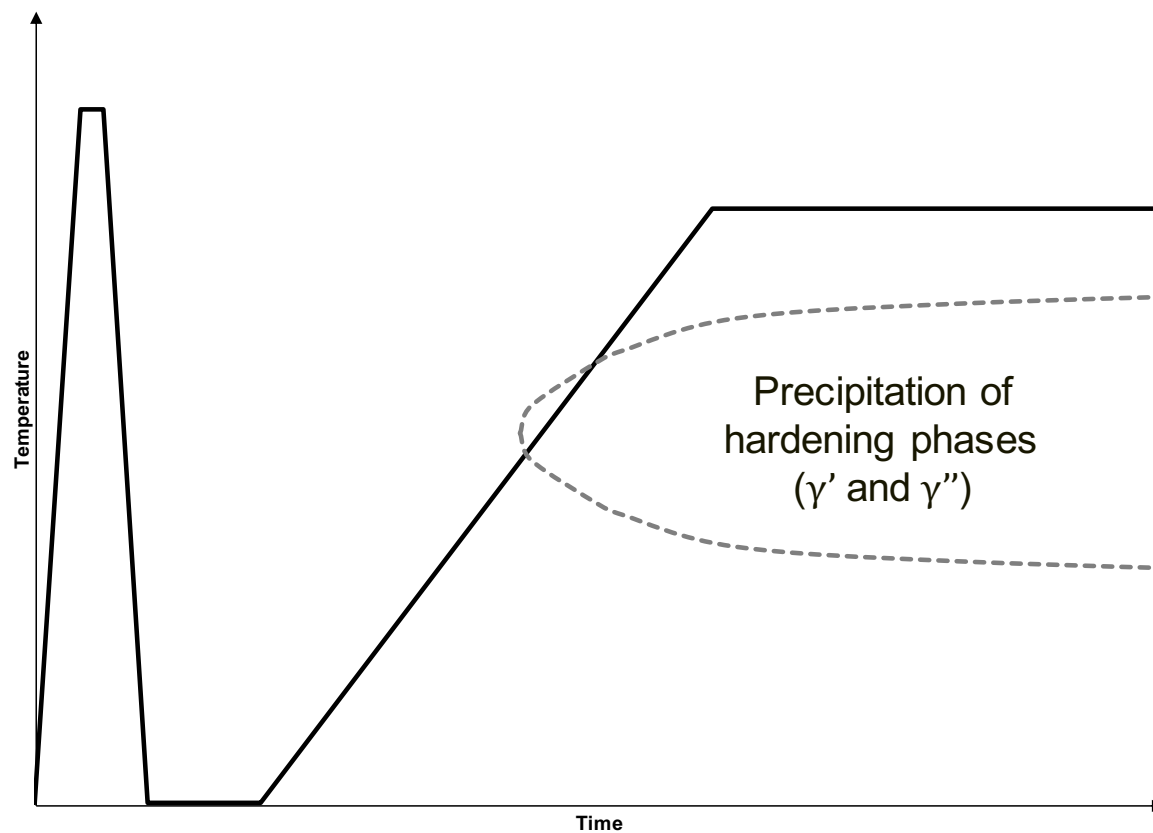
Aim of KME 706

- > **Provide a better understanding of ongoing mechanisms in Strain age cracking (SAC)**
 - > Which influencing factors exist
 - > How can these be influenced/ controlled
 - > How can SAC be prevented?
 - > Development of a testing procedure to assess the susceptibility of nickel-based superalloys towards SAC

Strain age cracking

- > **Occurs specifically in precipitation hardening nickel based superalloys**
- > **Cracks form during heating to post weld heat treatment**
 - > Warm cracking phenomenon, as no liquid phase is involved
- > **Influenced by**
 - > High temperature
 - > Precipitation of hardening phases
 - > Residual stresses

Strain age cracking (SAC)



Materials

> Alloy 718

- > Operating temperature up to 650°C
- > Gamma double prime hardening
- > 'Standard' alloy for hot structural parts in gas turbines

> ATI 718Plus

- > Maximum service temperature 700°C
- > Gamma prime hardening

> Haynes 282

- > Maximum service temperature 800°C
- > Gamma prime hardening

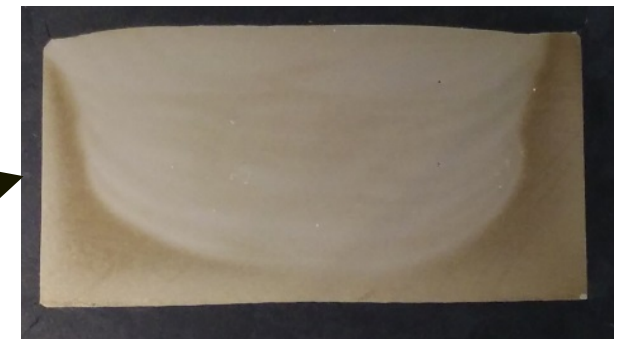
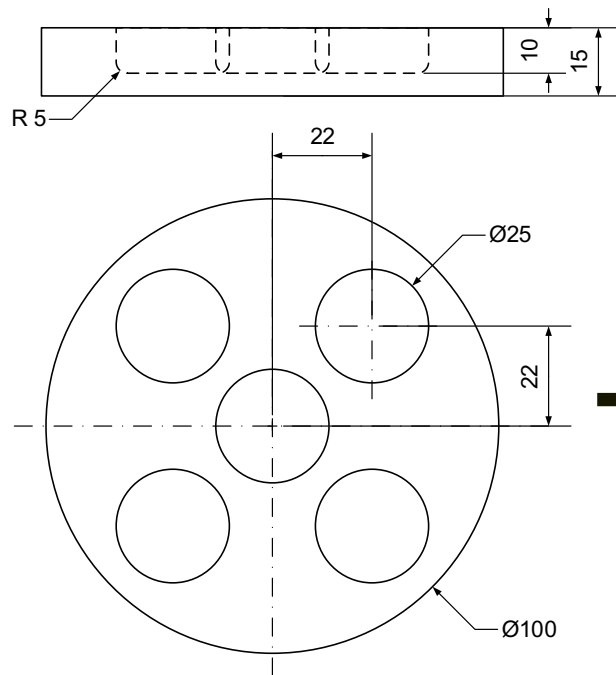
Approach

- > **Combination of different methods**
 - > Representative tests
 - > Simulative tests
 - > Microstructural characterisation

Ongoing work

> Repair welding

- > Influence of microstructure on weld cracking in HAZ and FZ
 - > Pre weld heat treatments
 - > Post weld heat treatments



Future work

Activity	2015	2016			
	Q4	Q1	Q2	Q3	Q4
Literature Review					
Material analyses					
Weldability testing					
PhD Courses					
Conferences					

Development of Weldability Assessment and Understanding of Hot Cracking in Boiler and Gas Turbine Materials

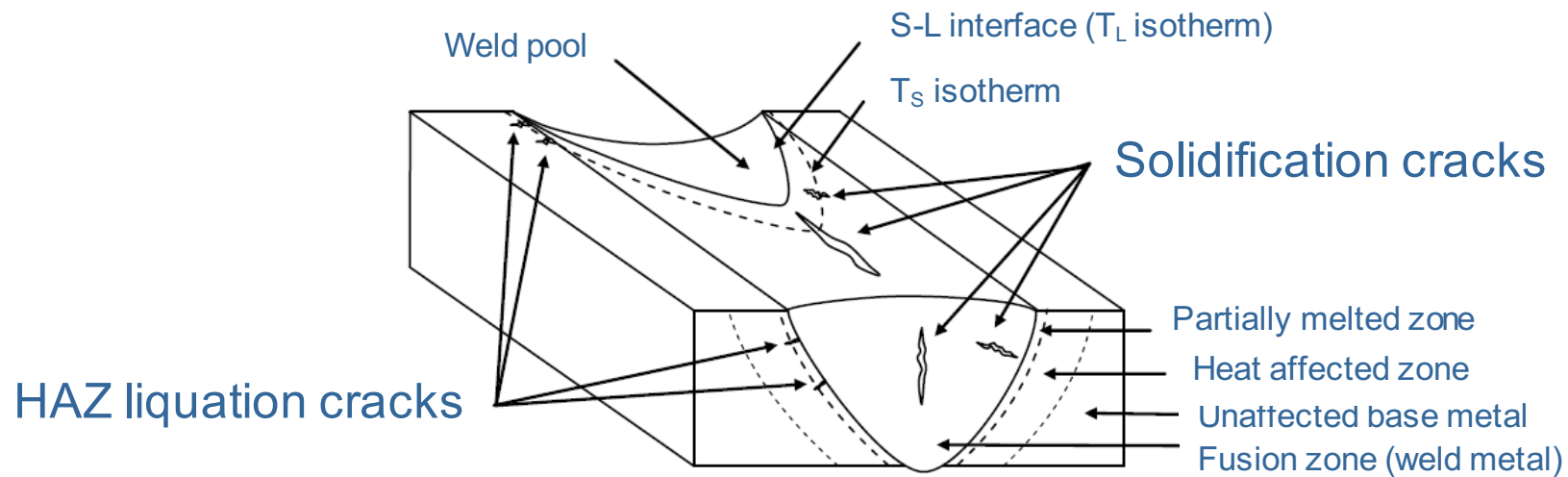
KME 719

Sukhdeep Singh, Joel Andersson & Lars Nyborg

Aim of KME 719

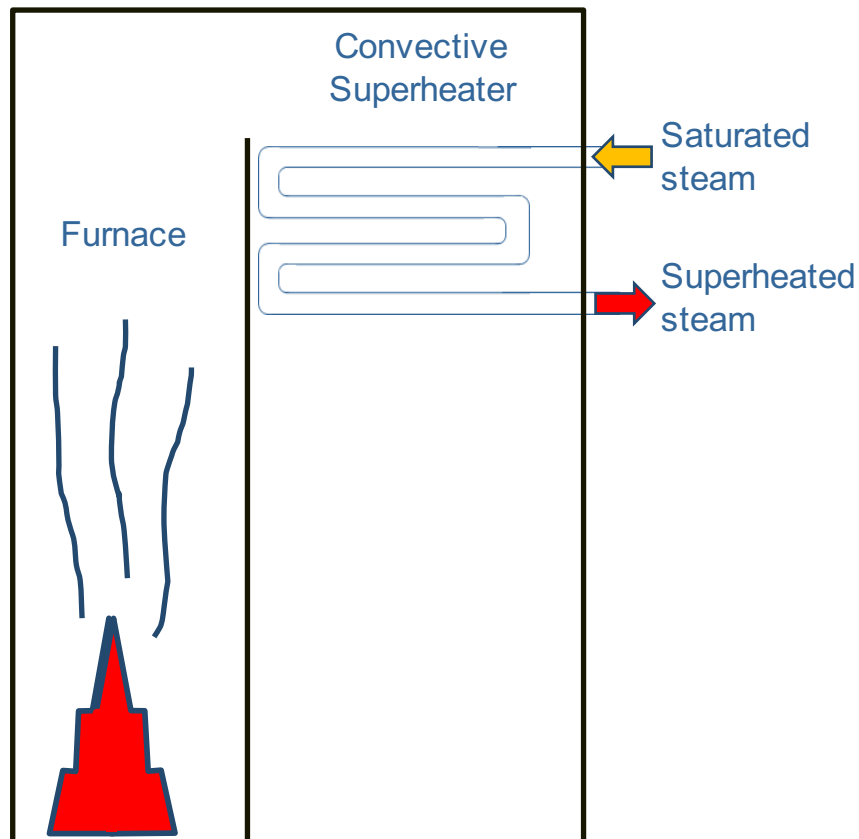
- **Increase the knowledge concerning hot cracking of austenitic stainless steels and Ni-based superalloys:**
 - Generate weldability test data on materials relevant to the boiler industry
 - Recommend materials and welding parameters for improved weldability
 - Establish a testing methodology that can be used for assessing weldability with respect to hot cracking susceptibility

Hot Cracking



Requirement for hot cracks to occur: **Liquid phase + Strain**

Austenitic Stainless Steels



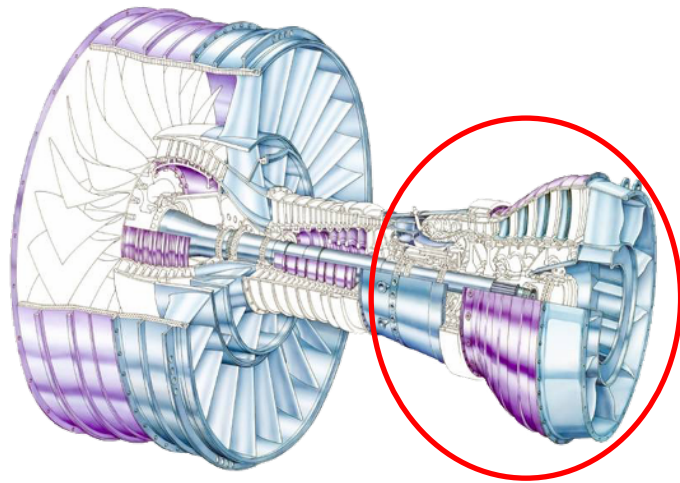
Requirements for superheater materials:

- High creep and thermal fatigue strength
- Resistance to fireside corrosion/erosion
- Resistance to steamside oxidation and spallation
- Fabricability

Alloy	Cr	Ni	Fe	Nb	Mn	Si	C	N
TP347 HFG	17-20	9-13	Bal.	0.9	≤2	≤0.7 5	0.06- 0.10	-
HR3C	23-27	17-23	Bal.	0.2-0.6	≤2	≤1.5	≤0.1	0.15-0.35

Composition in wt%

Nickel-Based Superalloys



Requirements for precipitation hardening Ni-based superalloys for gas turbine materials:

- High creep and thermal fatigue strength
- Oxidation and corrosion resistance
- Fabricability

Alloy	Cr	Ni	Fe	Co	Mo	Al	Ti	Nb	C	P	B	Cu	Mn	Si
Alloy 718	18.36	53.4	Bal.	0.33	3.15	0.56	0.92	5.46	0.04	0.008	0.001	0.14	0.09	0.05
Allvac 718 Plus	18	Bal.	9.35	9.17	2.69	1.46	0.75	5.50	0.02	0.005	0.005	0.01	0.03	0.05
Haynes 282	19.63	Bal.	0.35	10.35	8.56	1.41	2.21	-	0.068	0.002	0.004	-	0.008	-

Composition in wt%

Approach

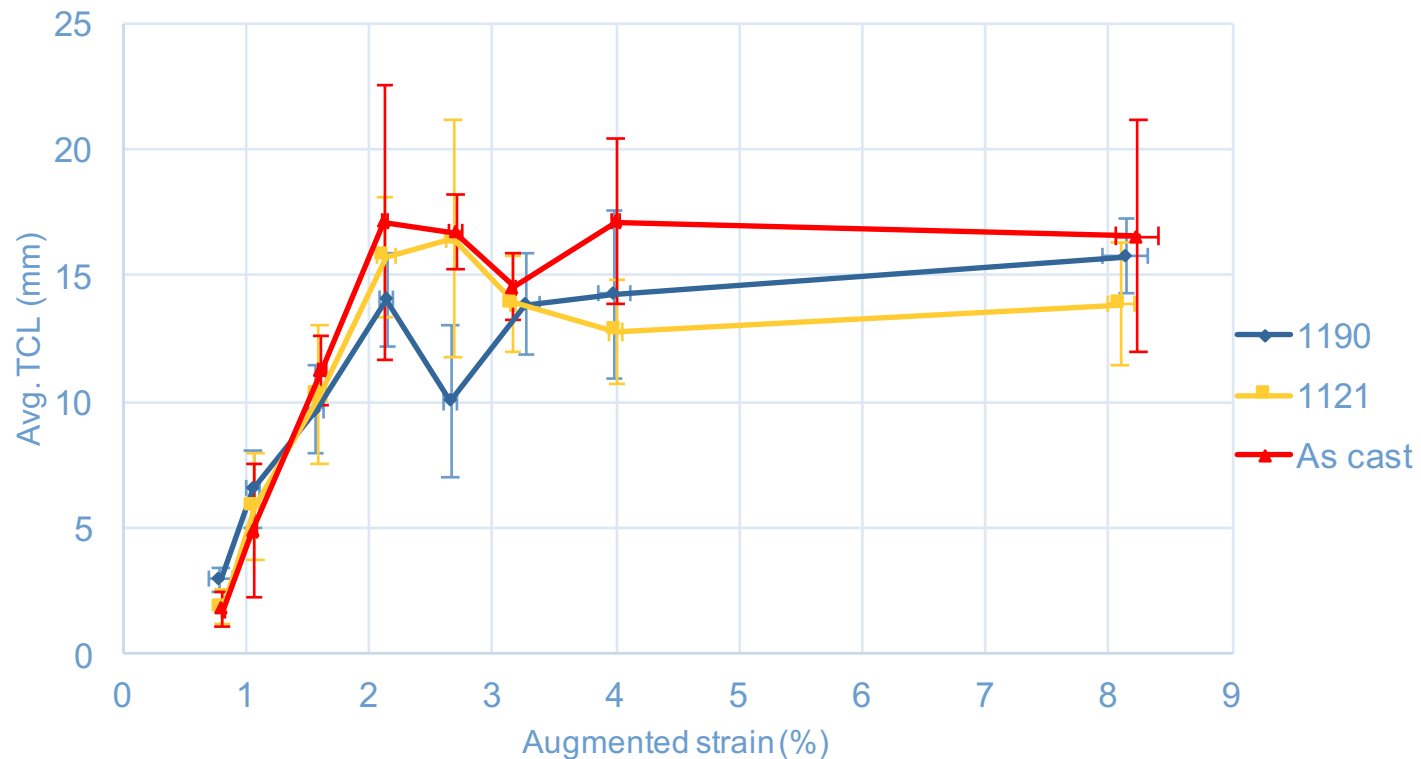
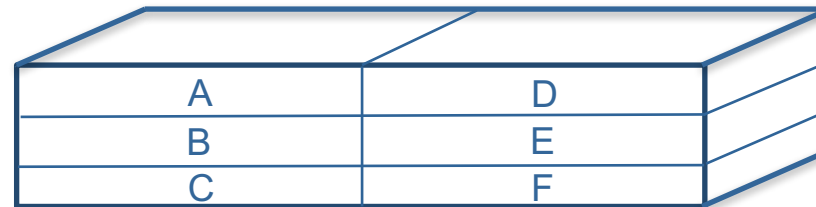
- > **Weldability test (Varestraint testing)**
- > **Thermomechanical simulation (Gleeble testing)**
- > **Material Characterization**

Ongoing work

Alloy 718 conditions:

- ❑ As Cast
- ❑ Cast HT1121°C/4h
- ❑ Cast HT1190°C/4h

Plates size 150 x 60 x 3.3 mm



Future Work

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Thank You!