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Microstructural Analysis of High-Strength Steel Post Gleeble Modelling

Lama mkanna

PhD student

Department engineer and teacher assistant /university of Dunaujvaros , Hungary

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Objectives

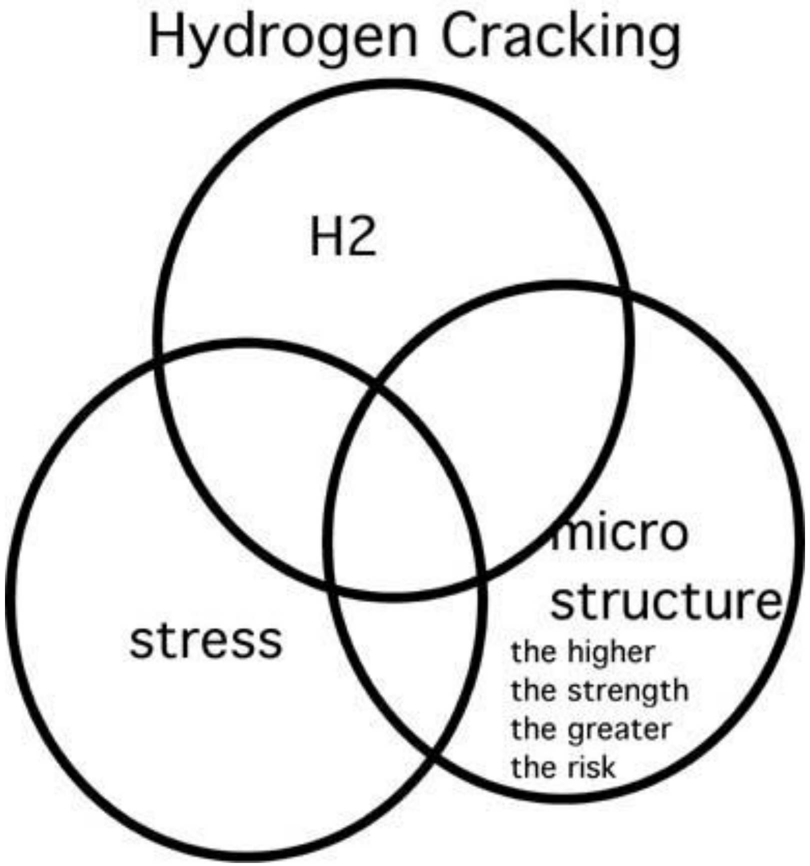
- Introduction
- High-strength steels are highly susceptible to cold cracking and how to avoid it
- Materials used in the research
- Gleeble 3500
- Hardness testing
- Microscope testing
- SEM
- Conclusion

Introduction

- High-strength steel alloys are widely used in critical engineering applications due to their exceptional mechanical properties. To ensure their reliability and performance under extreme conditions, a comprehensive understanding of their microstructural changes during testing and processing is crucial. This study investigates the microstructural evolution of high-strength steel samples subjected to Gleeble modelling , a thermomechanical simulation technique that replicates real-world conditions.

Vehicles
Passenger cars
Trucks
Heavy vehicles
Building steel structures
Cranes
Bridges
Pressure vessels
Etc.

High-strength steels are highly susceptible to cold cracking and how to avoid it



Higher strength steel,
Higher crack sensitivity!

High-strength steels are highly susceptible to cold cracking and how to avoid it

LOW HYDROGEN CONTENT IN THE WELD

- Low hydrogen content in the welding consumable
- Clean, rust-free surfaces
- Grease, oil and contamination free surfaces.

STRESS REDUCTION

- Designing low stiffness structures
- Applying stress reducing heat treatment

CONTROL OF STRUCTURE IN THE HEAT AFFECTED ZONES

- Preheating
- High specific heat input
- Control of temperature between the passes of weld

The critical cooling time can be calculated Based on heat process modeling

- Three-dimensional heat dissipation (3D):

$$\Delta t_{T_1-T_2} = \frac{(q/v)_{eff}}{2\pi\lambda}\left(\frac{1}{T_2 - T_0} - \frac{1}{T_1 - T_0}\right)$$

- Two-dimensional heat dissipation (2D):

$$\Delta t_{T_1-T_2} = \frac{{(q/v)_{eff}}^2}{4\pi\lambda\rho c s^2}\left(\frac{1}{(T_2 - T_0)^2} - \frac{1}{(T_1 - T_0)^2}\right)$$

- Critical sheet thickness:

$$s_{krit} = \sqrt{\frac{(q/v)_{eff}}{2c\rho}\left(\frac{1}{T_1 - T_0} + \frac{1}{T_2 - T_0}\right)}$$

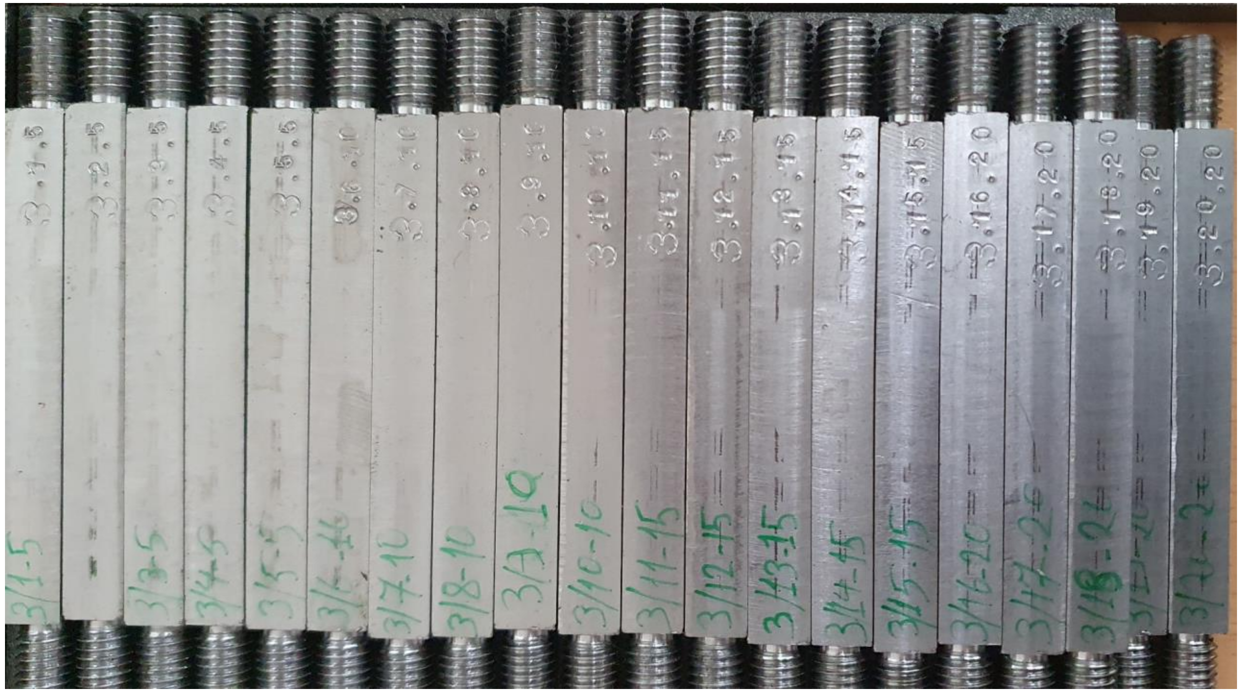
In the event that the required specific heat input cannot be applied, the preheating temperature can be determined on the basis of the possible heat input and the critical cooling time.

$$(q/v)_{eff} = \frac{UI\eta_{eff}}{v_{heg}}$$

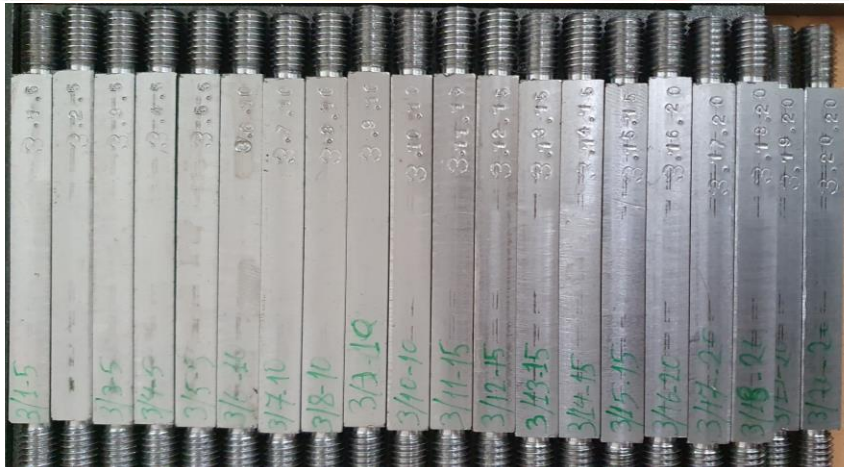
Materials used in the research

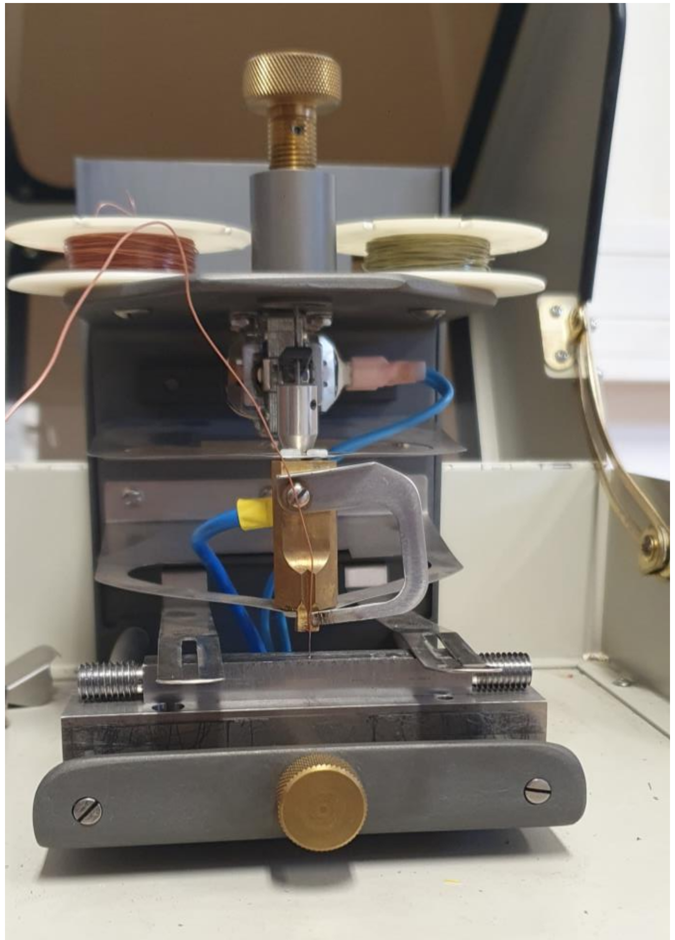
S355 MC
S500MC
S700MC
S960MC
S1100MC

It was modelling with different cooling time [5,10,15,20sec]



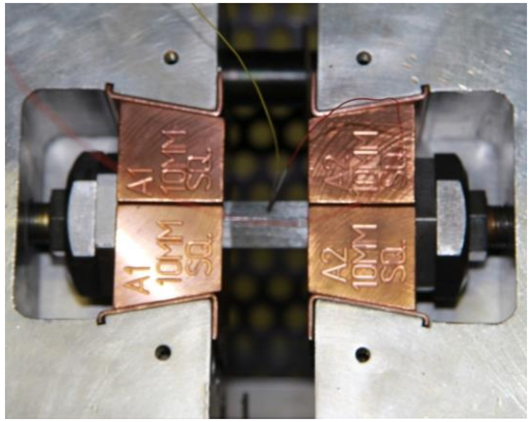
Gleeble 3500



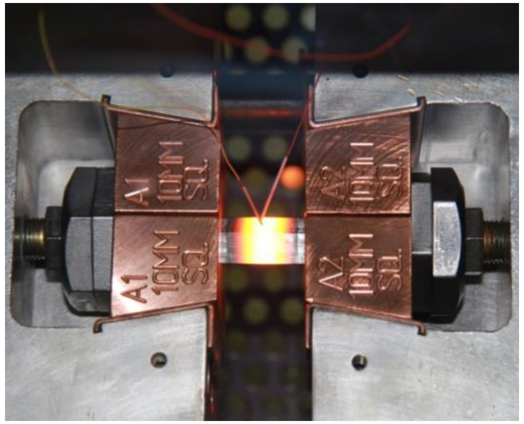


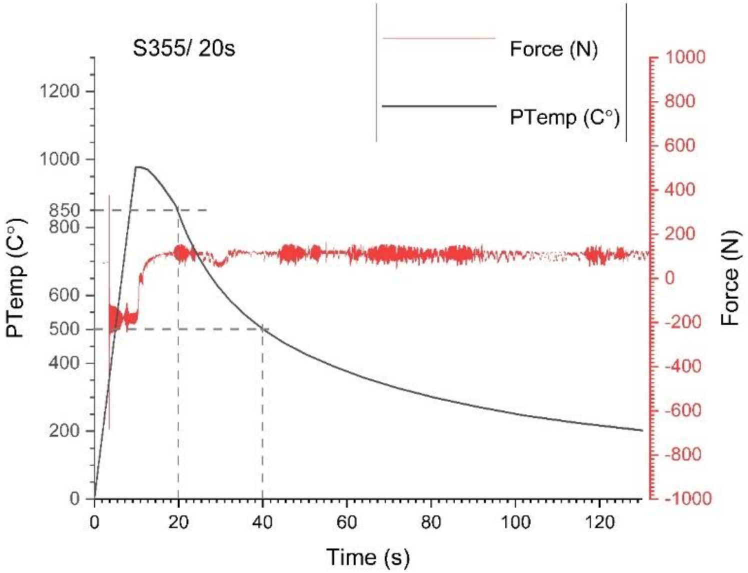
Gleeble 3500
Heat cycle simulation

Impactor before simulation



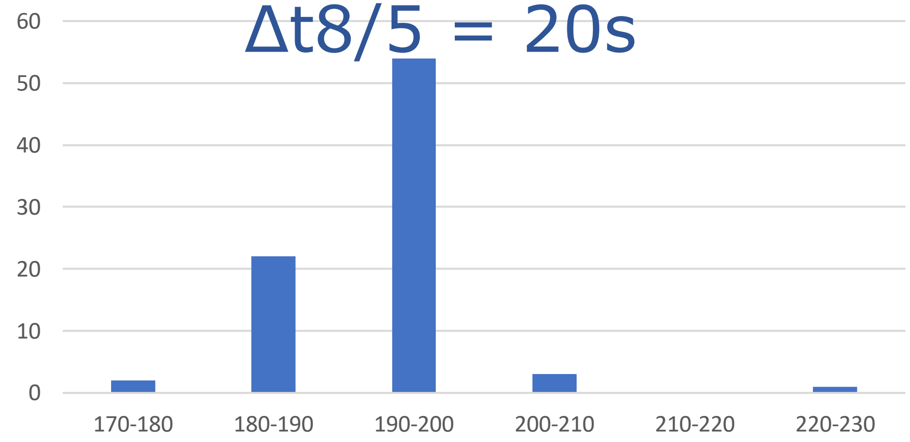
Impactor during simulation



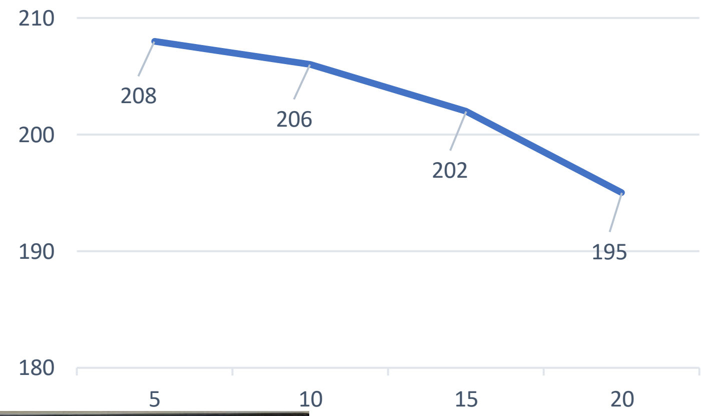


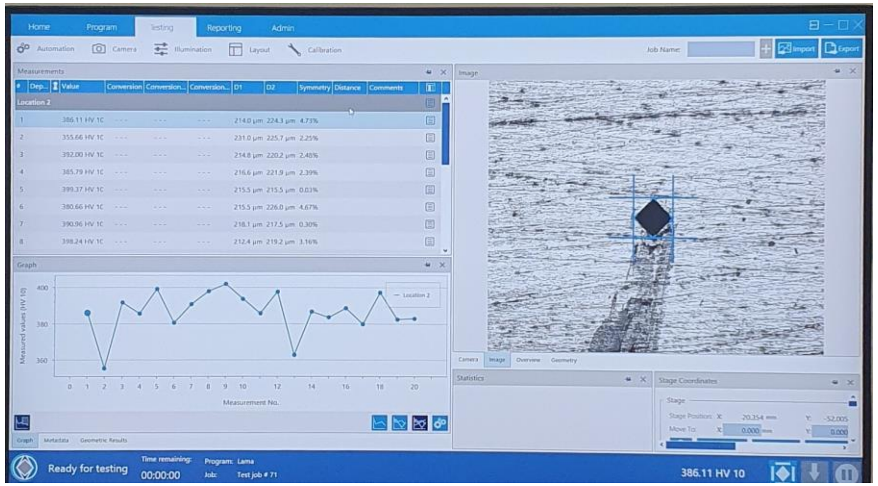
Hardness testing

HV10 – Frequency for S355MC
Δt8/5 = 20s



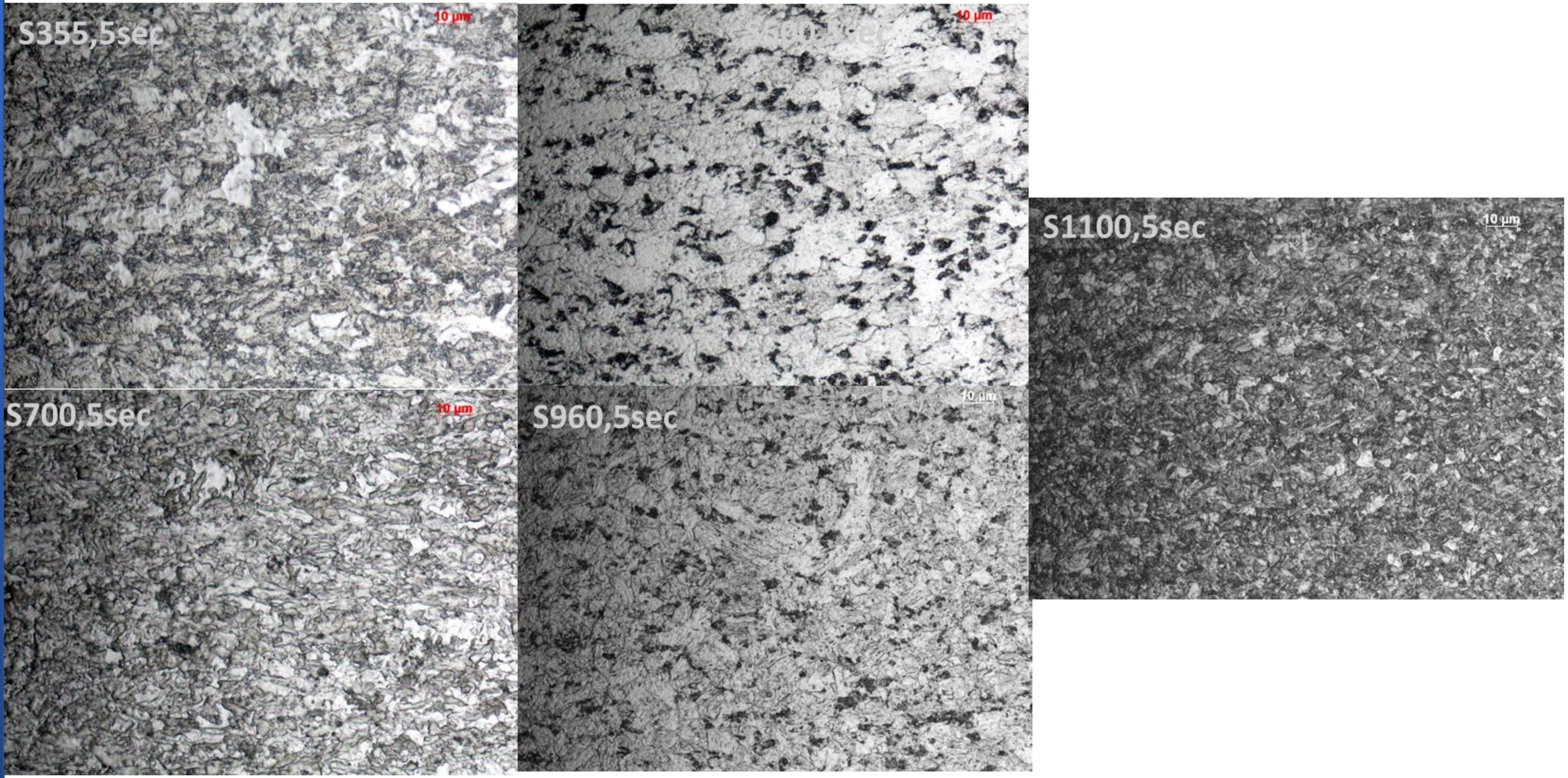
HV10 a Δt8/5 depending on S355MC steel





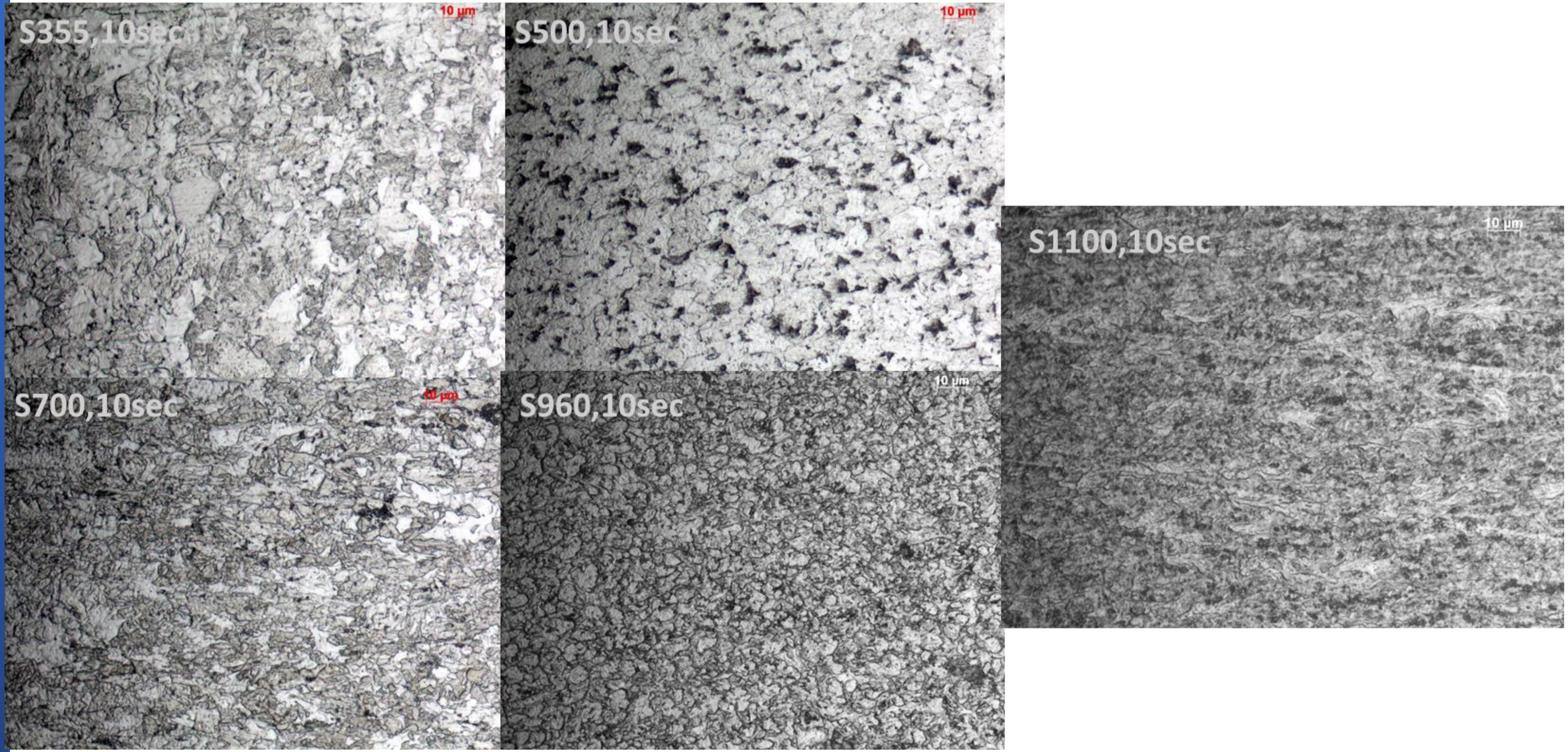
Microscope testing

HAZ



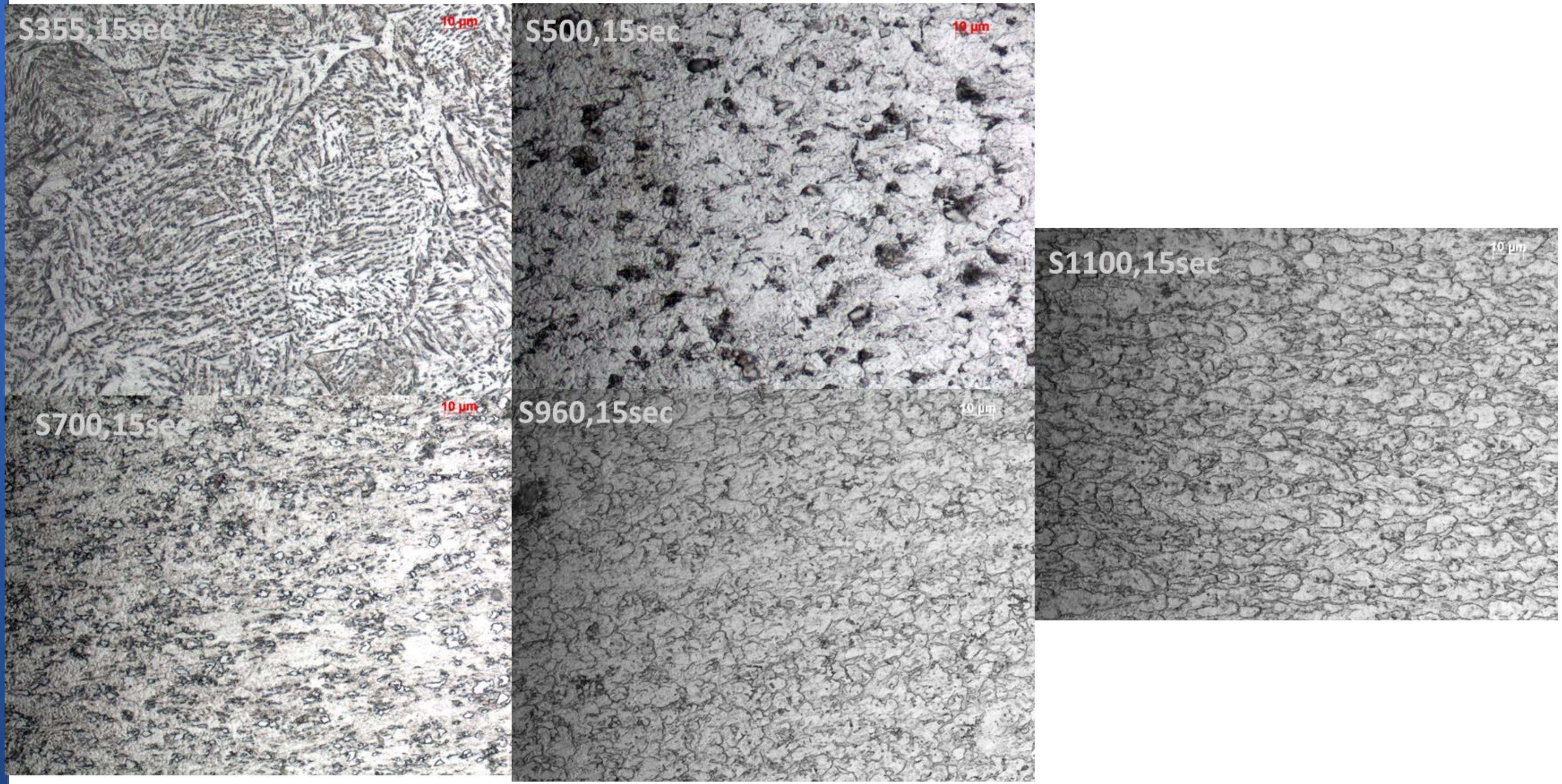
Microscope testing

HAZ



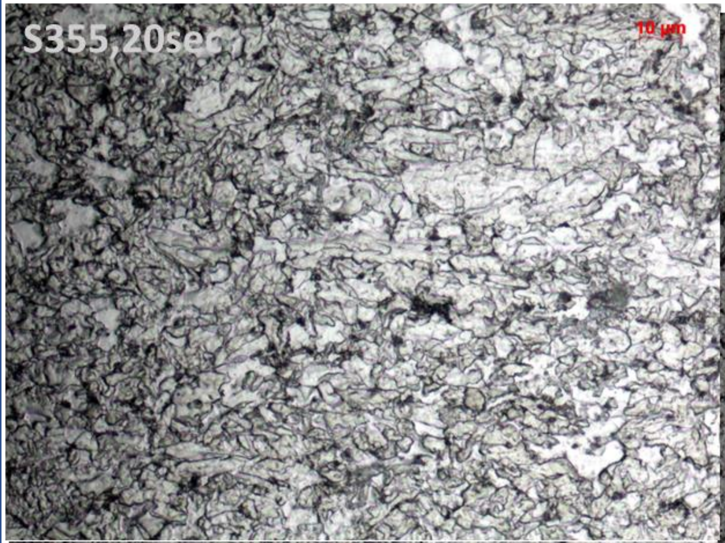
Microscope testing

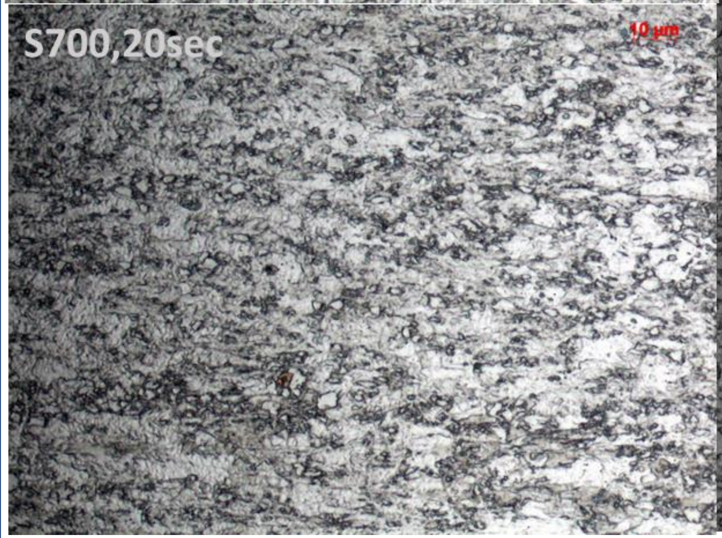
HAZ

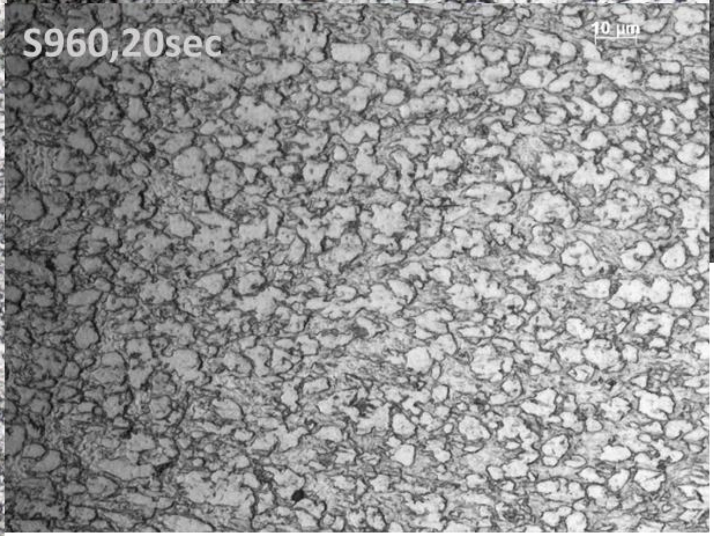


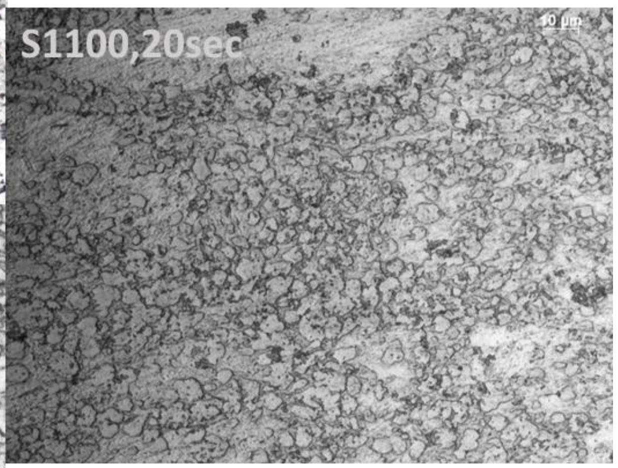
Microscope testing

HAZ

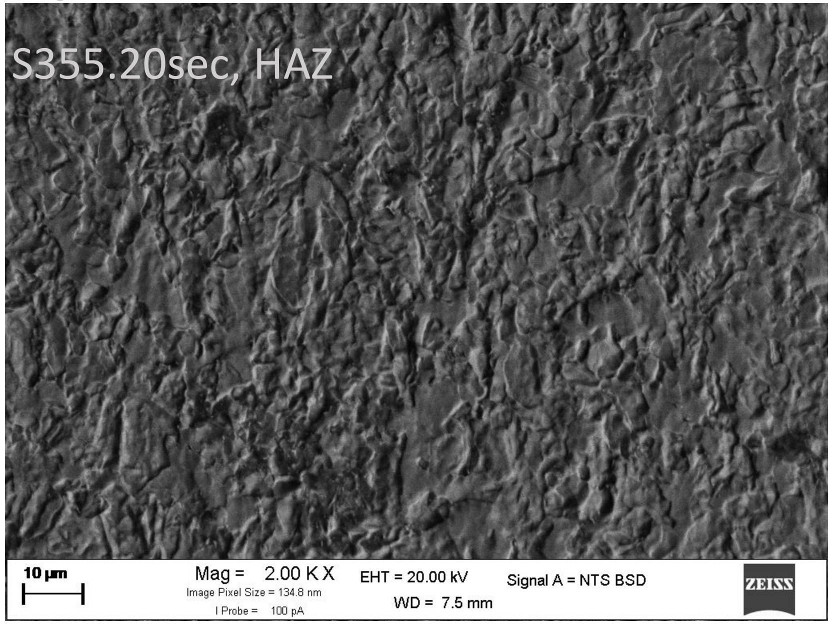




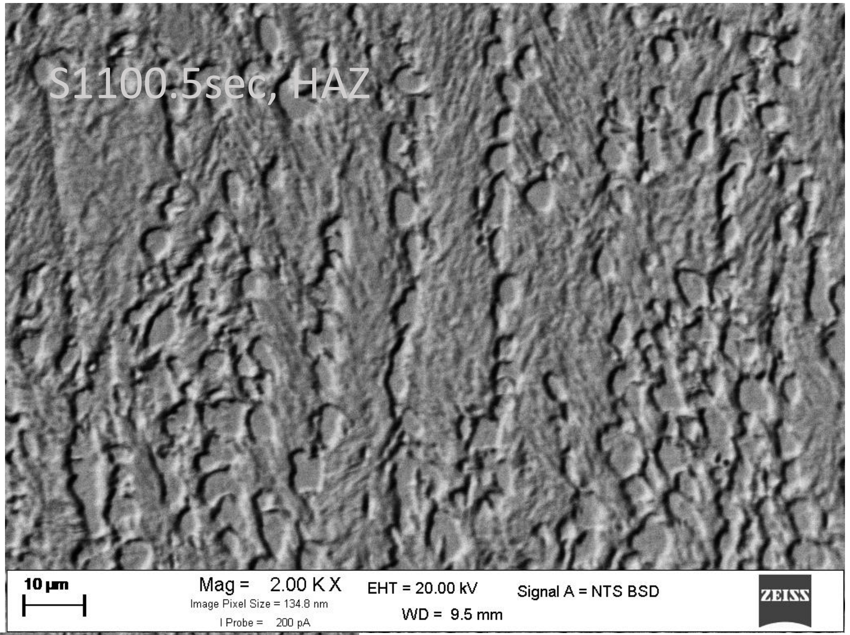




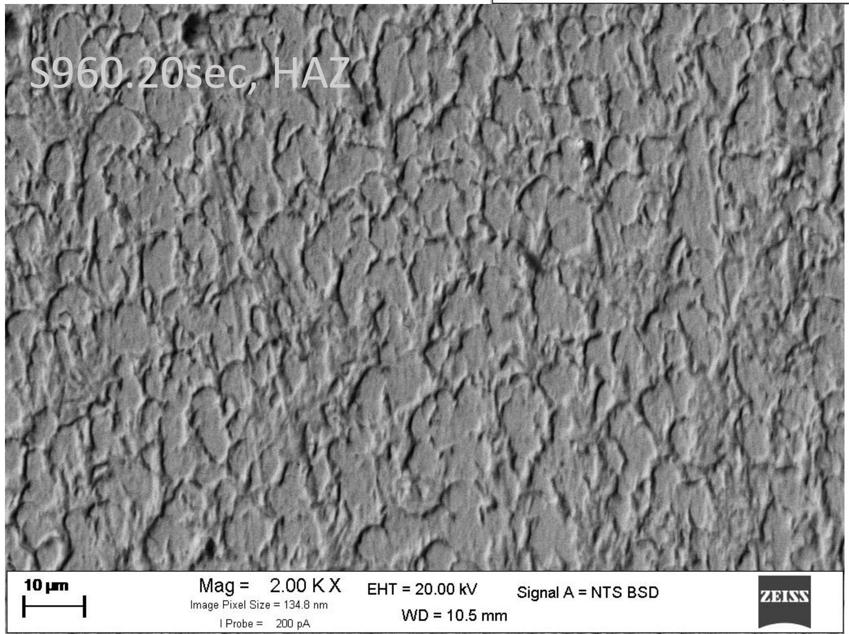
SEM



S355.20sec, HAZ
10 µm
Mag = 2.00 K X
Image Pixel Size = 134.8 nm
I Probe = 100 pA
EHT = 20.00 kV
WD = 7.5 mm
Signal A = NTS BSD
ZEISS



S1100.5sec, HAZ
10 µm
Mag = 2.00 K X
Image Pixel Size = 134.8 nm
I Probe = 200 pA
EHT = 20.00 kV
WD = 9.5 mm
Signal A = NTS BSD
ZEISS



S960.20sec, HAZ
10 µm
Mag = 2.00 K X
Image Pixel Size = 134.8 nm
I Probe = 200 pA
EHT = 20.00 kV
WD = 10.5 mm
Signal A = NTS BSD
ZEISS

Conclusion

- ✓ The use of high-strength steels is becoming more and more widespread in industry.
- ✓ High-strength steels are susceptible to cold cracking.
- ✓ According to our results the HAZ in case of S355 contain ferrite and pearlite in 5sec and the phase start to transform to martensite with the higher cooling time, in case of S500 the same with more appearance to pearlite, in case of S960 and S1100 contains martensite , ferrite and pearlite.
- ✓ These results will help the engineers/technologists and users of HSS for the improvement of research data and can be implemented in cranes & lifting processes and vehicles industry (trucks etc.)

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Thank you for the kind attention!