

Svetsbarhet hos nästa generations superlegeringar – metallurgiska mekanismer och industriell tillämpning

Joel Andersson



UNIVERSITY WEST

Creating change together.

Högskolan Väst

- Högskolan Väst, belägen i Trollhättan
- cirka 700 anställda och 14 000 studenter.
- Utbildningsutbudet omfattar 27 grundutbildningsprogram och 17 avancerade program,
- forskarutbildning inom arbetsintegrerat lärande och **produktionsteknik.**



Historik och utveckling inom produktionsteknik

1990 grundades högskolan

1993 startade kandidatprogram

1994 inleddes forskningsamarbete med Volvo Aero

1999 startade avancerad utbildning

2008 Produktionstekniskt centrum

2012 erhöills rättigheter att bedriva forskarutbildning

2023 etablerades komplett akademisk miljö inom produktionsteknik

Komplett akademisk miljö – produktionsteknik

Verksamhetsledare: Joel Andersson

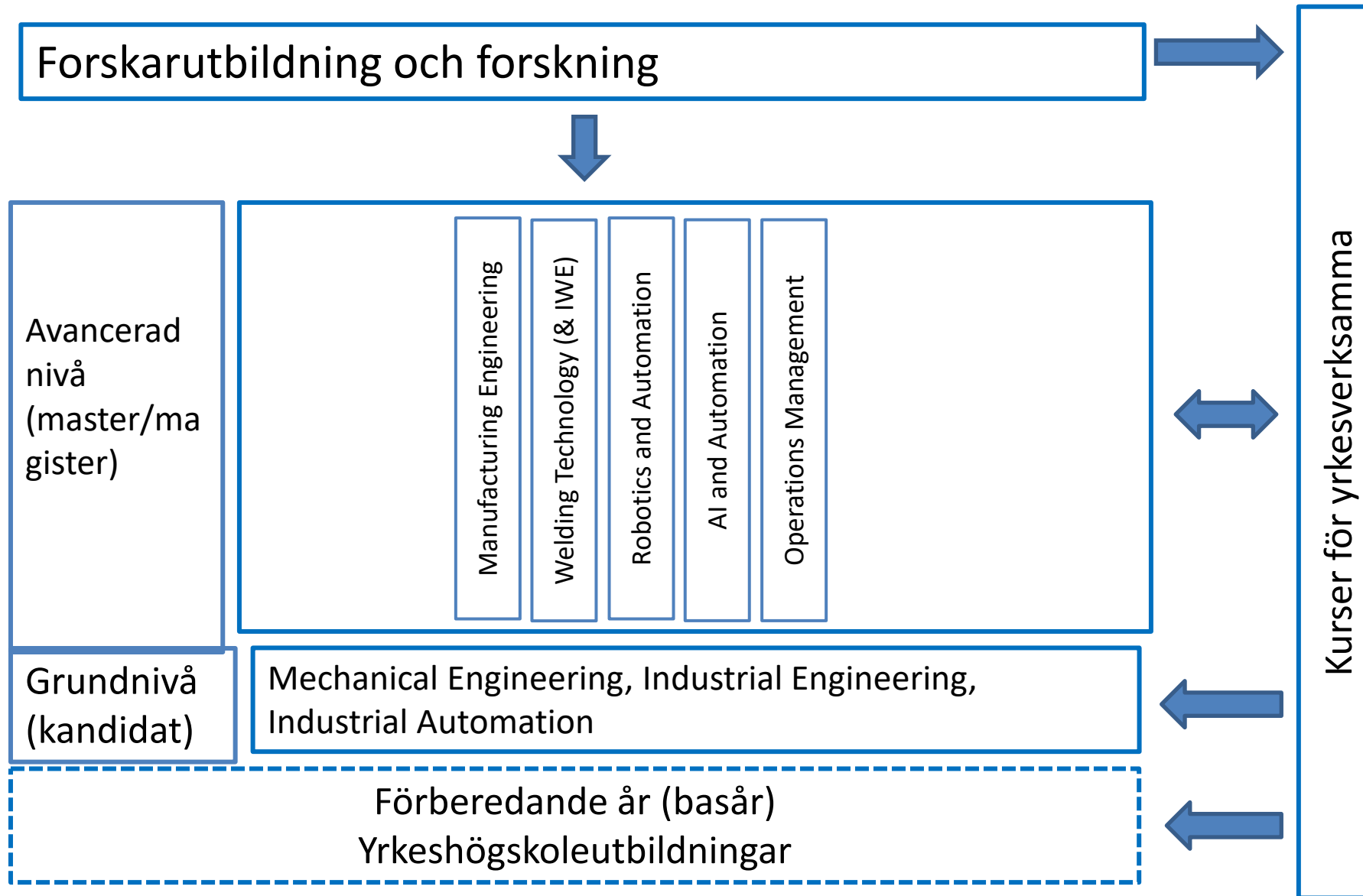
Biträdande verksamhetsledare: Lennart Malmsköld

- Forskningsområden:
 - Termisk sprutning
 - Additiv tillverkning (pulverbädd)
 - Svetsning och svetsbaserad additiv tillverkning
 - Simulering inom oförstörande provning
 - Flexibel automation
 - Logistik & verksamhetsledning
- Forskningsområden utanför Produktionsteknik
 - Datateknik
 - Elektroteknik

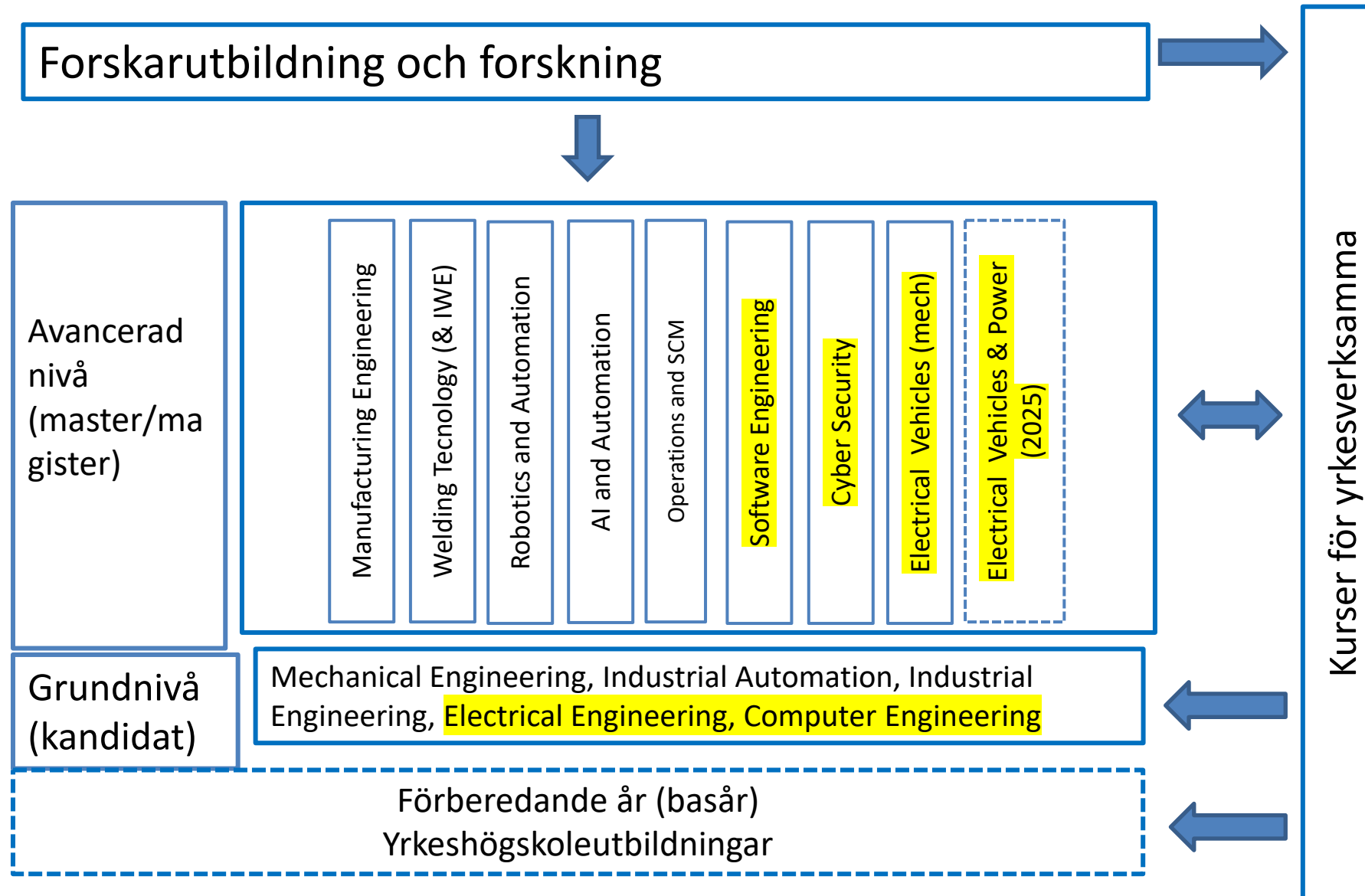
Nyckeltal

- Cirka 85 forskare
- Cirka 100 MSEK i årlig omsättning
 - 25 % intern finansiering, 75 % extern finansiering
 - Huvudsakligen svensk finansiering (85–90 %) samt EU (10–15 %)
- Samarbete med cirka 80 företag
- Hög ranking avseende sampublicering med industri

Utbildningsstruktur



Utbildningsstruktur

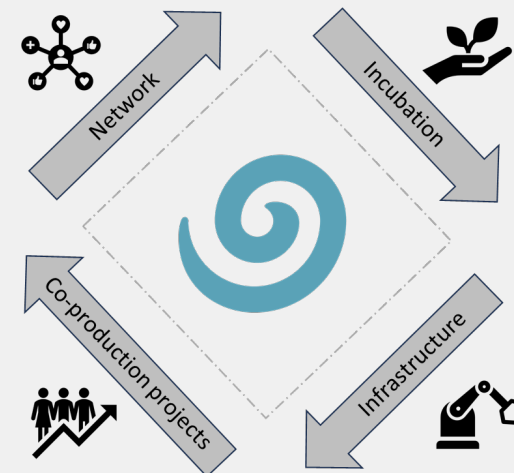
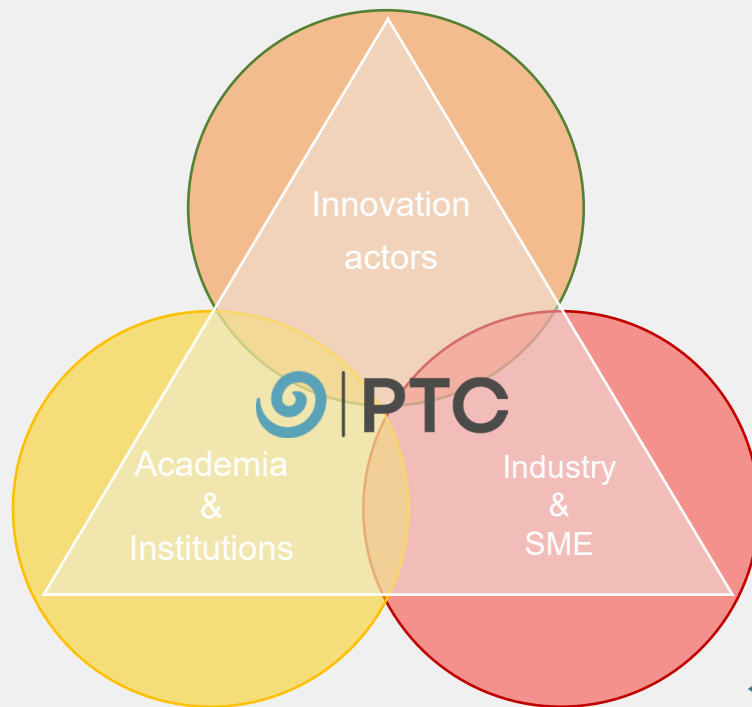


Några nyheter...



Produktionstekniskt Centrum

● innovatum
science
park



PROCADA WAIM LABZ aerobase



Nationellt centrum: Friktionssvetsning

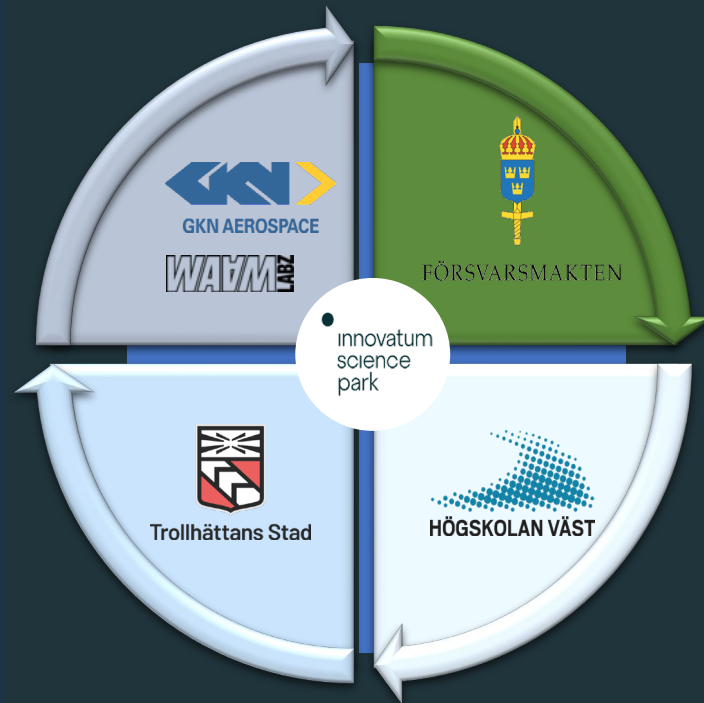
Målet är att stärka svensk industri och bygga ett nationellt ekosystem inom friktionssvetsning.



- ✓ Flexibelt portalsystem för svetsning, bearbetning och reparation
- ✓ Tillgång till Refill Friction Stir Spot Welding
- ✓ Processutveckling, övervakning och kvalitetssäkring
- ✓ Lokal tillverkning och utveckling av verktyg
- ✓ Fullskalig demonstrator
- ✓ Projektperiod: 3 år (2026–2029)



ADDITIV TILLVERKNING, MIKROFABRIKER OCH AMCC ROLL FÖR TOTALFÖRSVARET



AMCC – Advanced Manufacturing Coordination Centre

Nästa generations superlegeringar??

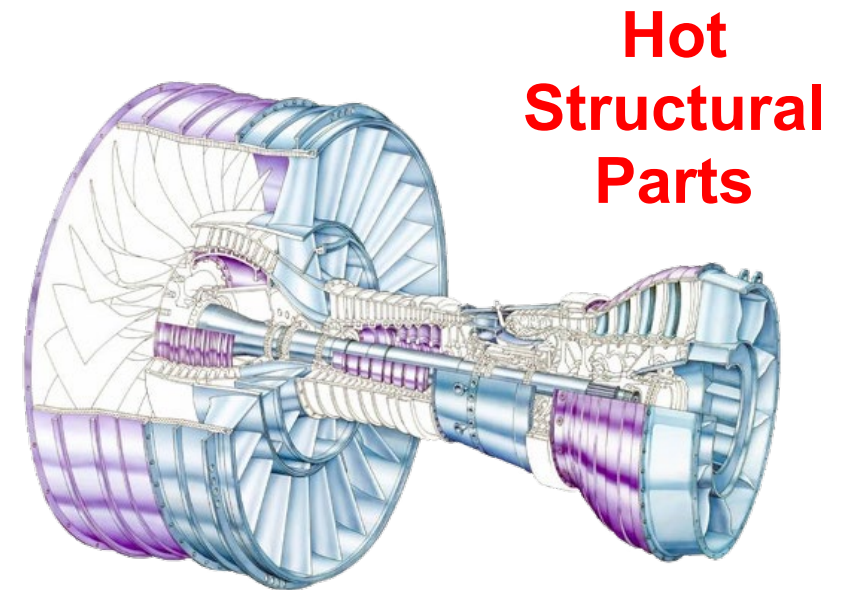
Structural aero-engine components - Alloy design, alloy selection...

Mechanical performance

Alloy of interest?!

Corrosion/oxidation

Processability

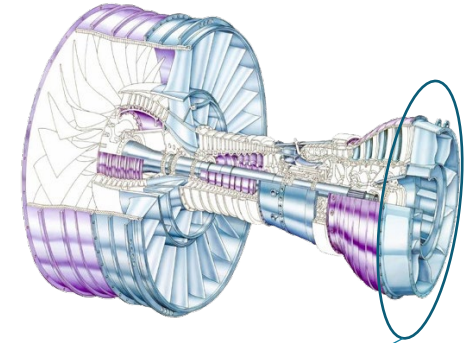


Alloy portfolio:

Alloy 718, ATI 718Plus, Waspaloy, Haynes 282...

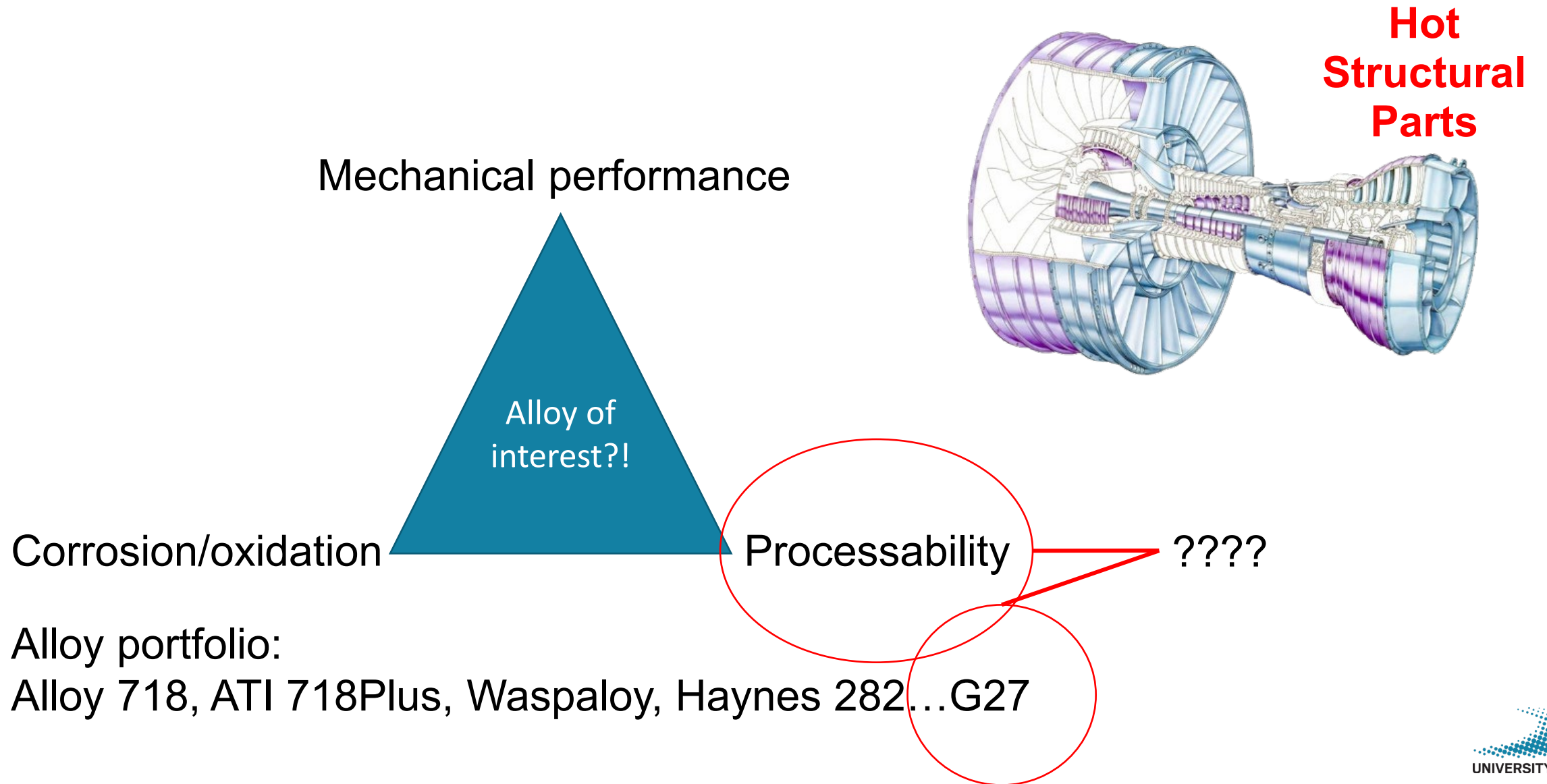
Welded assemblies → The "new" trend

1. One piece casting, the traditional way (IN718)!
2. Few suppliers for the largest structures!
3. Fabrication for low weight!
 - What about AM?
 - 60MEuro investment by GKN in Trollhättan 2024!



Many meters of welds!

Alloy design, alloy selection...new alloys!



G27 superalloy

G27 is a new γ' -hardening Ni-based superalloy recently developed by Carpenter Technology Corporation

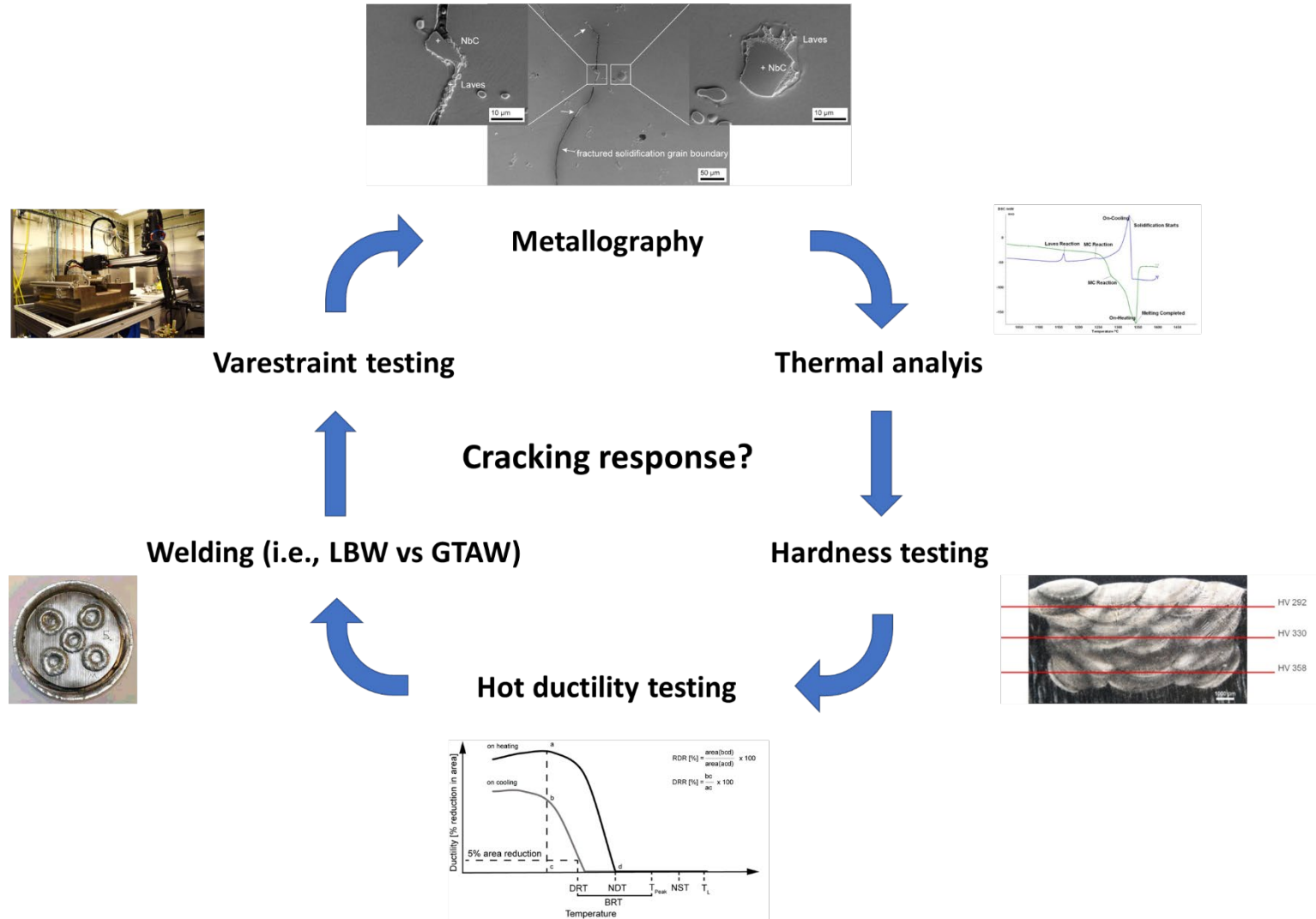
- Possesses properties superior to Alloy 718 and even rivals Waspaloy at service temperature up to $\sim 760^\circ\text{C}$
- Formulated to be **Co-free** \rightarrow lower raw material cost than Waspaloy and comparable to Alloy 718

Chemical composition of G27 (wt%)

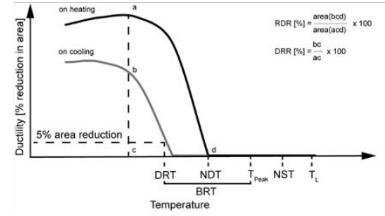
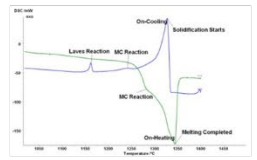
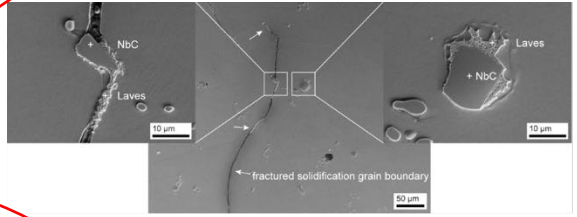
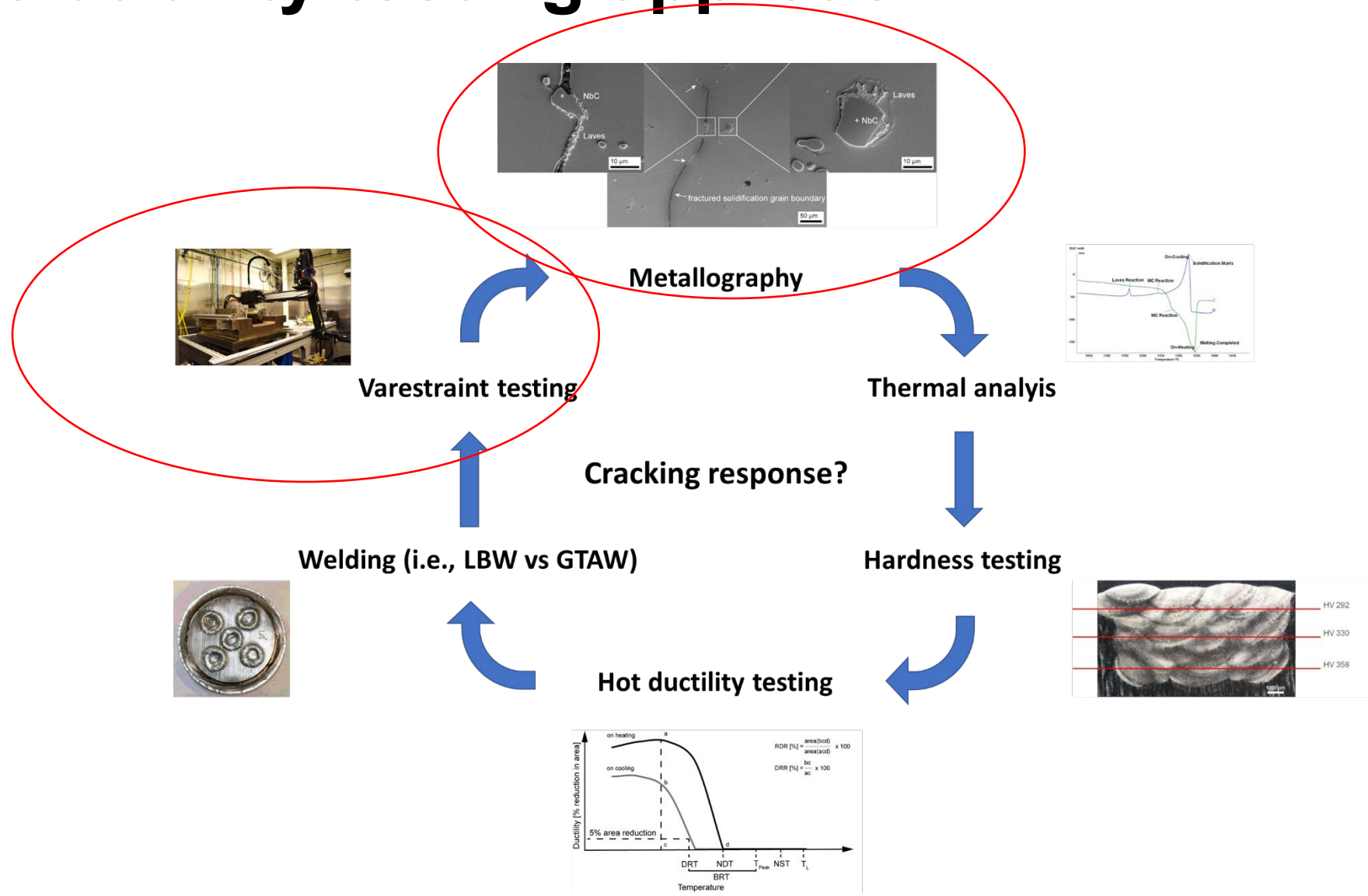
Ni	Fe	Cr	Co	Ti	Al	Nb	Mo	V	Cu	O
58.00	Bal.	15.11	0.18	1.89	1.90	3.7	4.02	0.10	0.04	0.001

S	P	Si	Sn	N	C	Ta	Zr	Mg	Se	B
<0.001	0.007	0.06	0.0018	0.006	0.029	<0.02	0.03	0.0037	<0.0003	0.005

Weldability testing approach

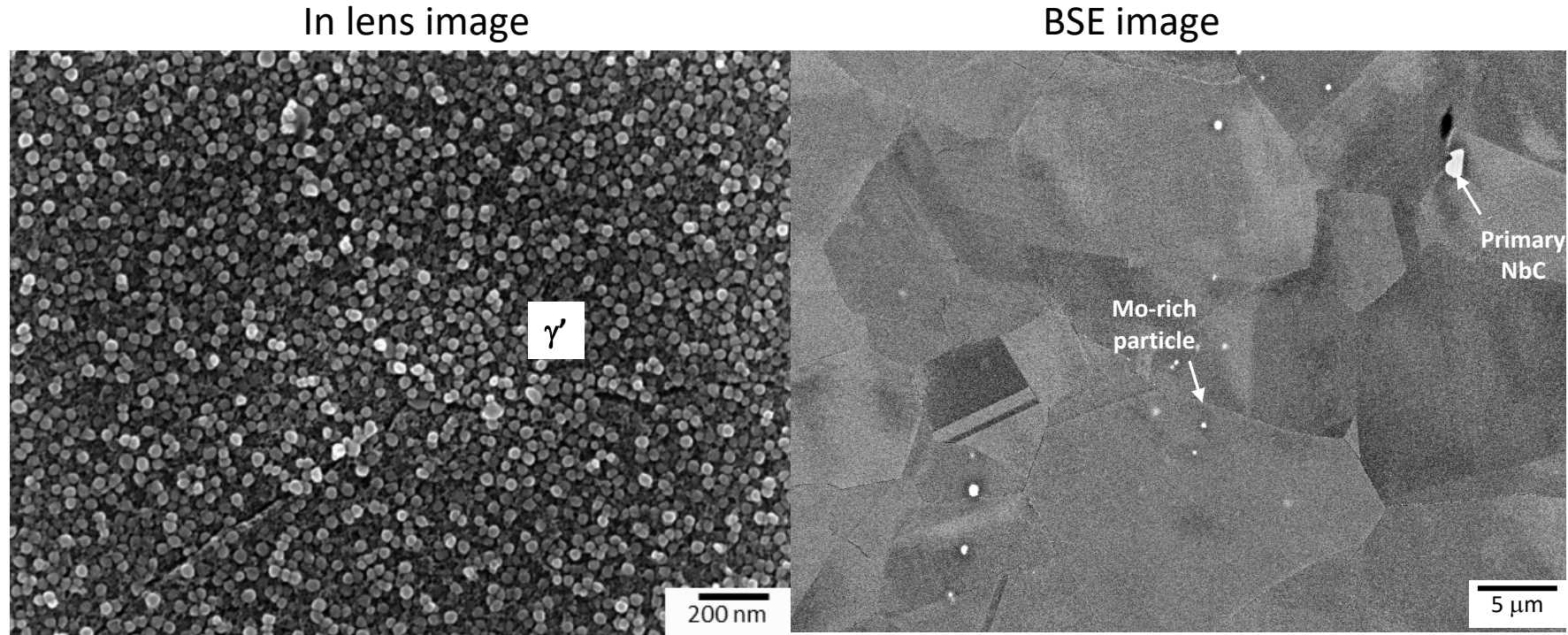


Weldability testing approach



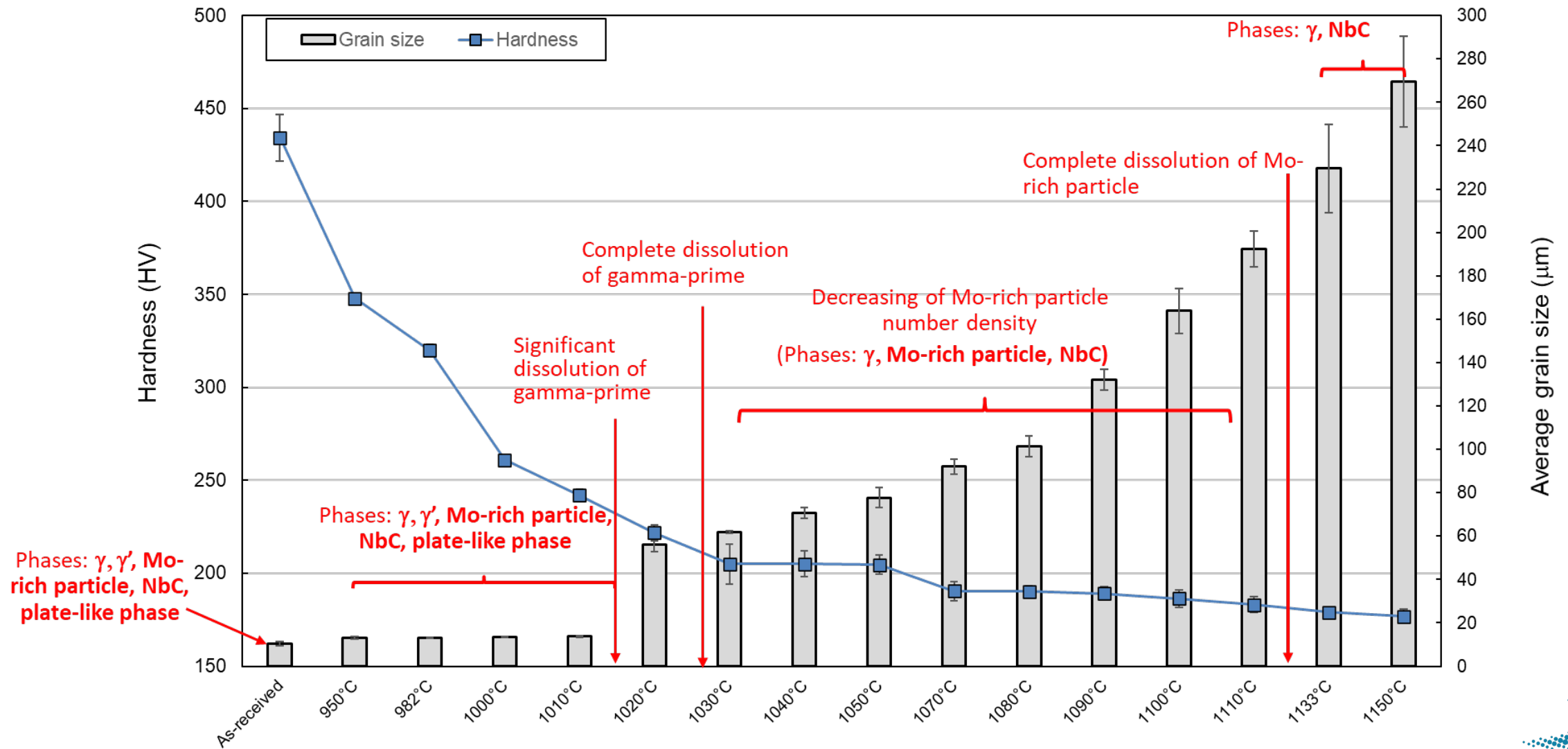
Microstructure of as-received G27

- As-received G27 (unannealed condition after hot-rolling)

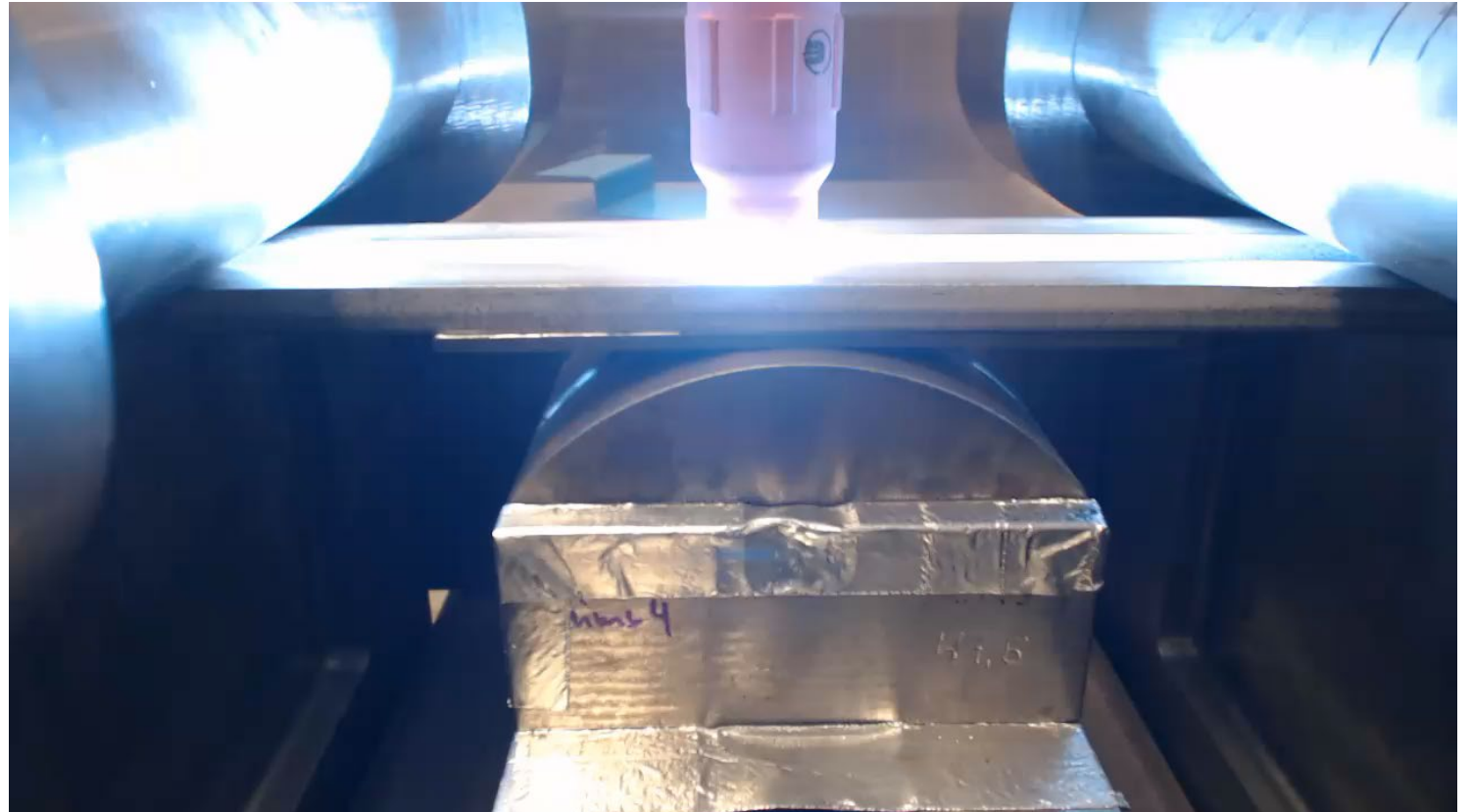
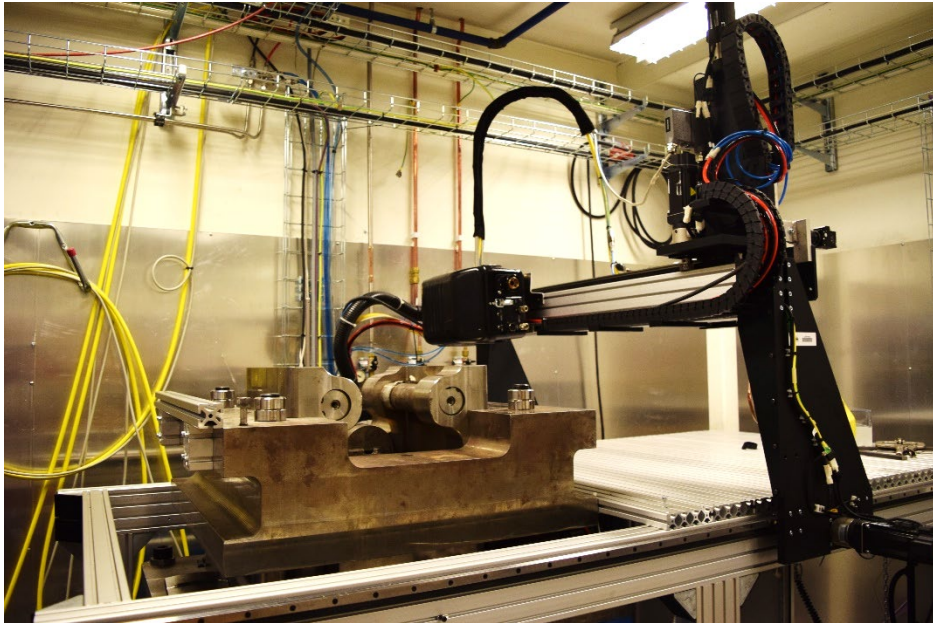


- Secondary phases: **high number density of γ'** , **NbC**, and **Mo-rich particle**
- γ' phase were likely to form during air cooling after hot rolling

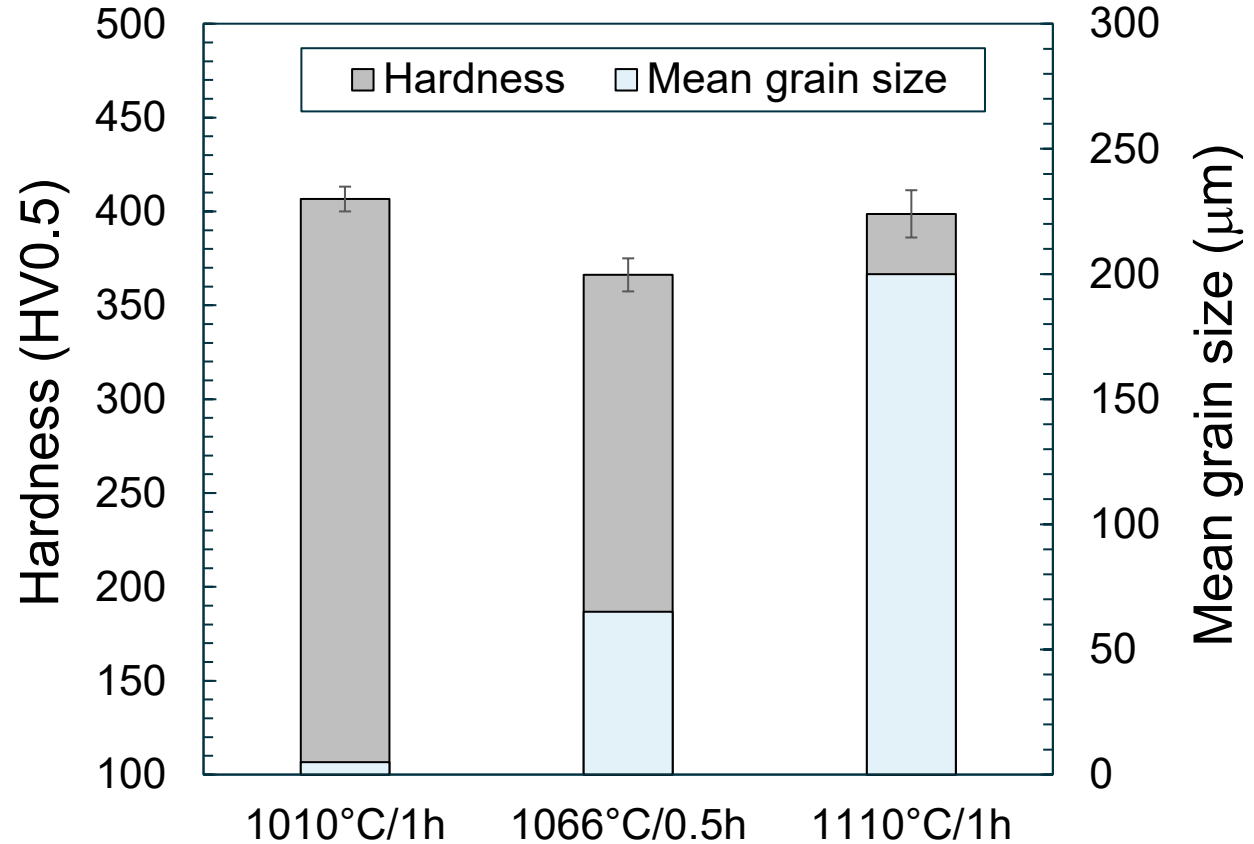
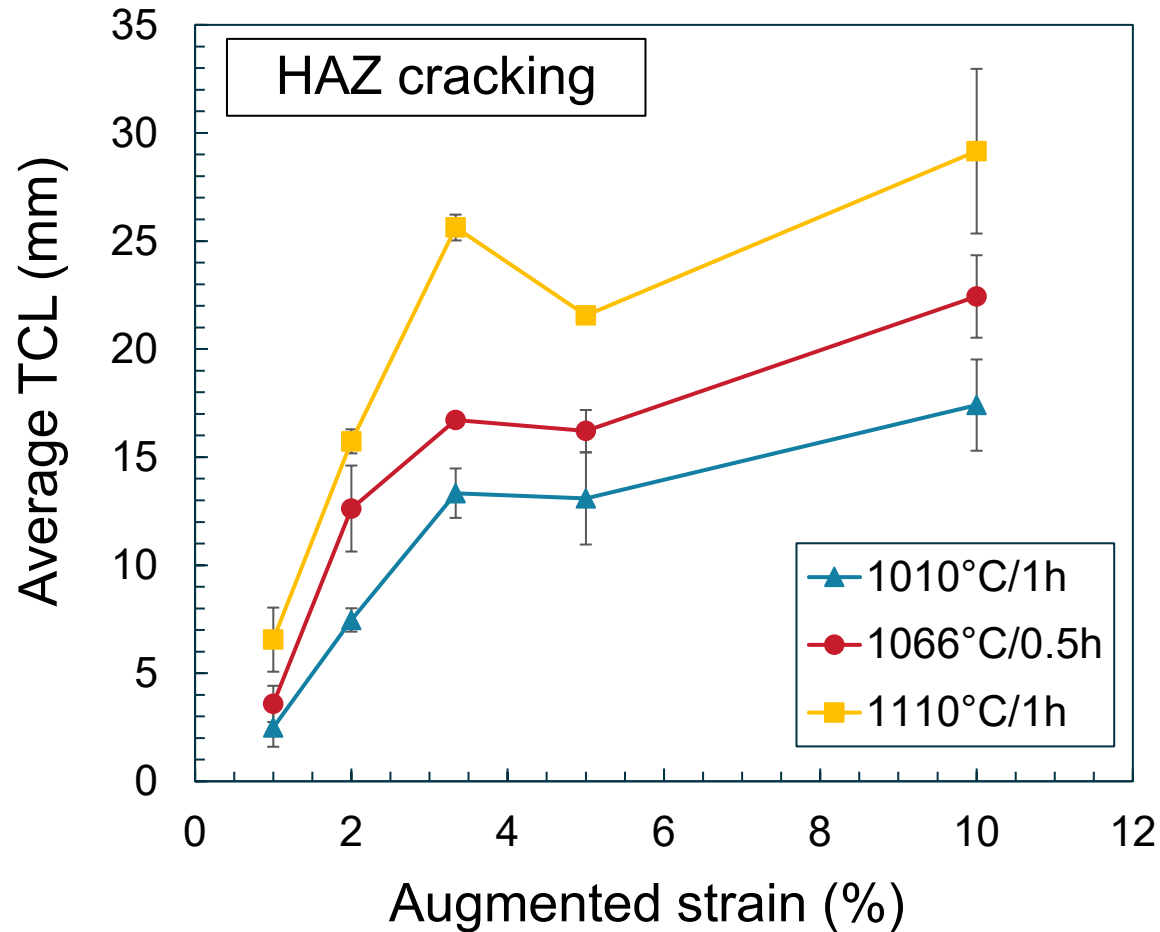
G27 - Microstructure evolution after SHT



Varestraint Testing

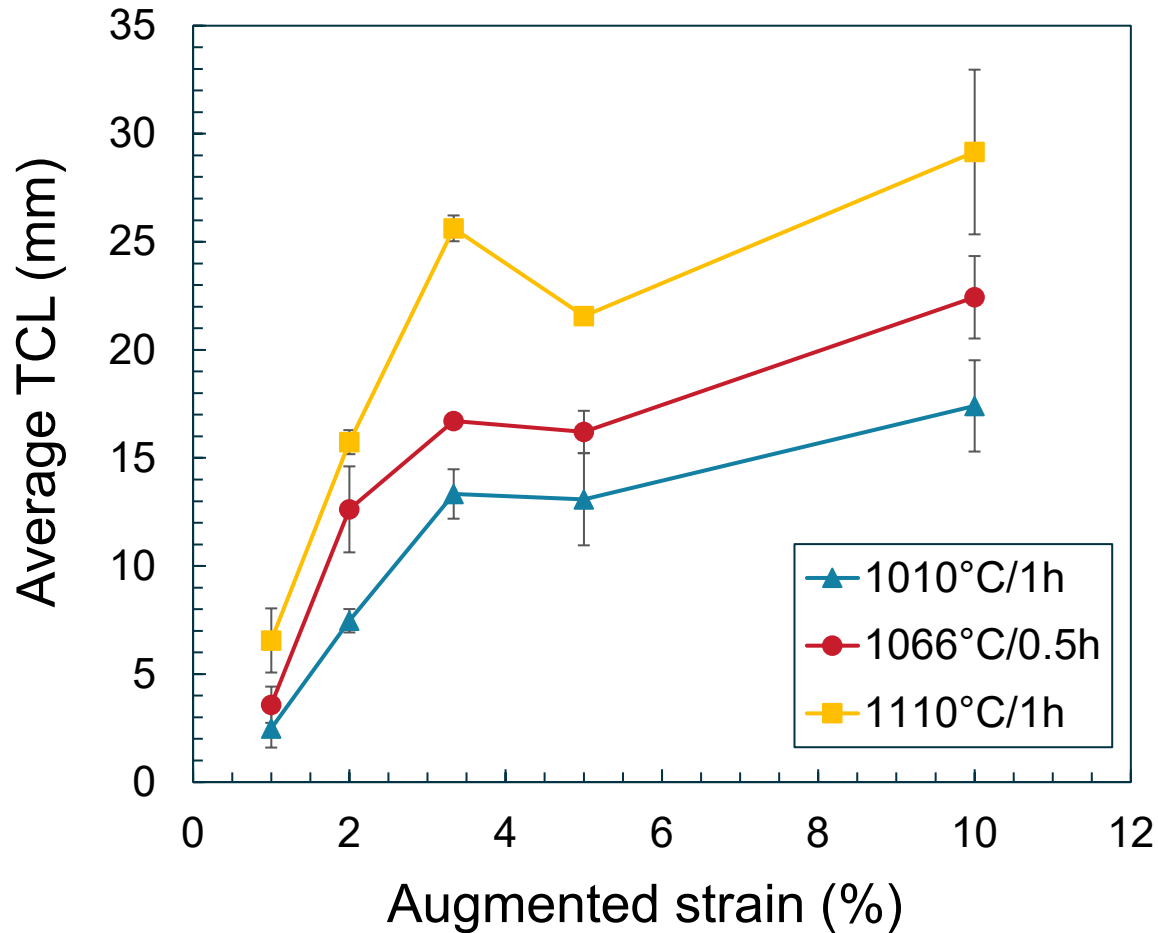


Varestraint testing of G27 - HAZ cracking

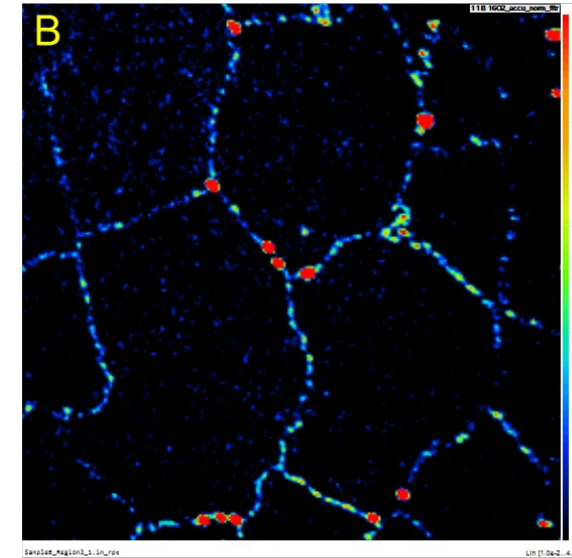


- Solution annealing at 1010°C/1h showed the highest resistance towards HAZ cracking, whereas 1110°C/1h was the most susceptible.
- No significant base metal hardness difference was found in all samples
- The effect of grain size on the HAZ liquation cracking in G27 is substantial.

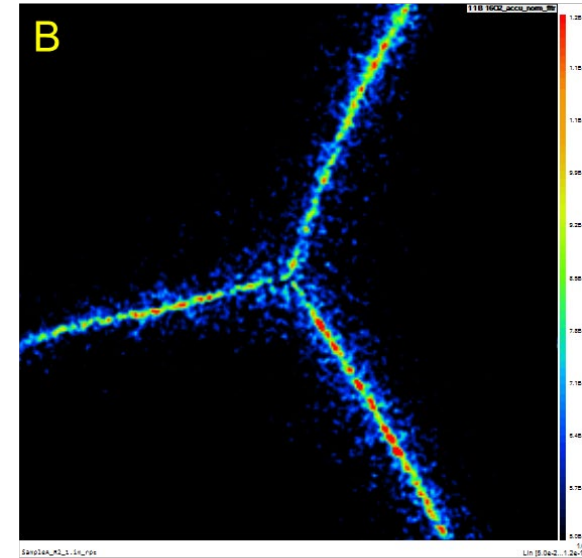
Varestraint testing of G27 – Effect of GB segregation of minor elements



1010°C/1h-annealed condition

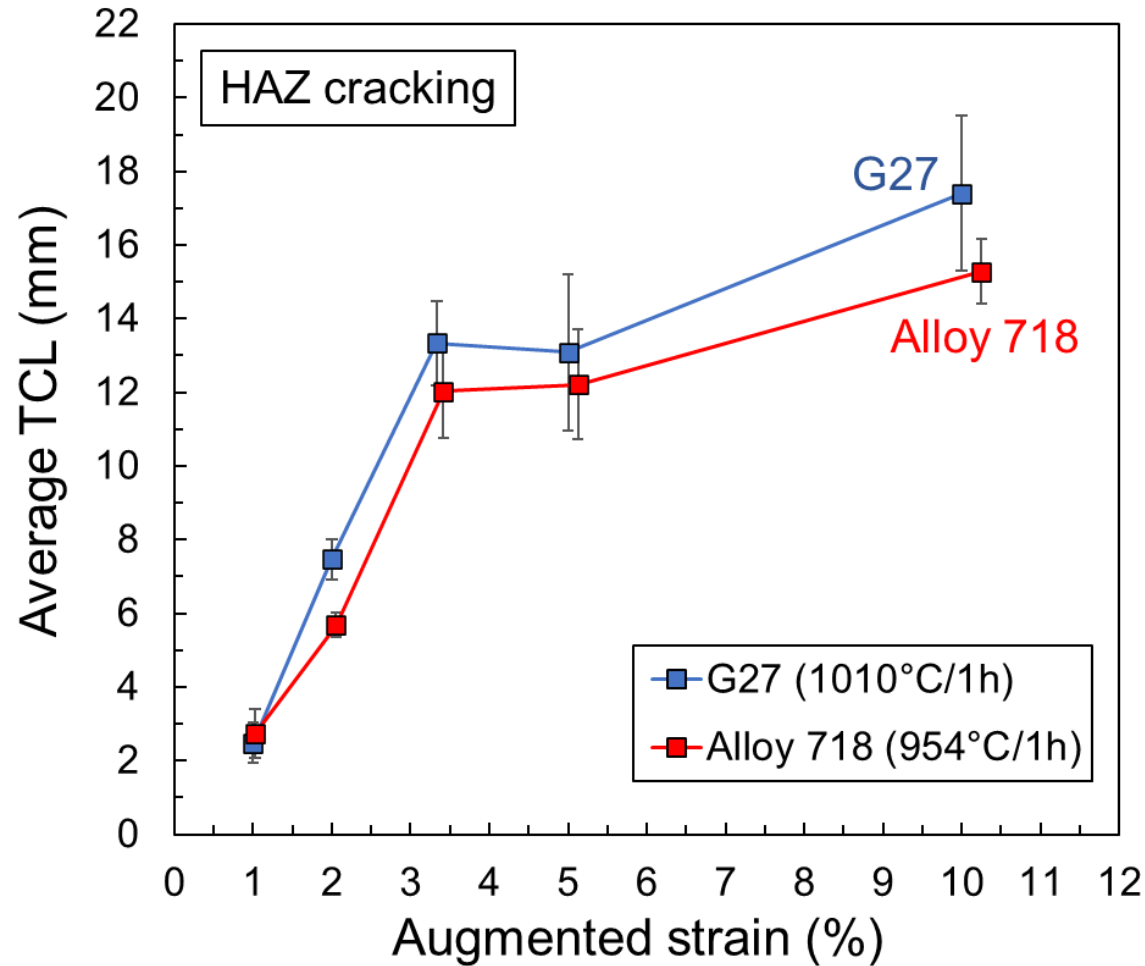


1110°C/1h-annealed condition



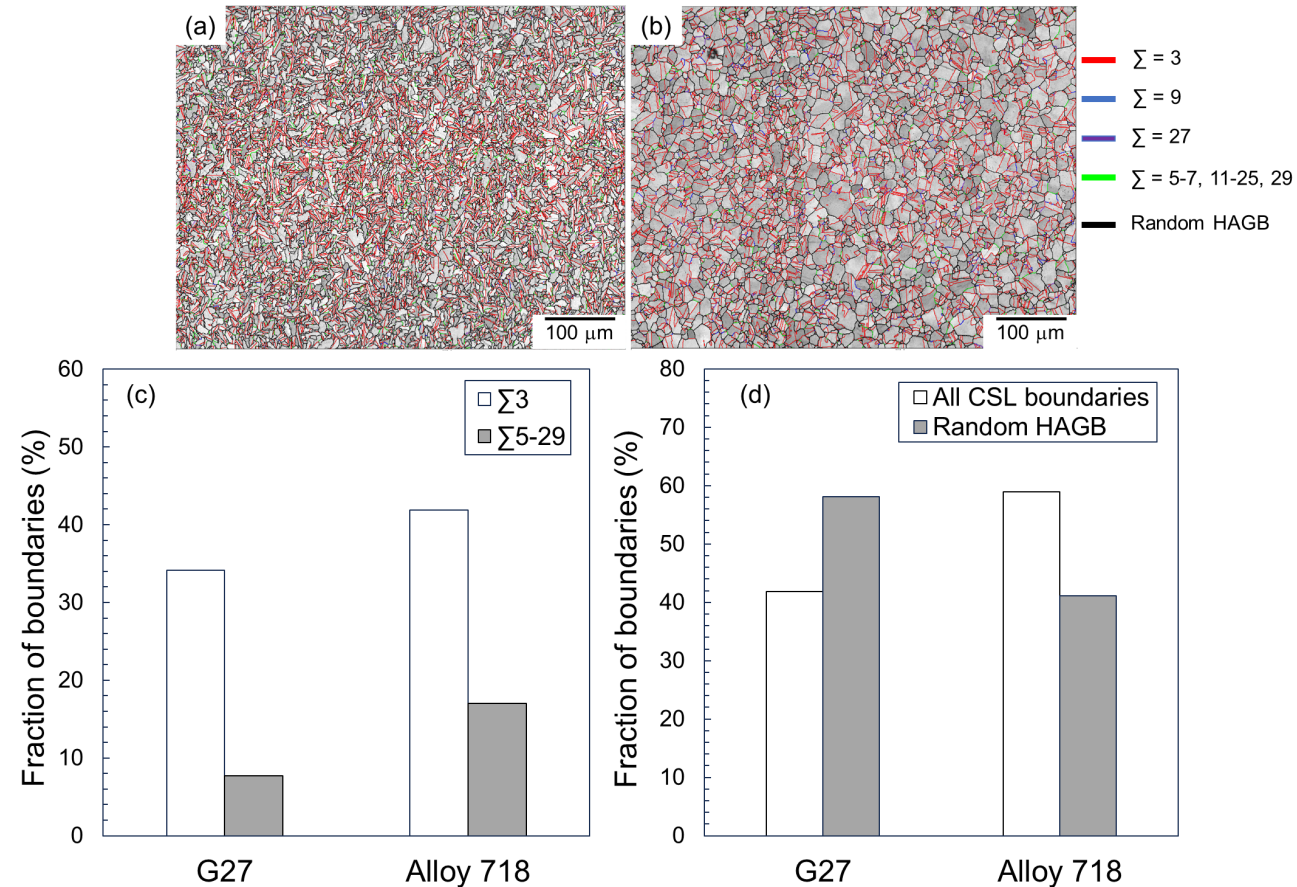
- B strongly segregates at the GBs as a continuous layer or free atomic form in 1110°C/1h
- B is also entrapped in discrete B-rich particles apart from segregating with a lower intensity at the GBs as a continuous layer in the 1010°C/1h condition.

Comparison of the cracking responses



- Despite having a smaller grain size almost twice than Alloy 718, G27 seem more susceptible to HAZ liquation cracking

The distribution of CSL boundaries and random HAGB



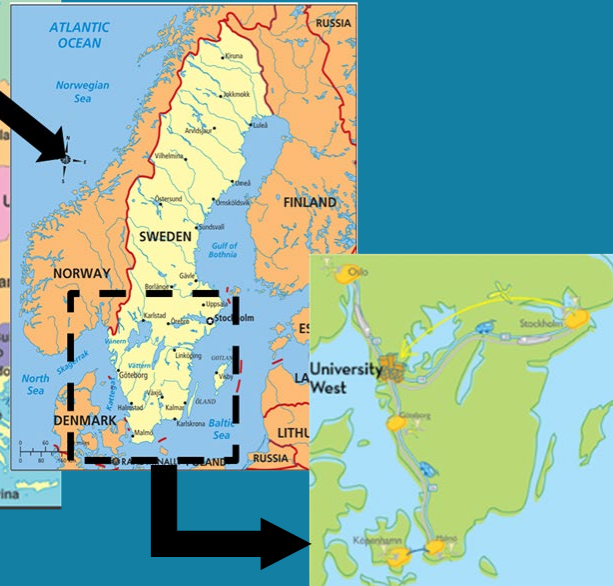
- A lower fraction of CSL boundaries in G27 than in Alloy 718 could also contribute to the higher susceptibility to HAZ liquation cracking in G27

Summary

- PTC Ecosystem:
 - OEMs, SMEs, research institutes, universities, public authorities, and incubators collaborating in open innovation environments
- Alloy G27
 - Cracking increases with grain size where 1010 °C/1 h (fine grains, Mo–B binds B) → low segregation and 1110 °C/1 h (coarse grains, Mo–B dissolves) → high segregation.
 - Compared to 718: G27 is more crack-prone despite finer grains, likely due to a wider resolidification temperature range of intergranular liquid and a lower CSL boundary fraction



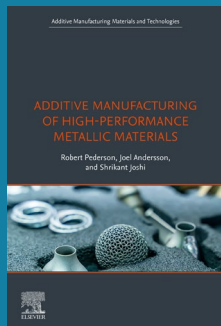
- Located in the beautiful town of Trollhättan
- Situated close to Goteborg, Sweden's 2nd largest city



Thank you!

Professor Joel Andersson
Director Production Technology
Co-Founder WAAMLABZ

joel.andersson@hv.se



UNIVERSITY WEST

Creating change together.