ANDRITZ GROUP

DEVELOPMENT OF QUENCHING PROCESS RECIPE USING SIMULATION

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Product Manager

OCTOBER 2024

ENGINEERED SUCCESS

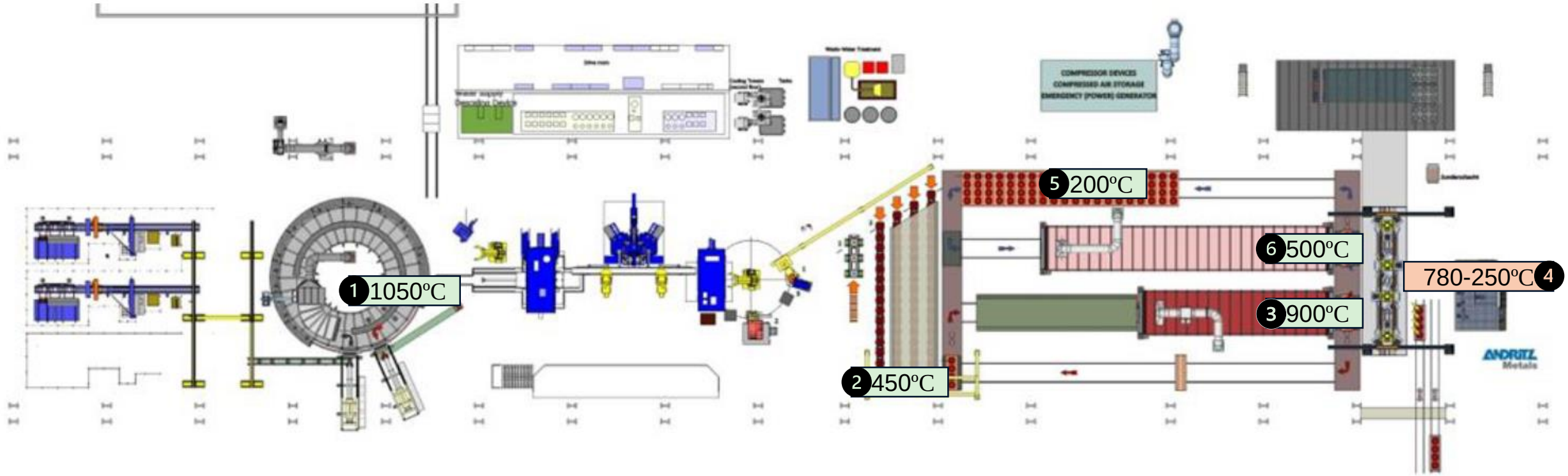
INSERT CHAPTER OVERVIEW

SYSTEM DESCRIPTION

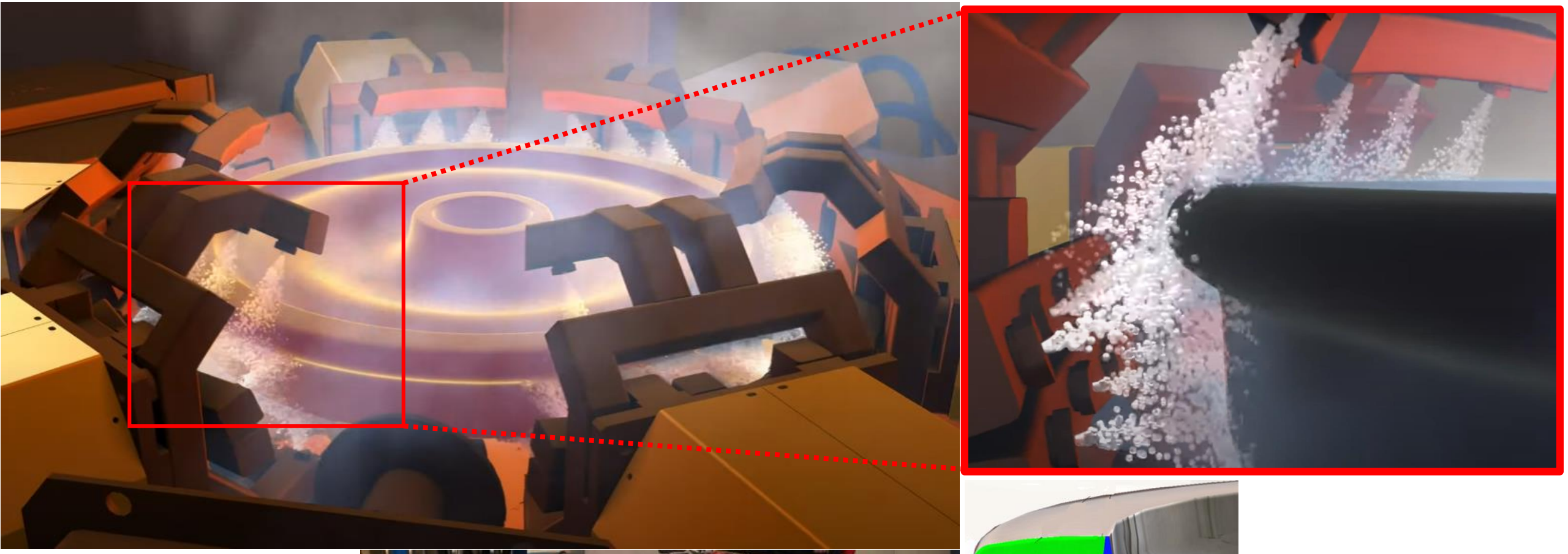
Simulation problem definition

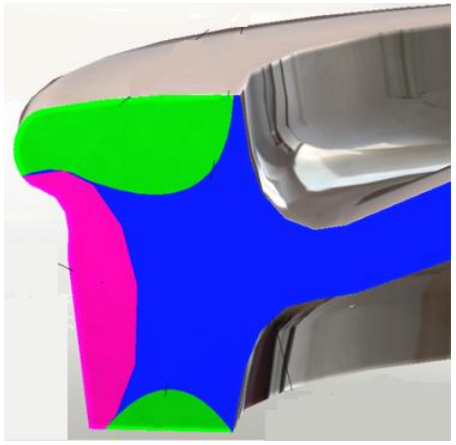
Combined production line for railway wheels

REHEATING FURNACE (AMG) + FORGING EQUIPMENT (SCHULER) + HEAT TREATMENT LINE (AMG)



SYSTEM DESCRIPTION






MSA
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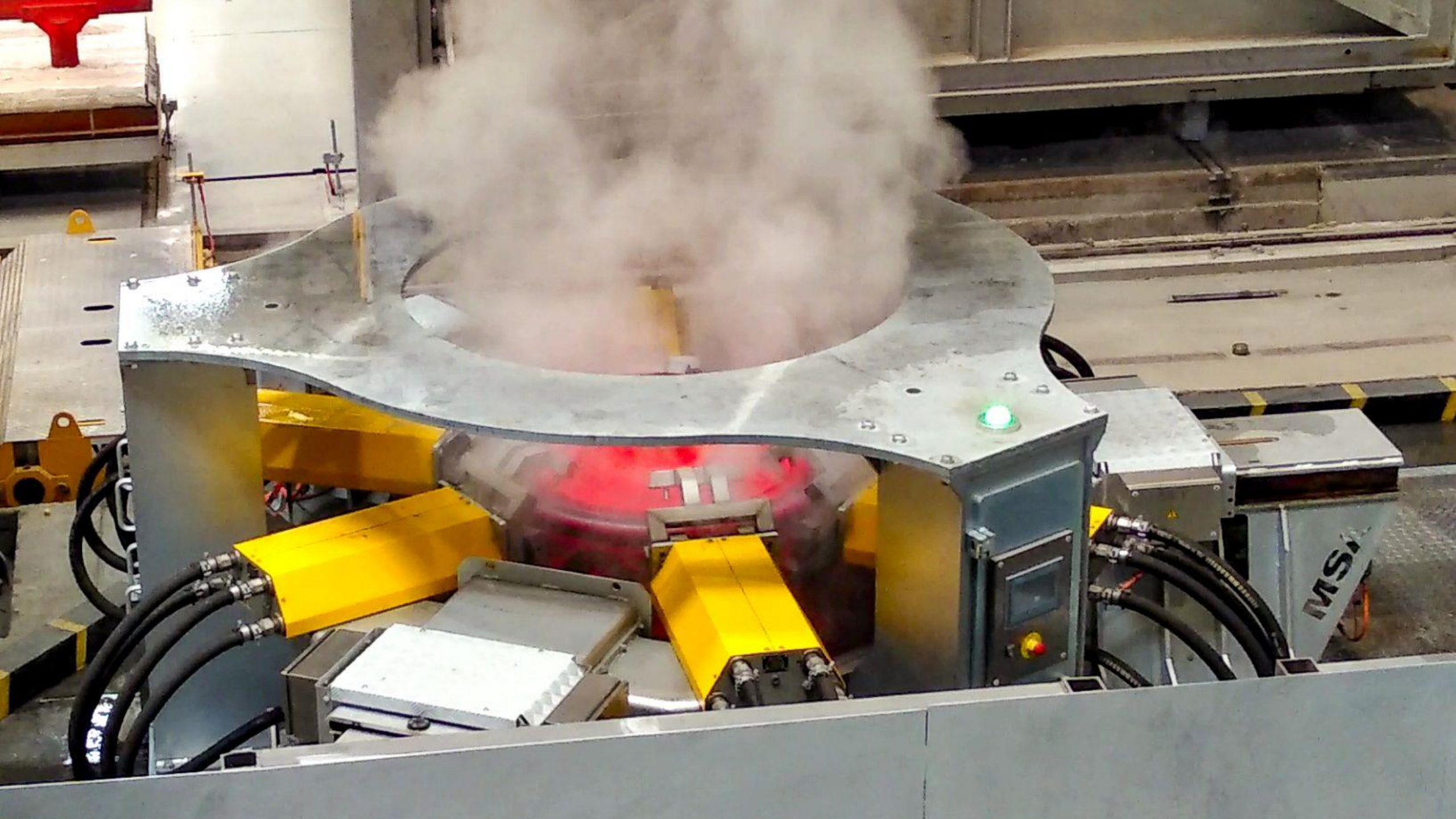
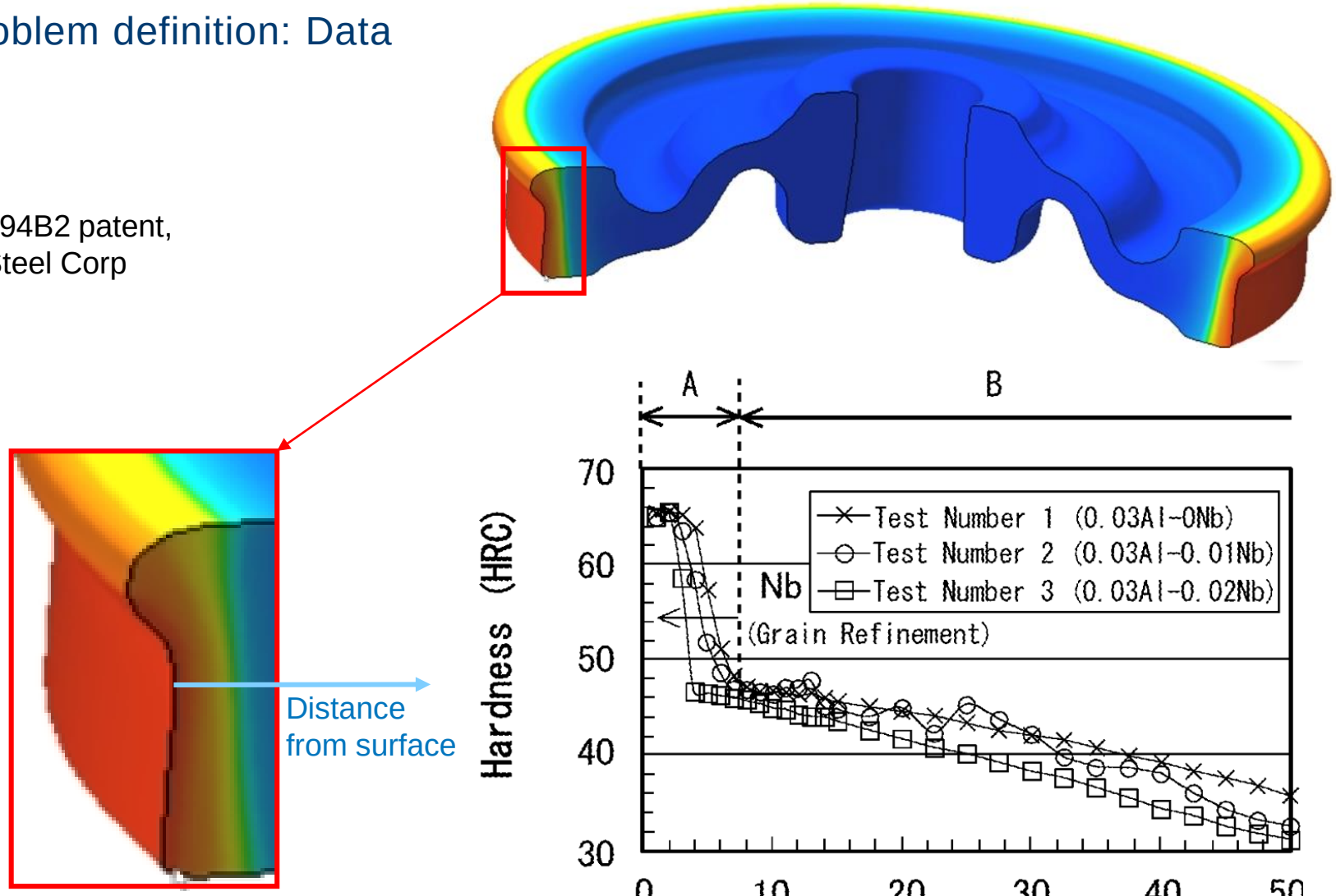


PROBLEM STATEMENT

Simulation problem definition: Data

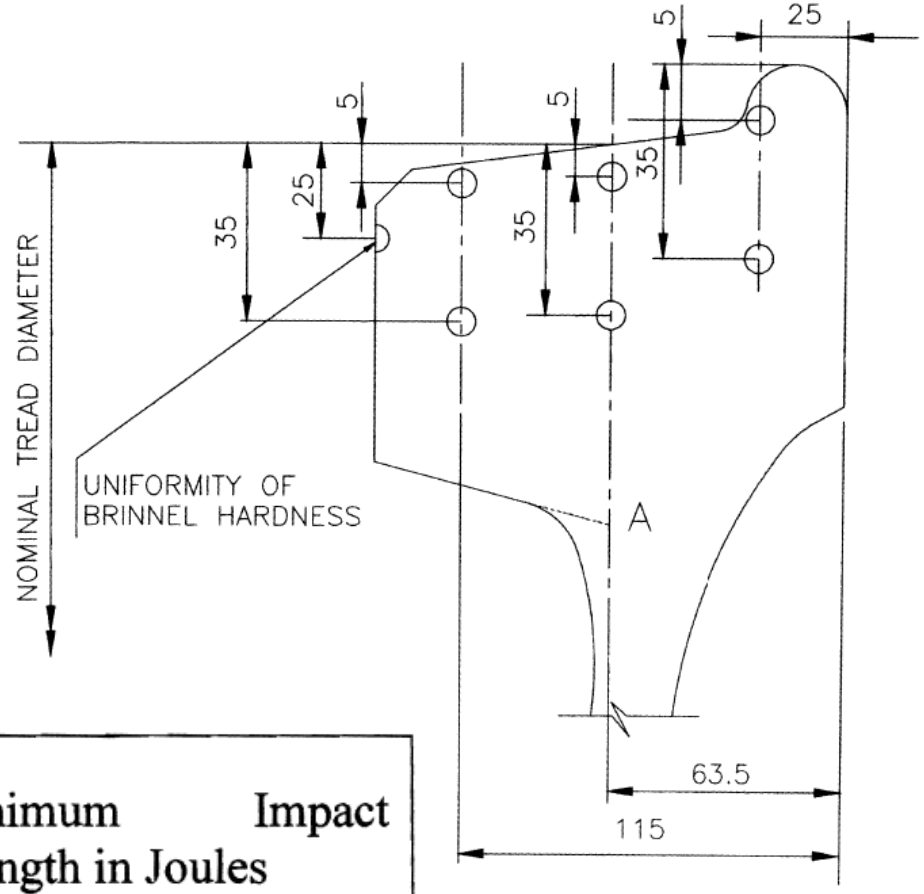
Ref: US11890894B2 patent, 2019, Nippon Steel Corp



HARDNESS VALUE IN EN IRS-R-19/93 STANDARD

Test for measurement of hardness

- The difference between extreme hardness values within a batch shall not exceed 30 BHN.
- The microstructure of wheel shall be "Fine Pearlite structure with ASTM grain size 6 or finer."



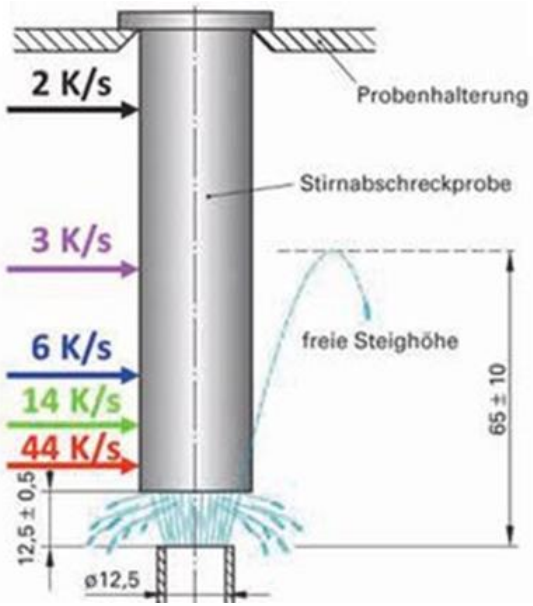
Tensile strength N/mm^2	Yield Strength N/mm^2	Minimum Elongation Percentage Gauge Length: 5.65 $\sqrt{So}$	Hardness range BHN	Minimum Impact strength in Joules at +20 °C.
See position 1 of figure 1				
820 – 940	≥ 520	14	241 to 320	Average value : 17 Individual value: 12

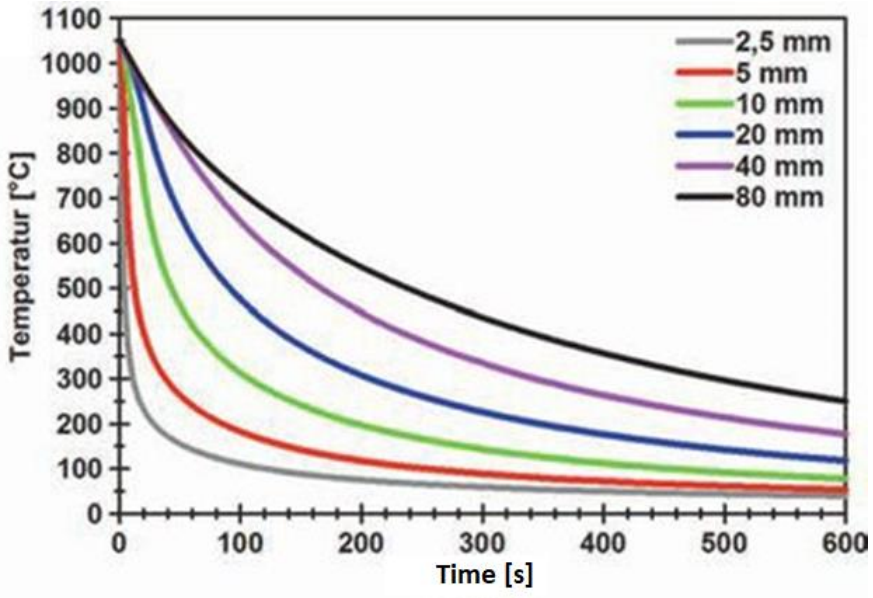
INSERT CHAPTER OVERVIEW

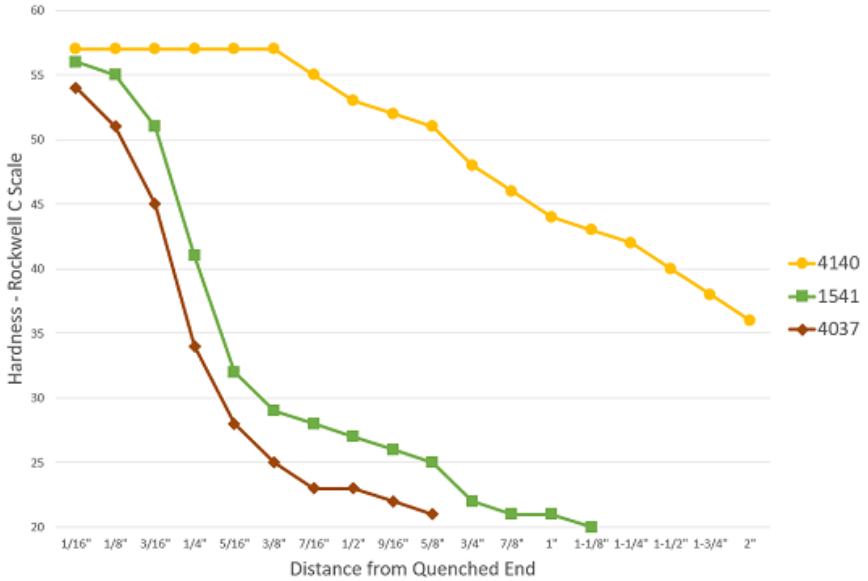
SIMULATION FLOW AND REQUIRED DATA

Standard Test for Hardenability

Jominy Test: based on ISO 642 is what we want to focus on and validate by simulations results







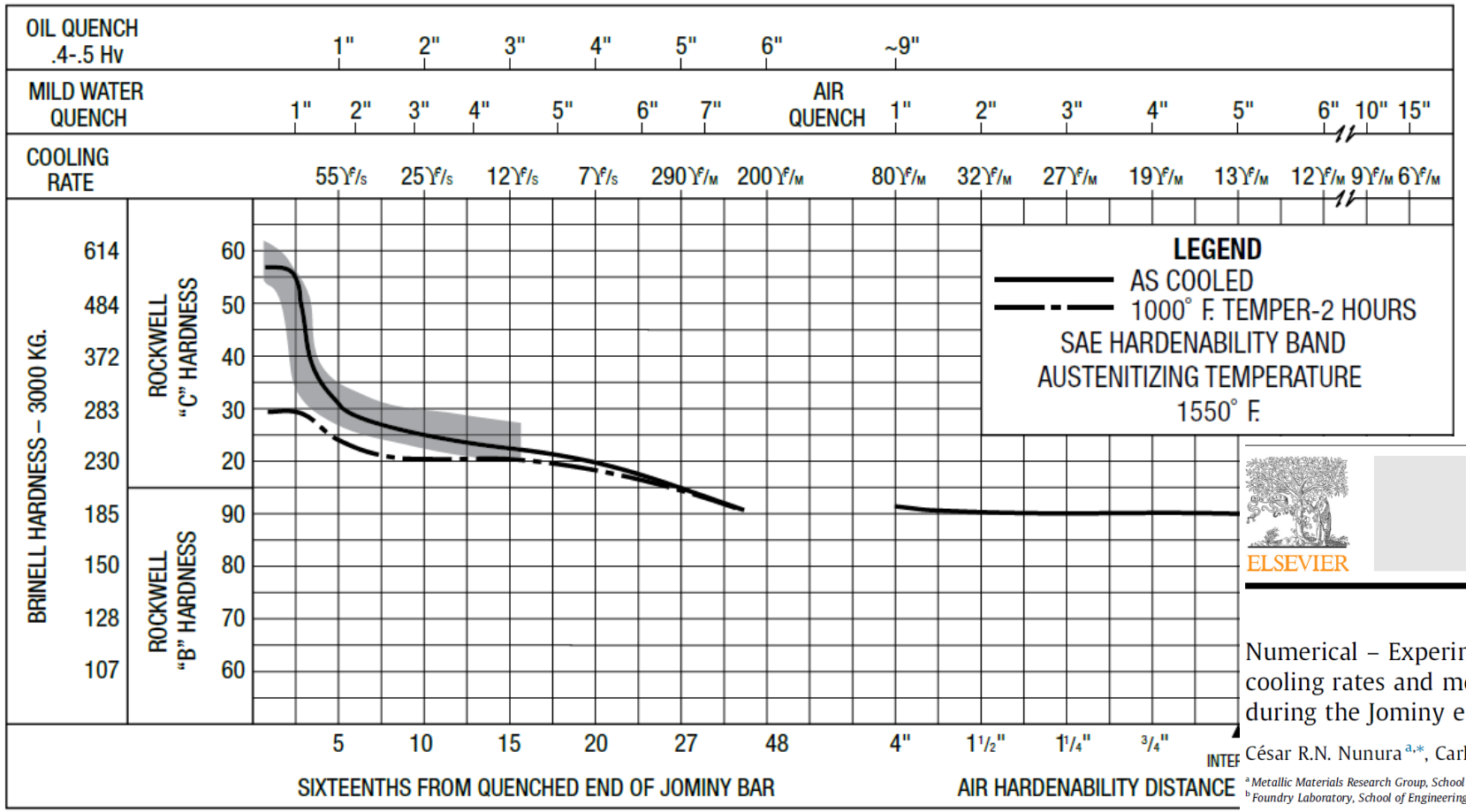
CHEMICAL COMPOSITIONS AND HARDENABILITY

Experimental Data for the 1045 Steel

TYPE	HEAT TREATMENT
1045	NORMALIZED 1600° F. — AUSTENITIZED 1550° F.

CHEMICAL ANALYSIS	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Al	V	W	B
	.42	.79	.019	.023	.22	.11	.18	.04	.04	—	—	—	—

ROUND SECTION WITH SAME HARDNESS AT MID-RADIUS



TIMKENSTEEL

Practical Data for Metallurgists

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Numerical – Experimental correlation of microstructures, cooling rates and mechanical properties of AISI 1045 steel during the Jominy end-quench test

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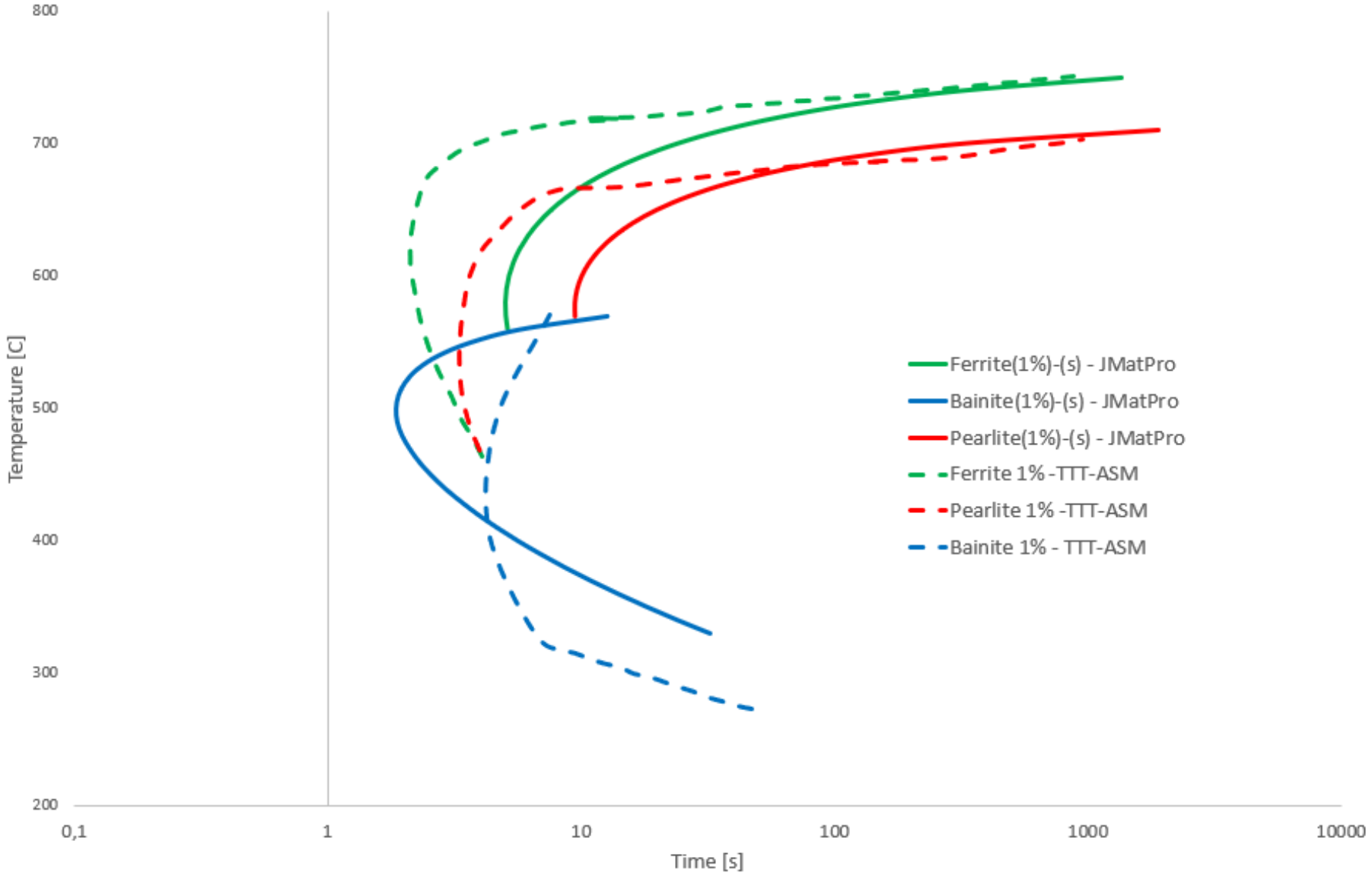
CHEMICAL COMPOSITIONS AND TTT DIAGRAM

Experimental Data for the 1045 Steel and JMatPro output

Atlas of Time-Temperature Diagrams for Irons and Steels

Edited by
George F. Vander Voort
Carpenter Technology Corporation
Reading PA

ASM International®



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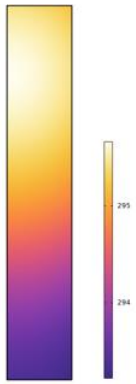
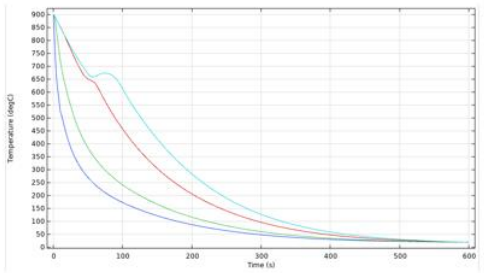
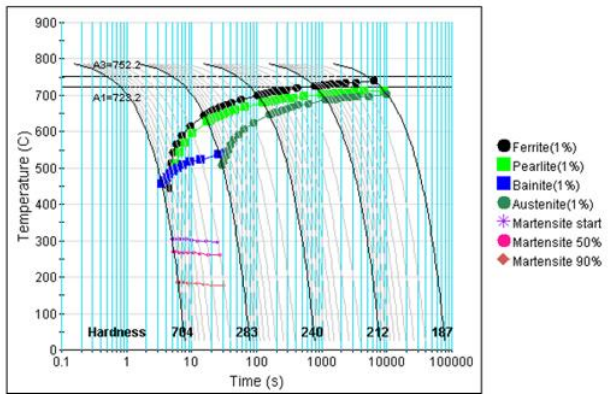
COMSOL SIMULATION FLOW





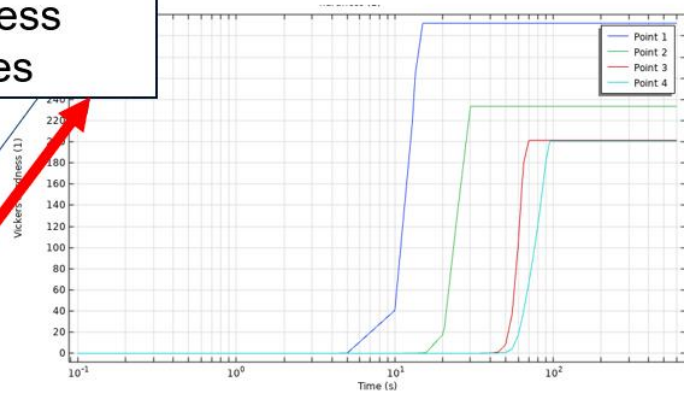


Temperature

Thermal Stress

Heat generated due to the plastic strain

Hardness Values



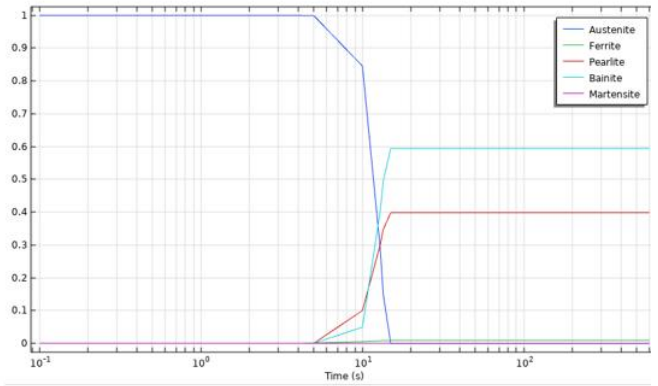
Latent heat

Material Information

Stress induces transformation

Temperature dependent transformation

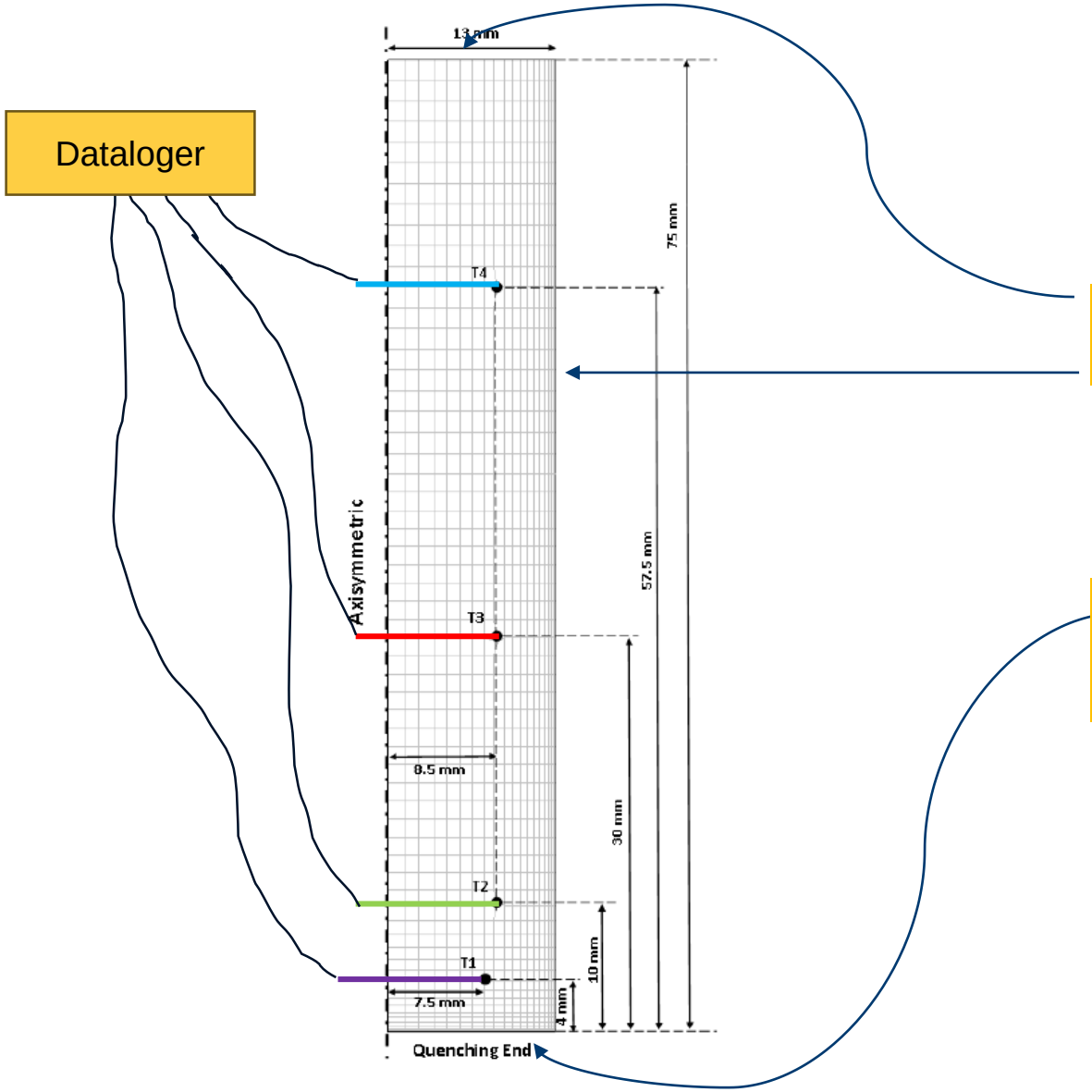
Transformation stress and Transformation plasticity



Phase Transformation

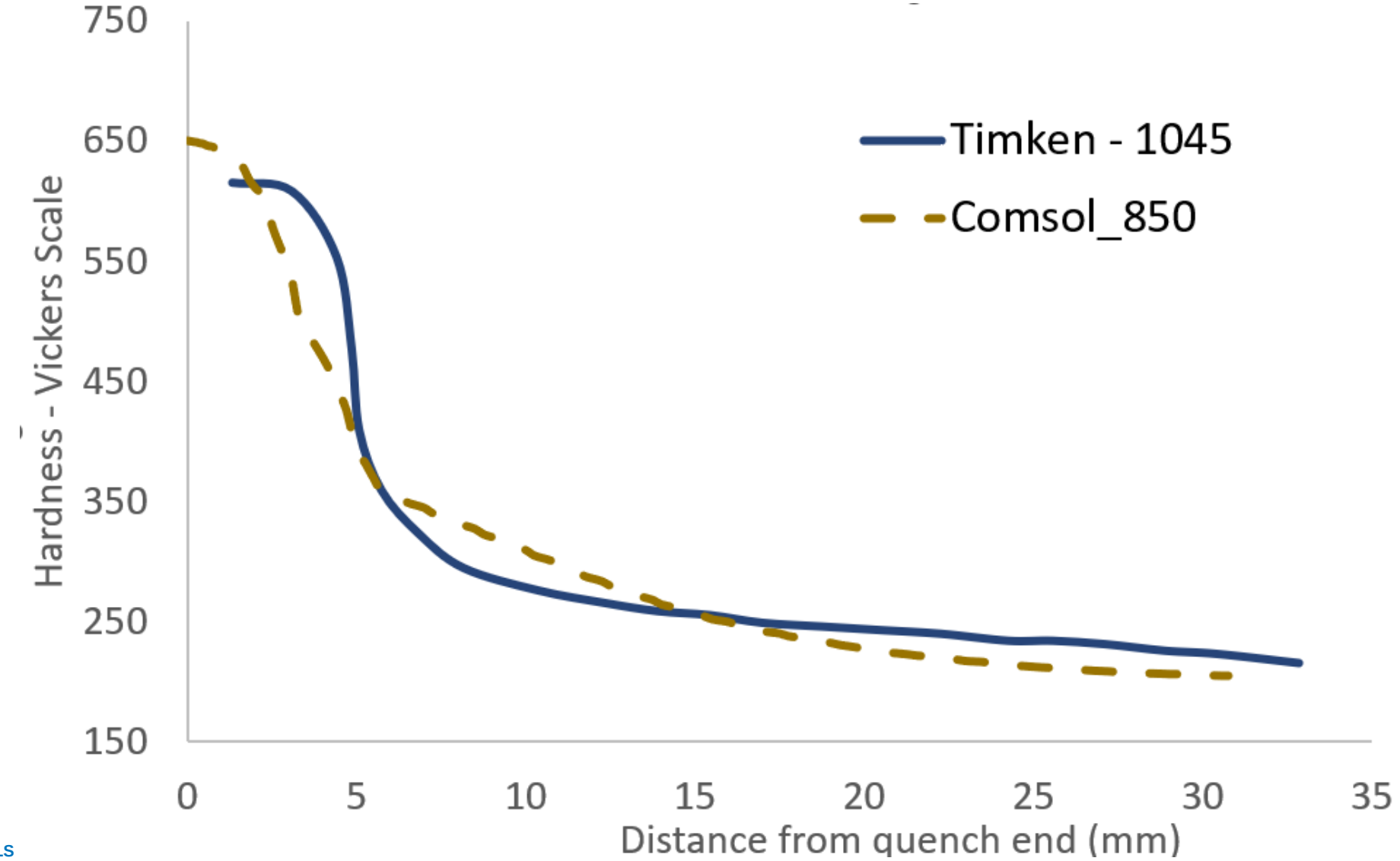
.xml

MODEL BOUNDARY CONDITIONS

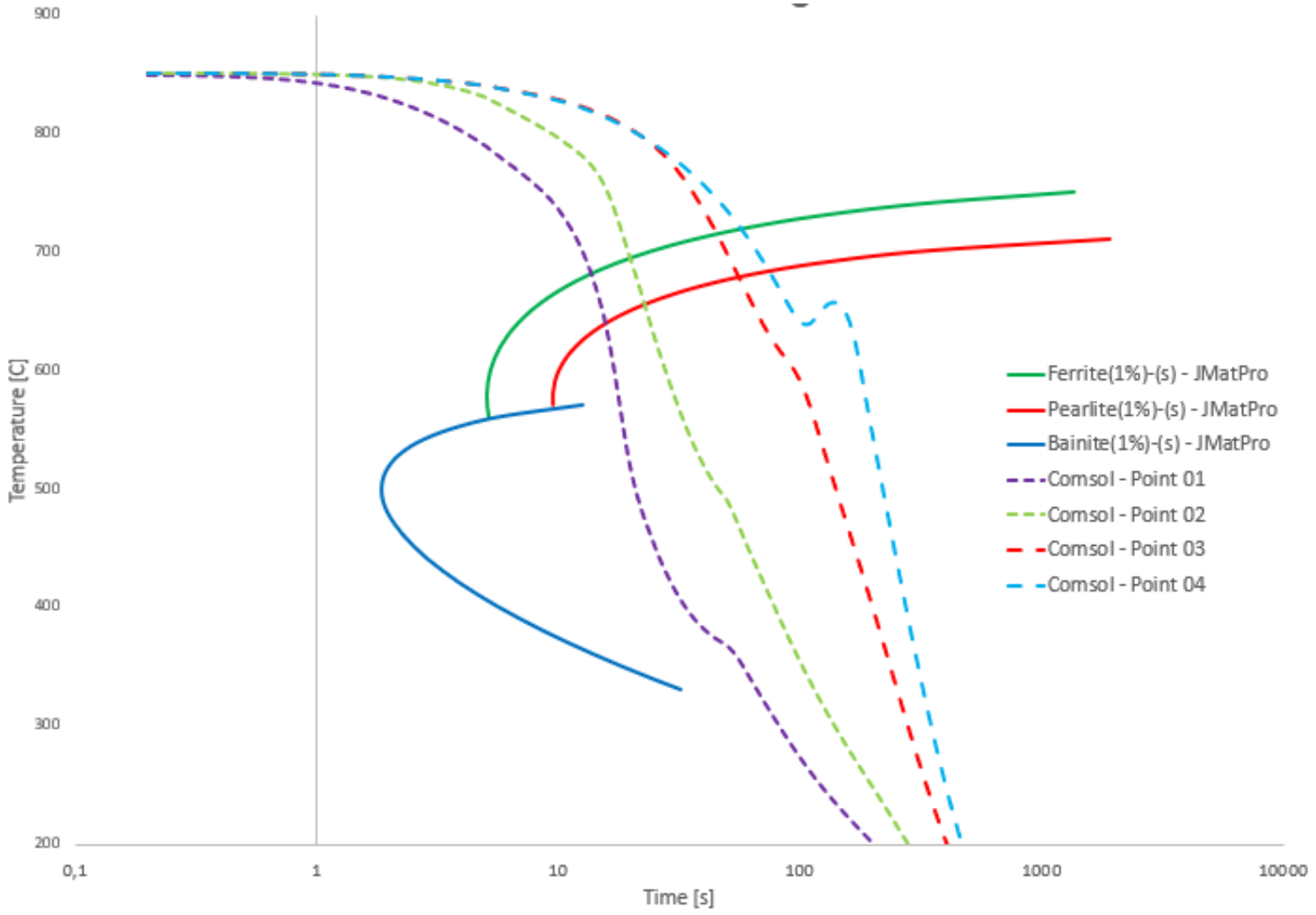


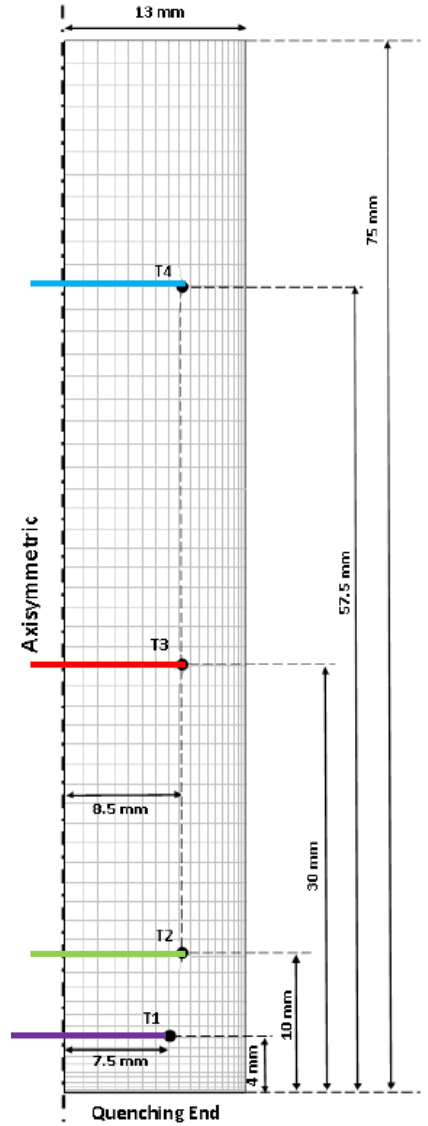
INSERT CHAPTER OVERVIEW

COMSOL SIMULATION RESULTS

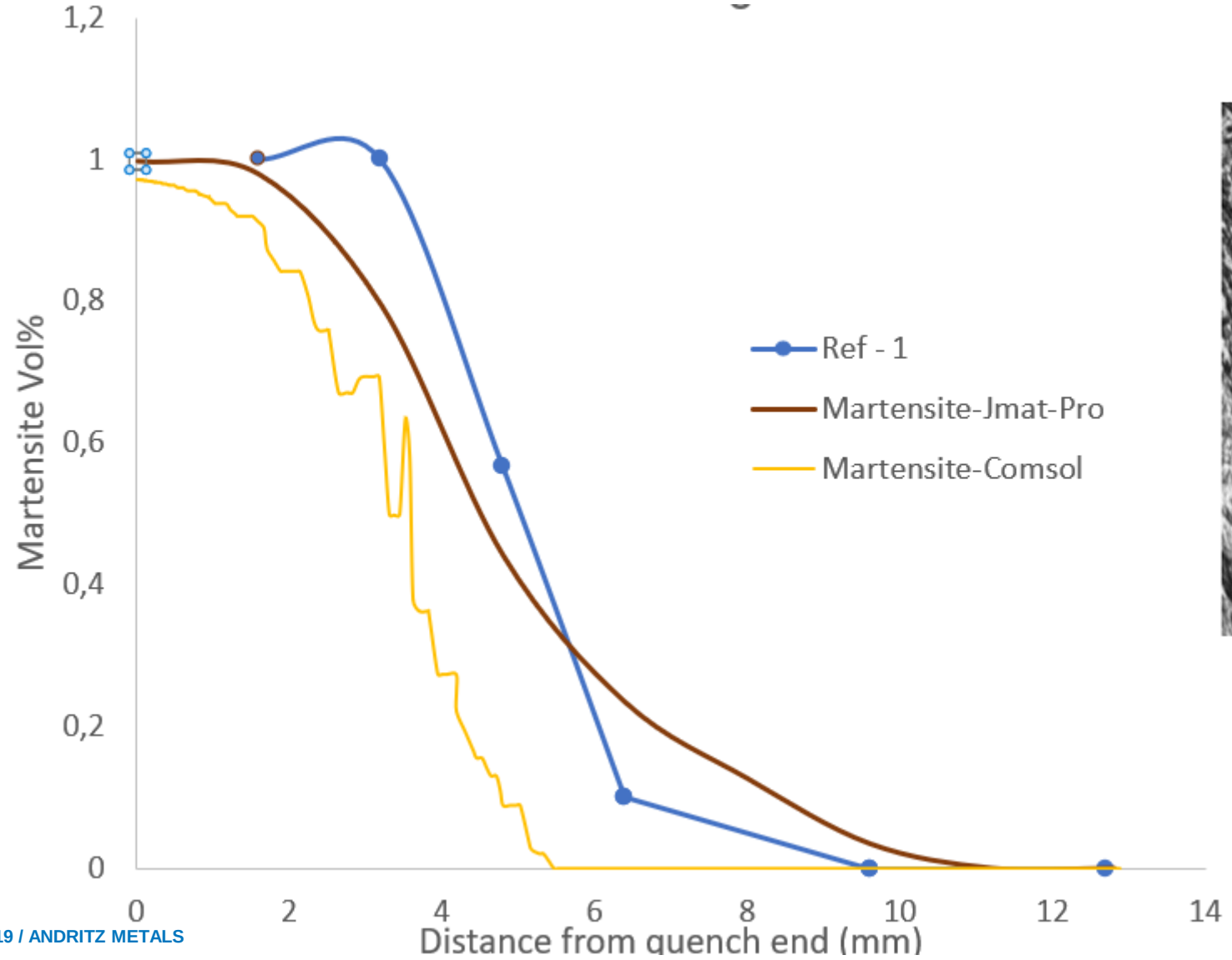


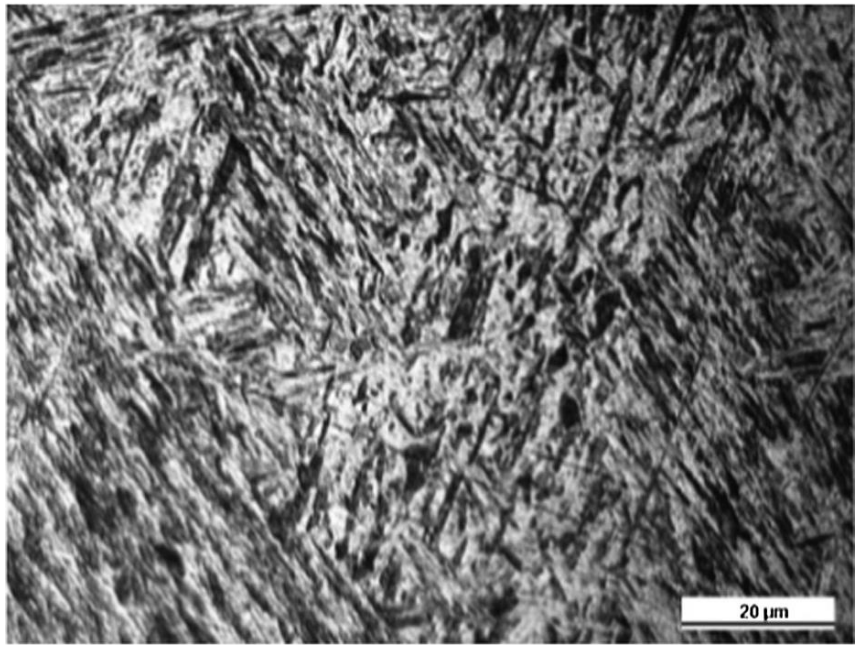
AUSTENATIZING TEMPERATURE EFFECT





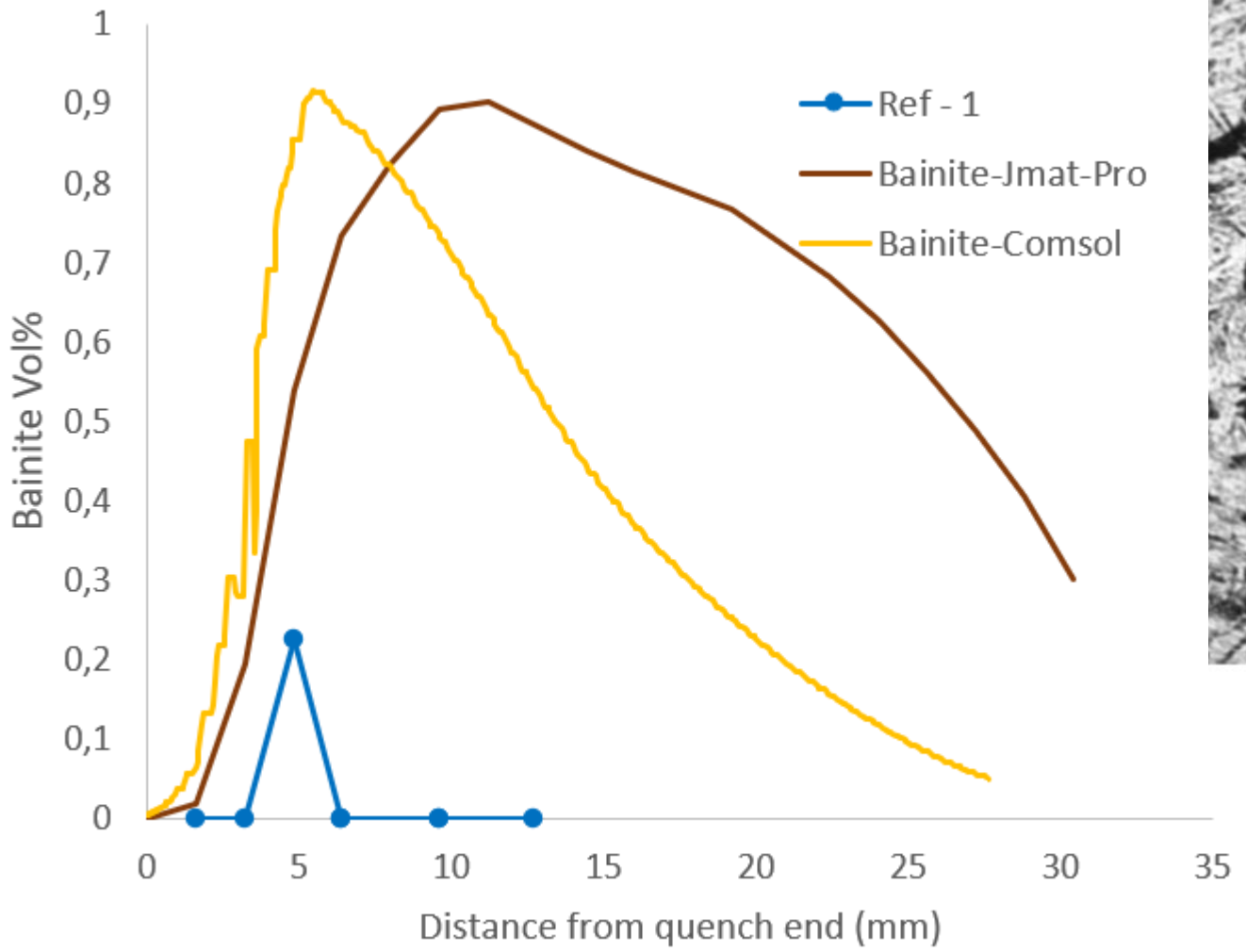
MARTENSITE PHASE FRACTION

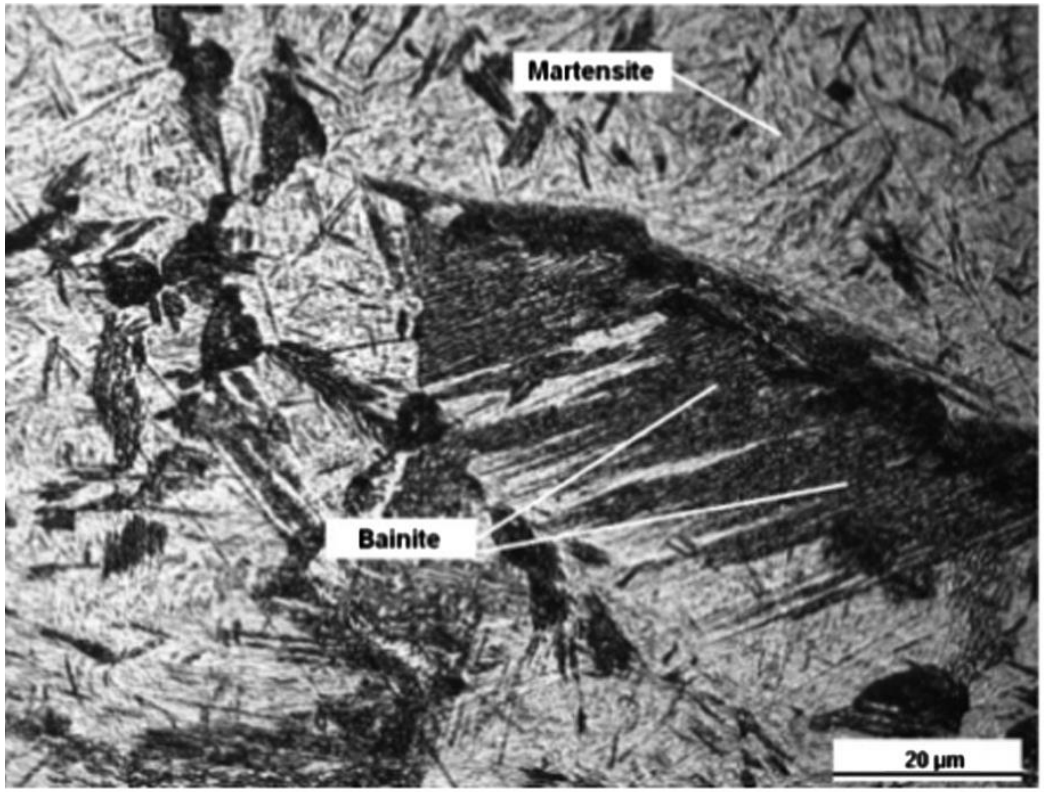




Martensitic microstructures for
Distance from quenched end: 1.6 mm.
Etching: Nital 3%.

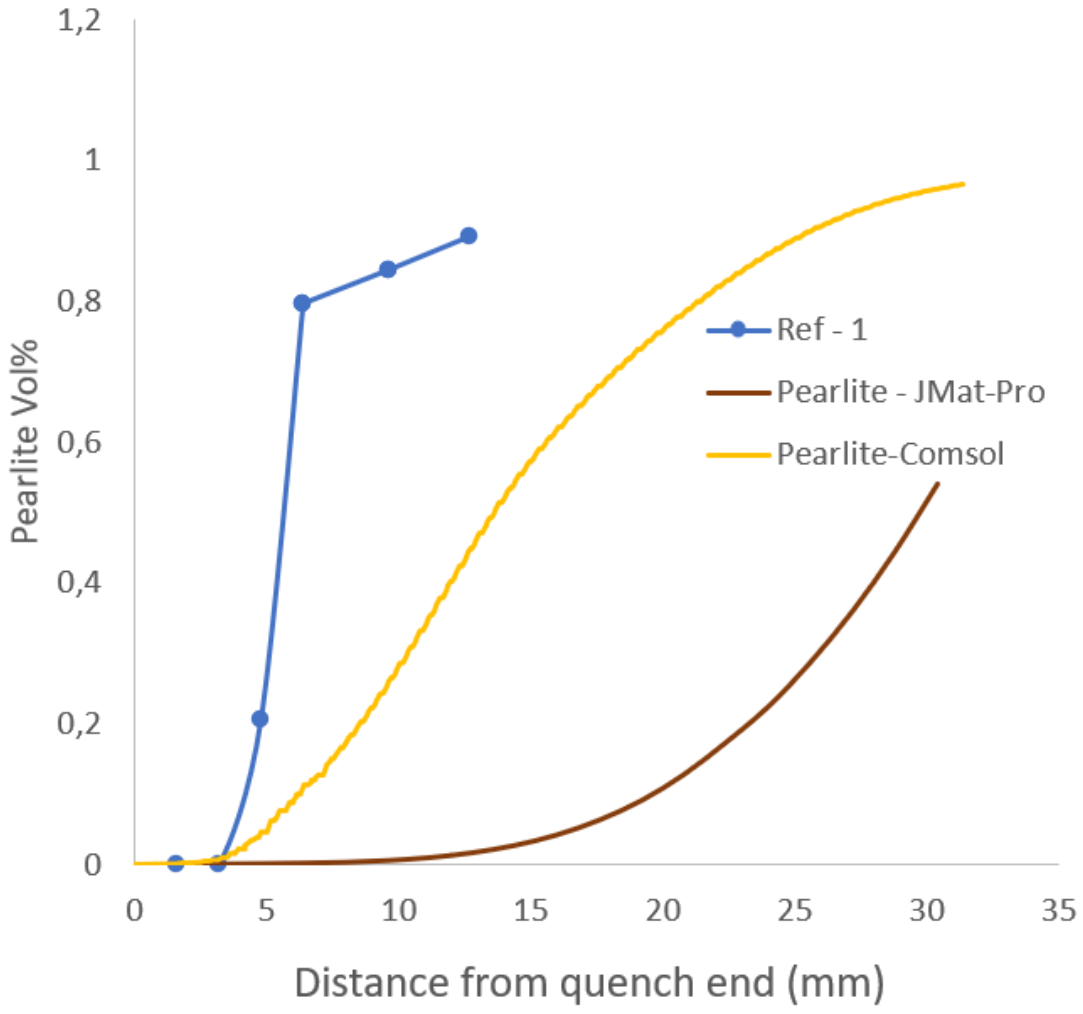
BAINITE PHASE FRACTION

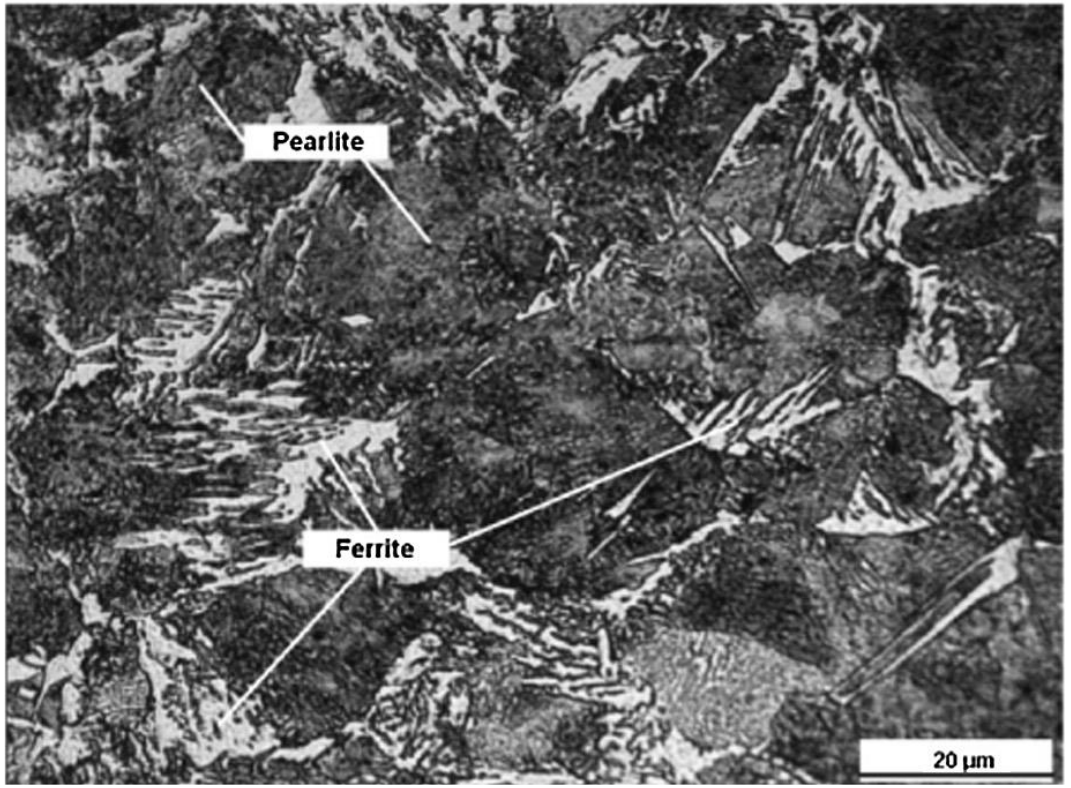




Microstructures for
Distance from quenched end: 4.8 mm.
Etching: Nital 3%.

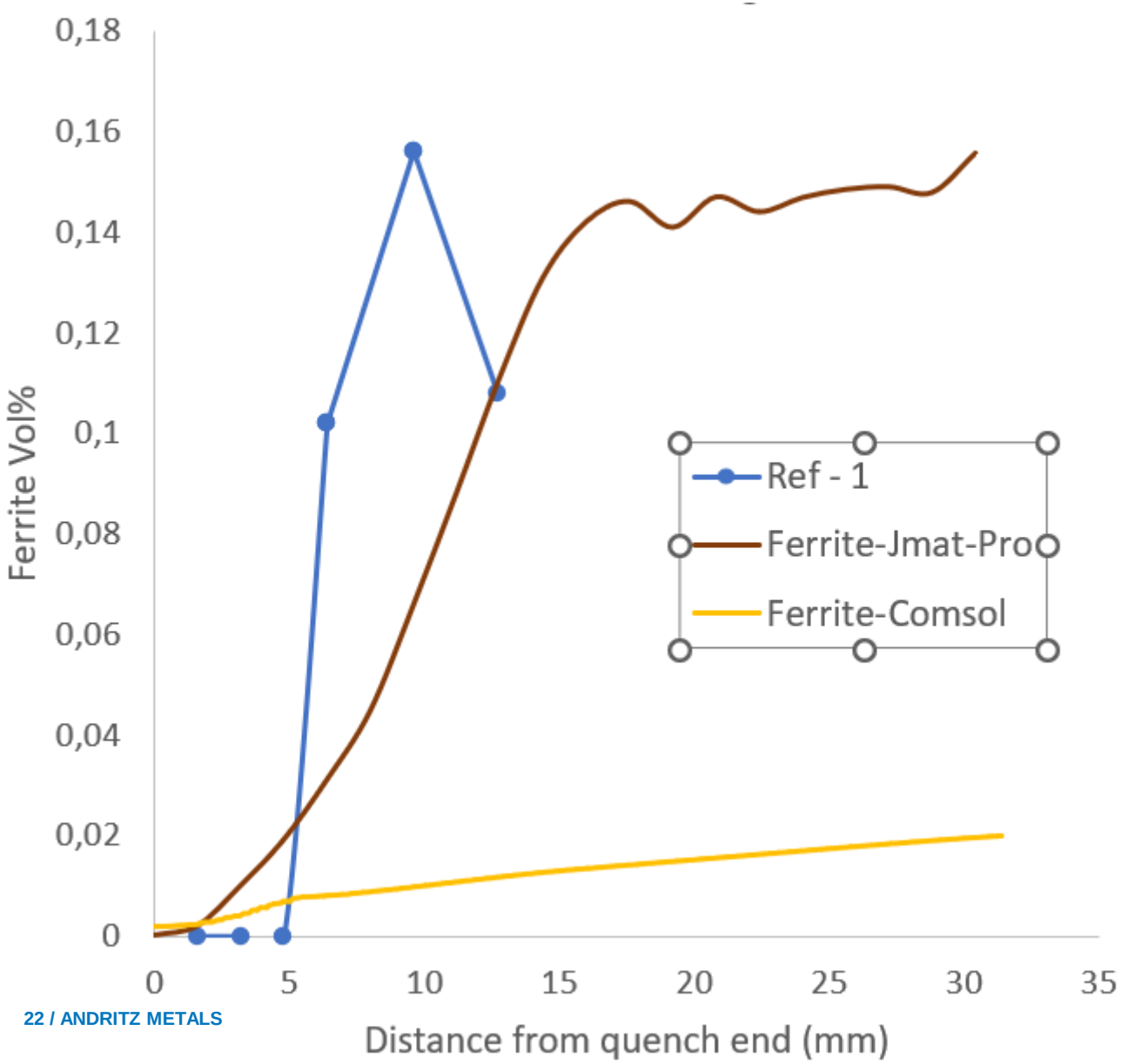
PEARLITE PHASE FRACTION

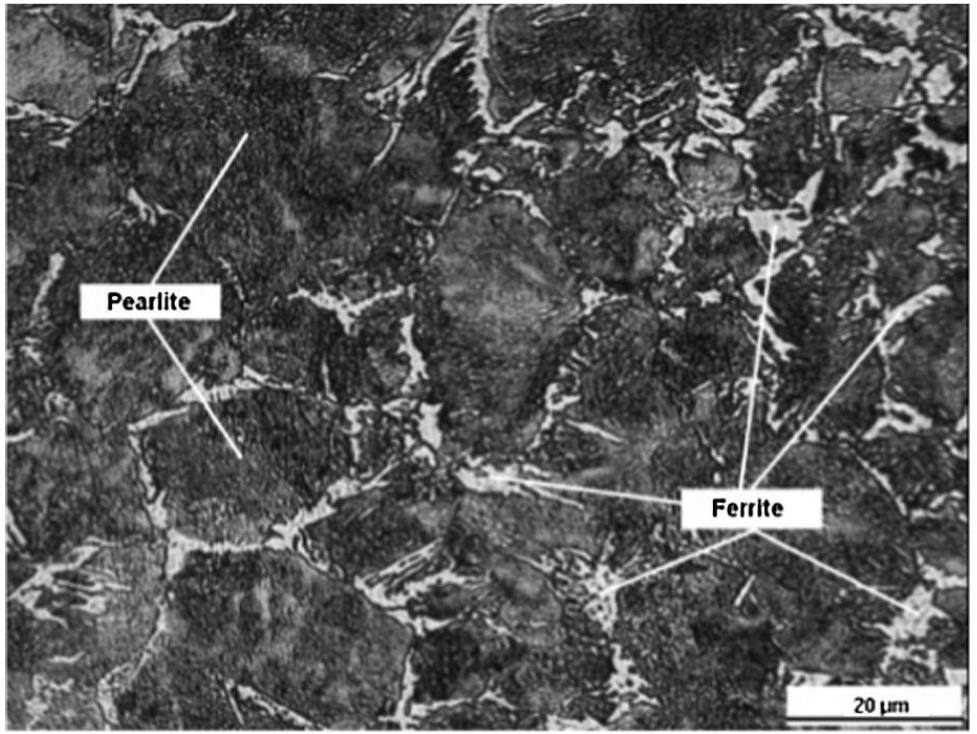




Microstructures for
Distance from quenched end: 12.7 mm.
Etching: Nital 3%.

FERRITE PHASE FRACTION





Microstructures for
Distance from quenched end: 12.7 mm.
Etching: Nital 3%.

INSERT CHAPTER OVERVIEW

CONCLUSION

- The combination of JMatPro and COMSOL can well predict the hardness of material after quenching.
- Some further parametric study is required to be sure about the values of different phases from simulation.
- The validated results can be used to design process for railway quench.

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