ESTEP SPRING DISSEMINATION EVENT

5-6 JUNE 2025 KRAKOW (POLAND)

Development of a technology of manufacturing of welding pipes made of multiphase steels CP and DP

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Upper Silesian Institute of Technology

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Outline

1. Background and Objectives
Why the project was initiated and what challenges it addressed.

2. Project Scope and Approach
Key R&D activities, from modeling to semi-industrial testing.

3. HF-ERW & HT Processes Development
Integration of high-frequency electric resistance welding with in-line heat treatment.

4. Technological Achievements
Process parameters, microstructures, mechanical properties.

5. Industrial Readiness and Applications
Pilot line, scalability, and use cases in automotive and construction sectors.

6. Conclusions and Outlook
Project outcomes, future potential, and implementation prospects.

Background and Objectives

Konkurs "6/1.1.1/2020"

wniosek o dofinansowanie projektu

nr:POIR.01.01.01-00-1569/20

data złożenia 2020-09-14 12:05:51*(87231)*

Instytucja Pośrednicząca	Narodowe Centrum Badań i Rozwoju
Program Operacyjny	Inteligentny Rozwój 2014-2020
Oś priorytetowa	Wsparcie prowadzenia prac B+R przez przedsiębiorstwa
Działanie	Projekty B+R przedsiębiorstw
Poddziałanie	Badania przemysłowe i prace rozwojowe realizowane przez przedsiębiorstwa
Działanie	Projekty B+R przedsiębiorstw
Konkurs	6/1.1.1/2020 SS Duże/MSP/JN 4
Zakres	Projekty z regionów lepiej rozwiniętych i słabiej rozwiniętych
Ogłoszenie konkursu	1 lipca 2020
Nabór wniosków	2020-08-03 - 2020-09-14

Total project cost:
approx. PLN 15.5 million

Public funding (NCBR):
approx. PLN 8.5 million

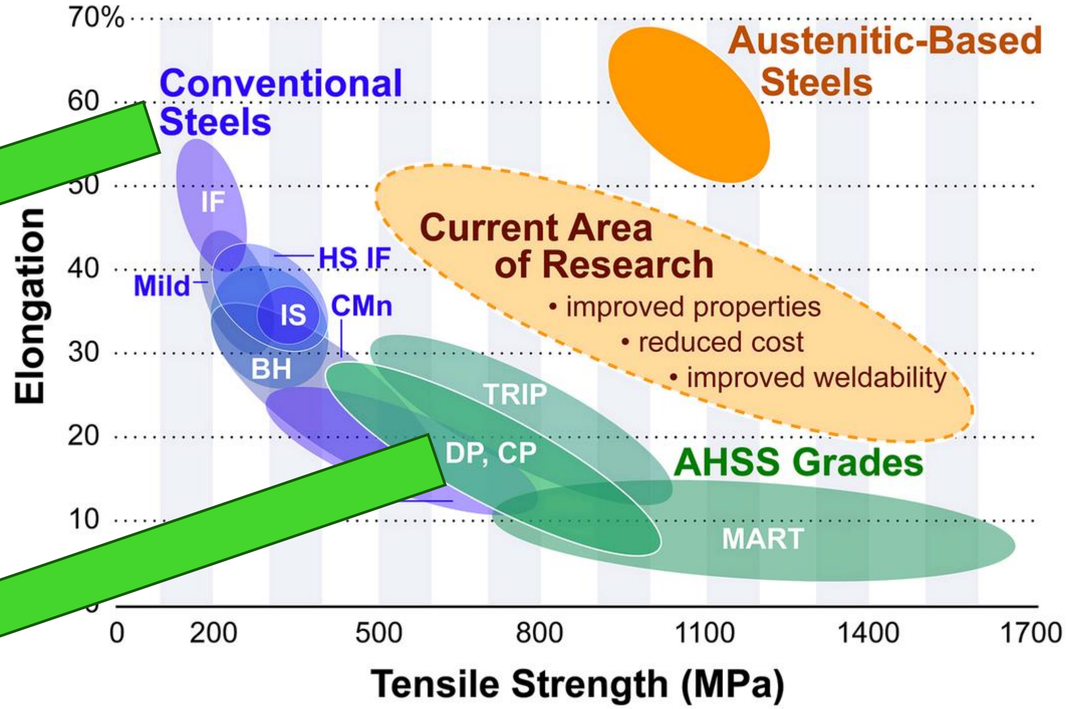
Own contribution:
approx. PLN 7.0 million

Duration:
2021-05-01 ÷ 2023-10-31

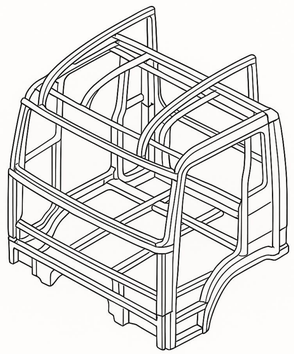
Background and Objectives

Mild steels properties:
$R_{p0.2}$=210÷350 Mpa
R_m=370÷550 Mpa
A=20÷35%

CP & DP steels properties:
$R_{p0.2}$=330÷950 Mpa
R_m=600÷980 Mpa
A=6÷20%



Truck cabins



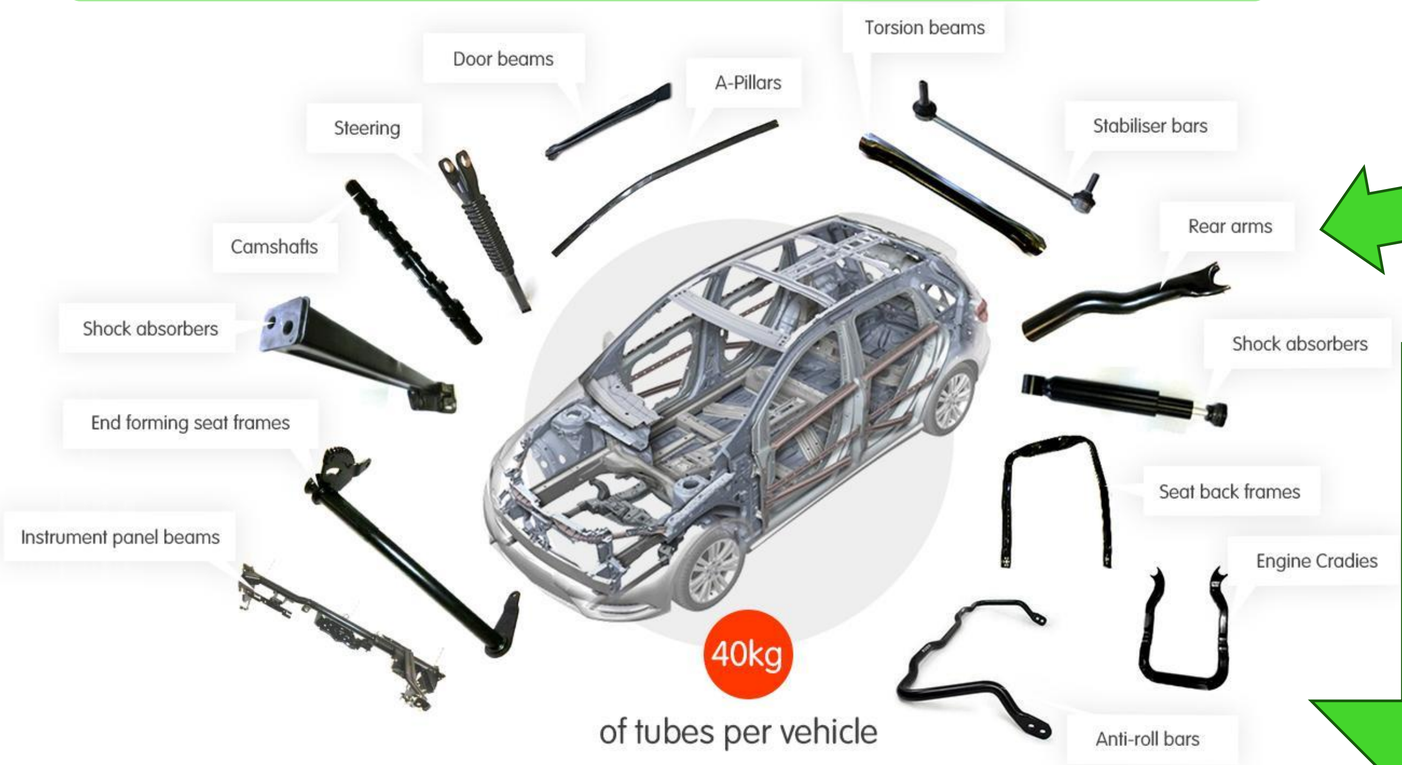
Car seats

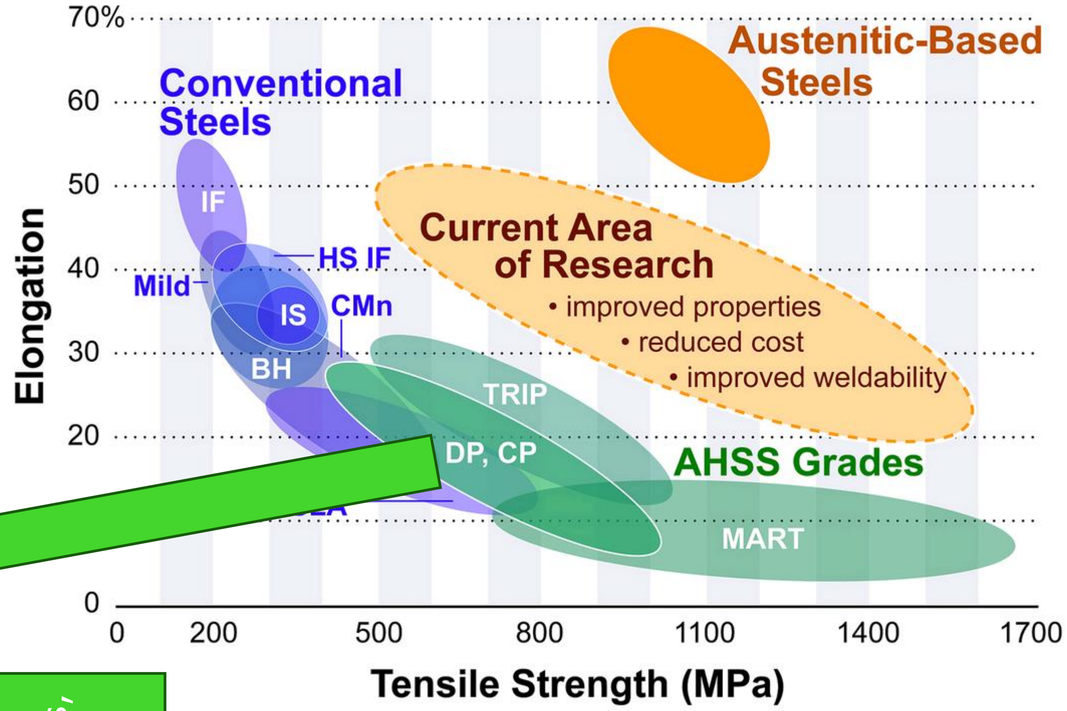
Sources:
[1] https://www.kamleshmetalalloy.com/blog/how-to-choose-the-right-structural-steel-tube/
[2] www.autosteel.org/Programs/Future Steel Vehicle.aspx
[3] https://www.ssab.com/en-us/brands-and-products/docol/applications/

80 YEARS
1945 - 2025

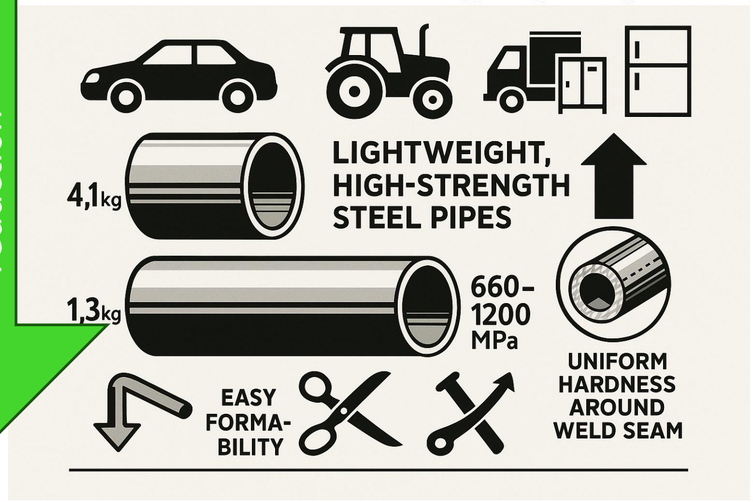
Background and Objectives

Tubular Products used in novel vehicles





Using CP & DP steels: reduced wall thickness, resulting in weight reduction



Sources:
[1] www.autosteel.org/Programs/Future Steel Vehicle.aspx
[2] https://automotive.arcelormittal.com/products/tubular

80 YEARS
1945 – 2025

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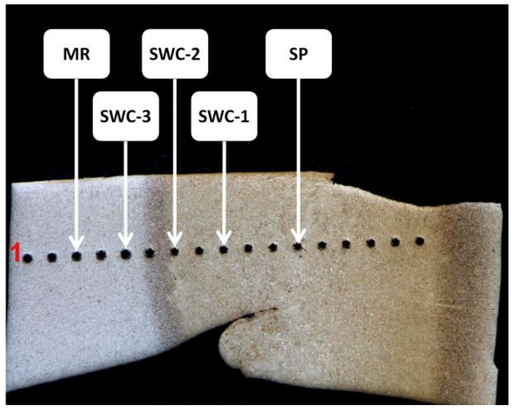
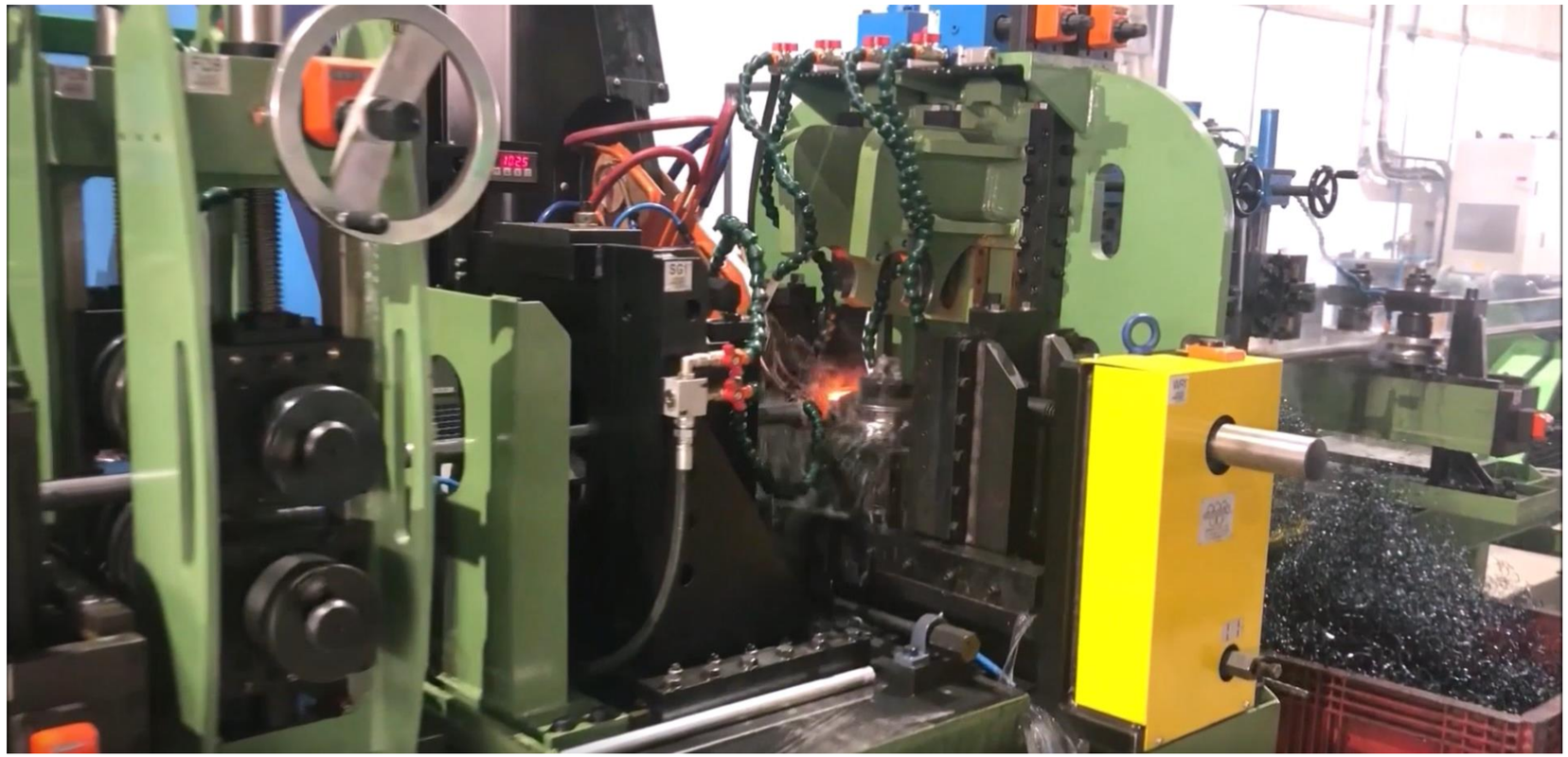
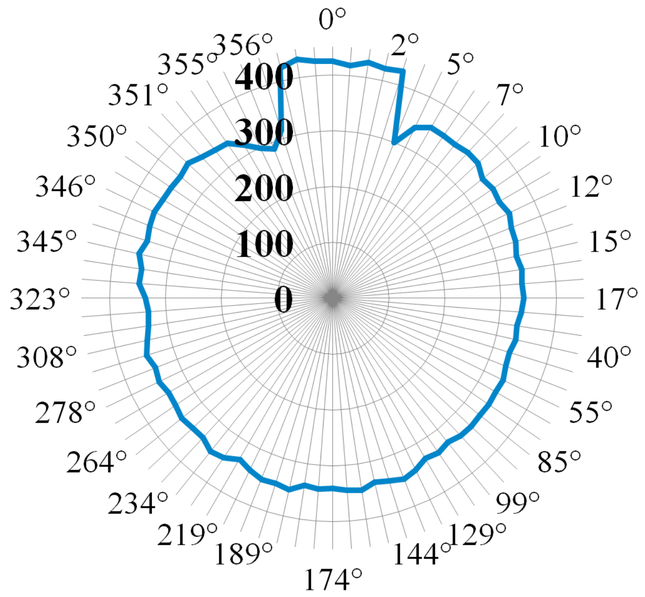
Background and Objectives





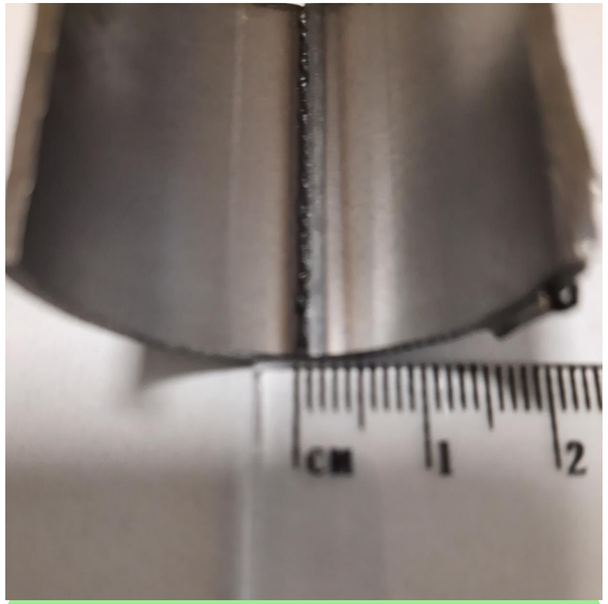


Hardness measurements (HV1) along the circumference of a welded DP steel pipe

The typical production line speed for welding pipes made of **mild steel without** heat treatment is around 100–120 m/min (up to 140 m/min). However, applying the same process to DP or CP steels results in structural and hardness gradients. Therefore, heat treatment is essential for pipes made of these advanced steels.

80 YEARS
1945 - 2025

Background and Objectives



Seamed pipe made from HCT980C type CP multiphase steel grade **without** heat treatment

Production of **multiphase steel** welding pipes **with** an additional **integrated heat treatment system** requires more time, and to achieve this with a limited production line length, it is necessary to slow down the line speed.

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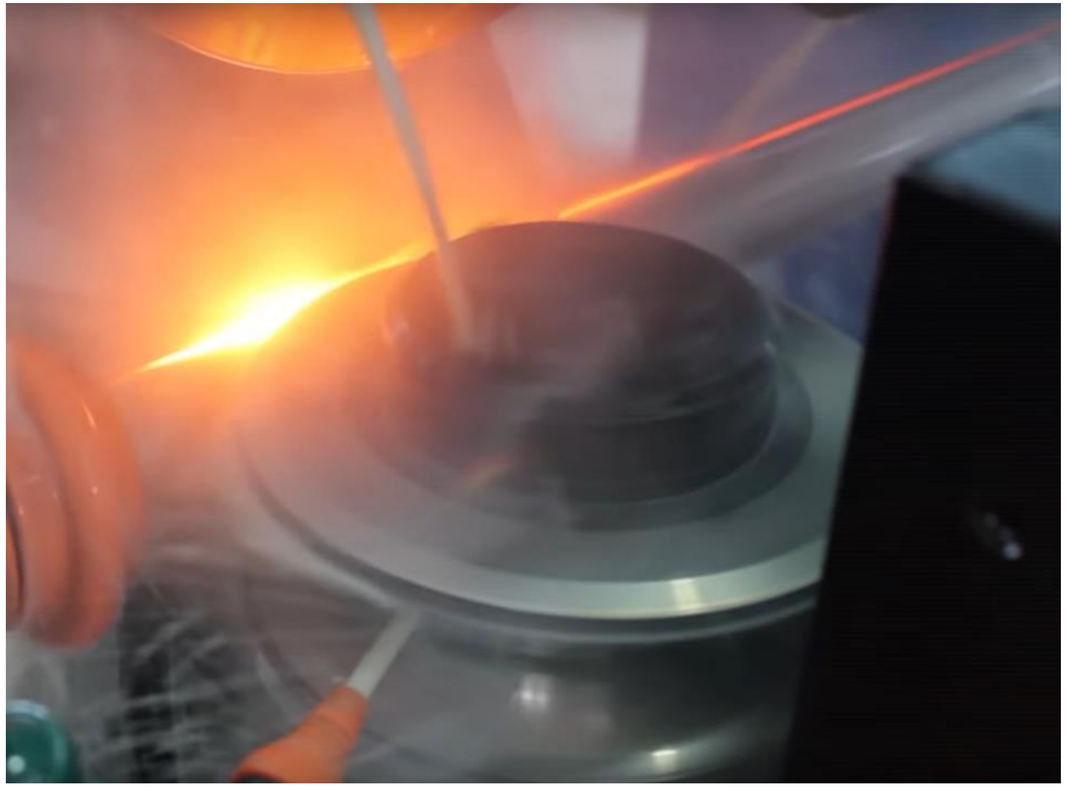
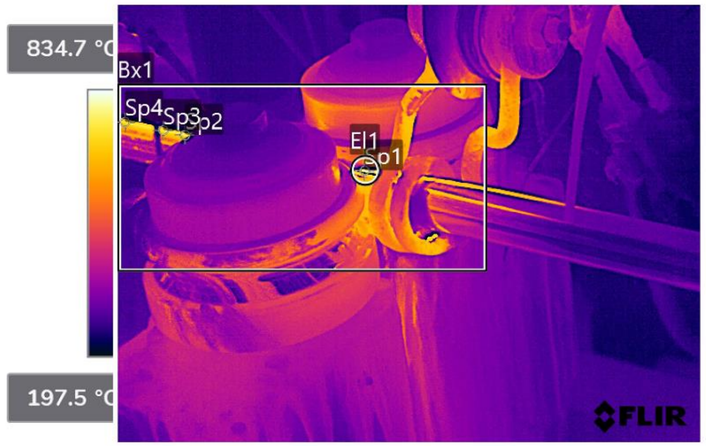
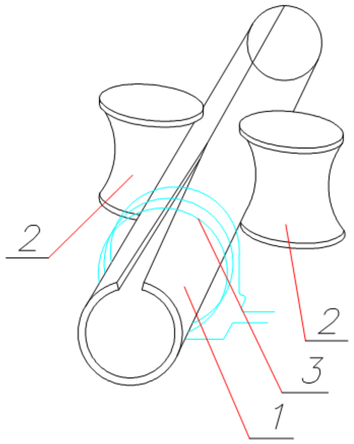
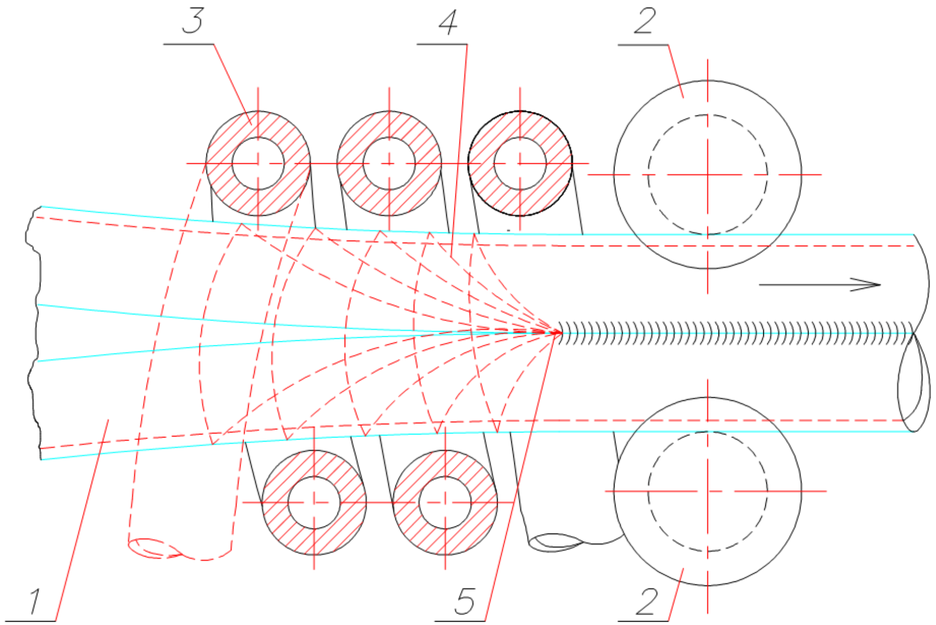
Background and Objectives







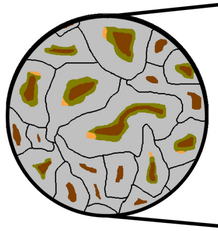


Assuming a slow line speed, one of the objectives of the project was to develop material characteristics that would enable the selection of **optimal welding parameters** for multiphase steel to achieve high-quality pipe welds.

80 YEARS
1945 - 2025

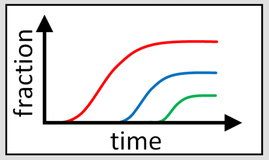
Project Scope and Approach

MF model
(MICROSTRUCTURE EVOLUTION & PHASE TRANSFORMATIONS)

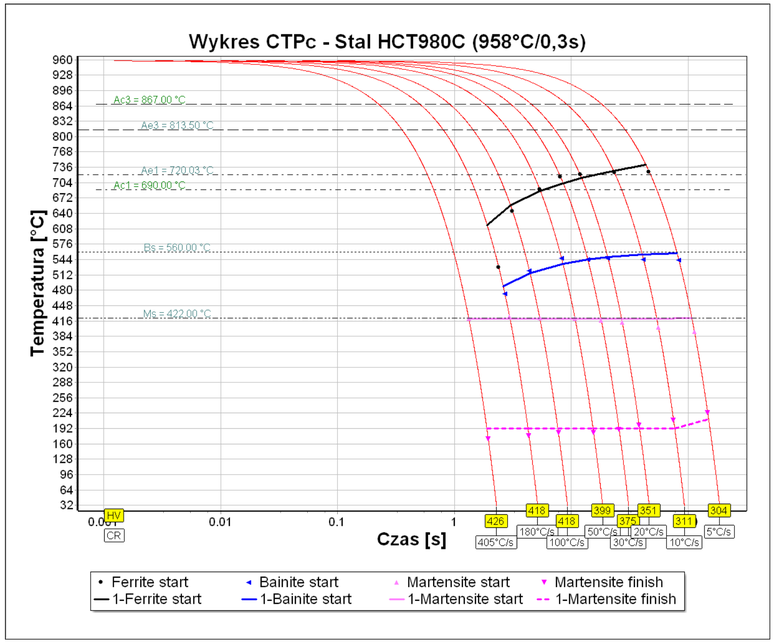


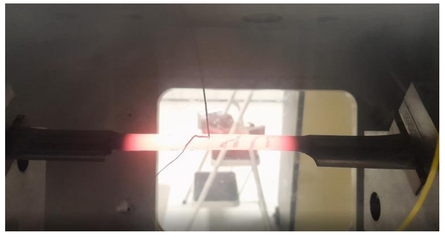
JMAK equation

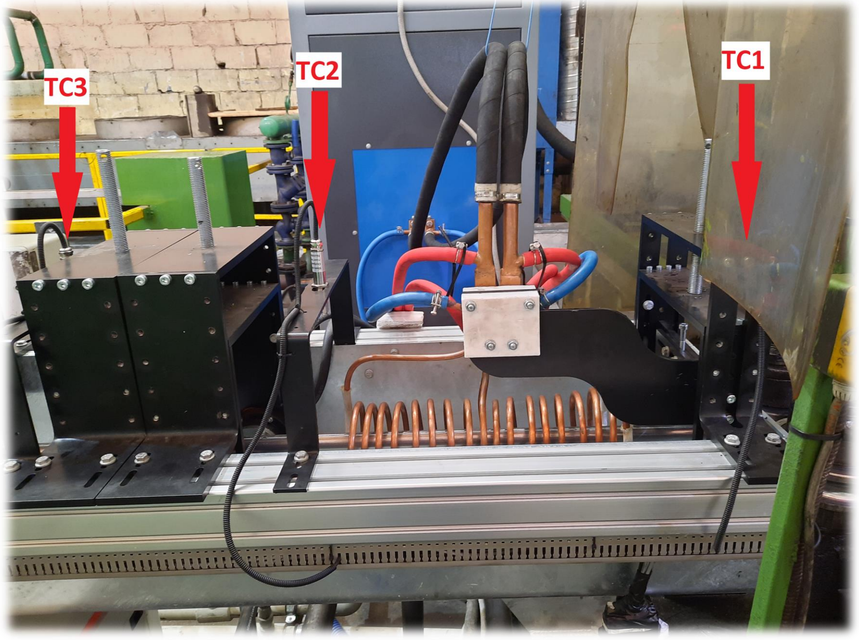
$$X = 1 - \exp(-kt^n)$$

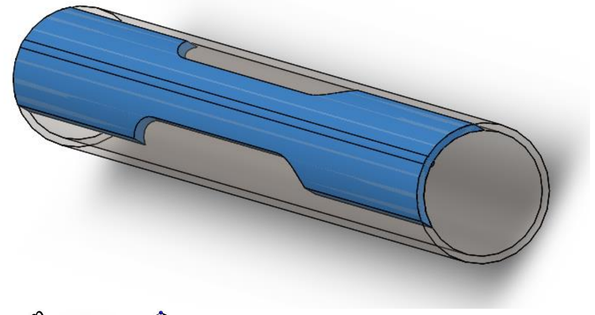


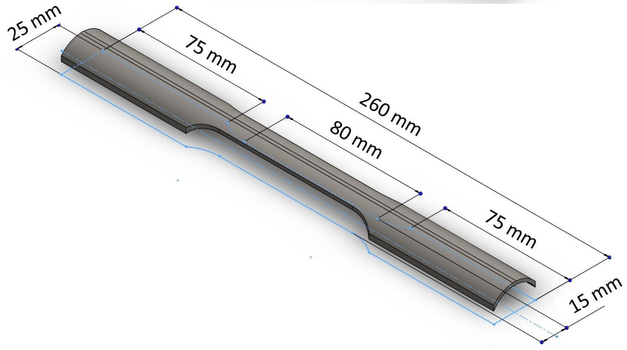
micro-scale





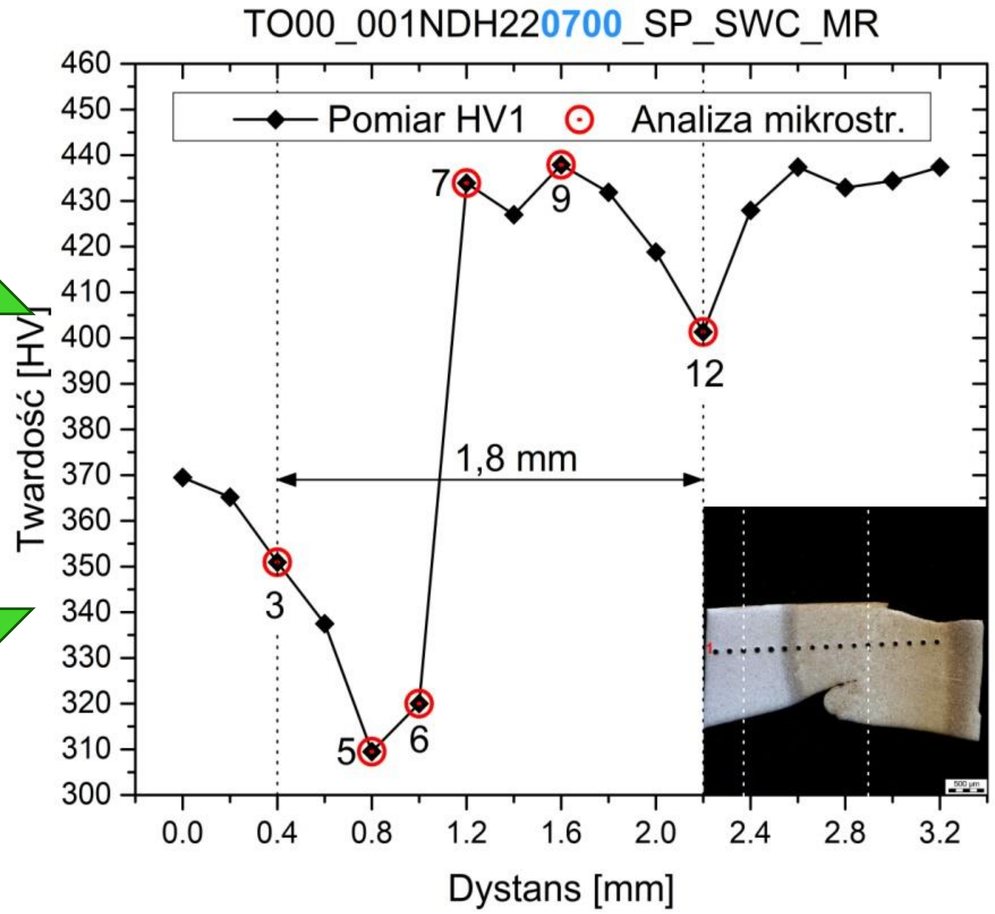


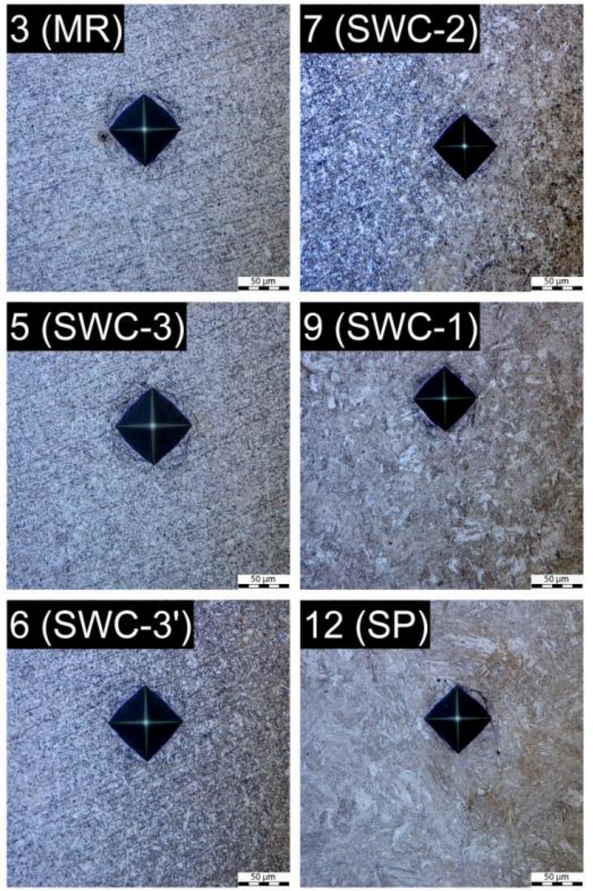


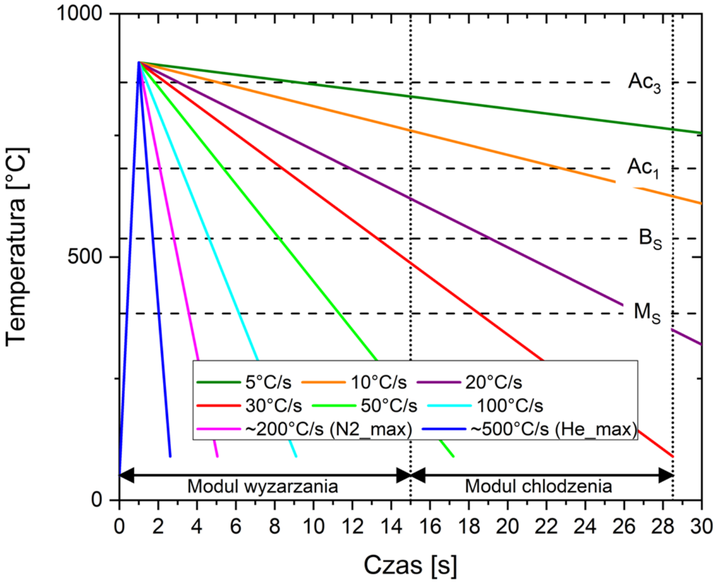


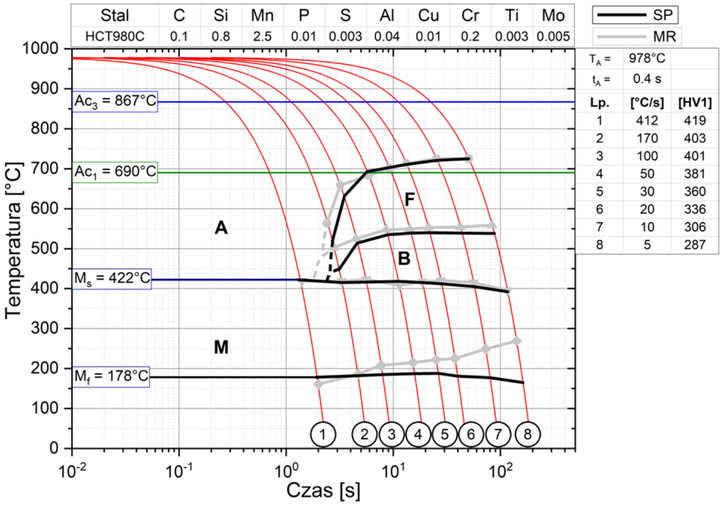
Project Scope and Approach

GOAL:
Hardness difference reduction <70HV



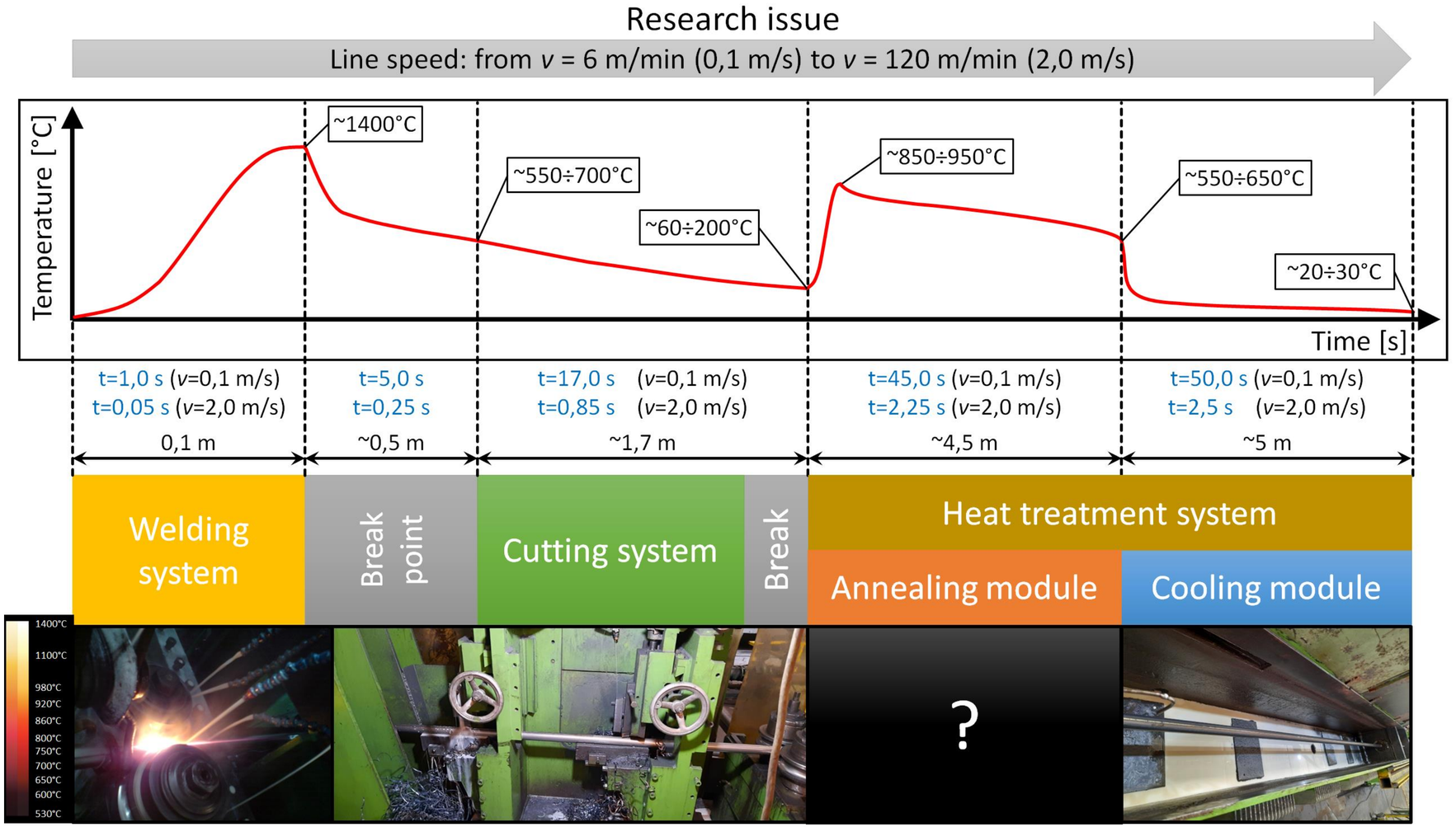






We faced several challenges: precise control of thermal cycles, ensuring hardness consistency across the weld zone, and designing a heat treatment system compact enough for integration in a production line.

HF-ERW & HT Processes Development



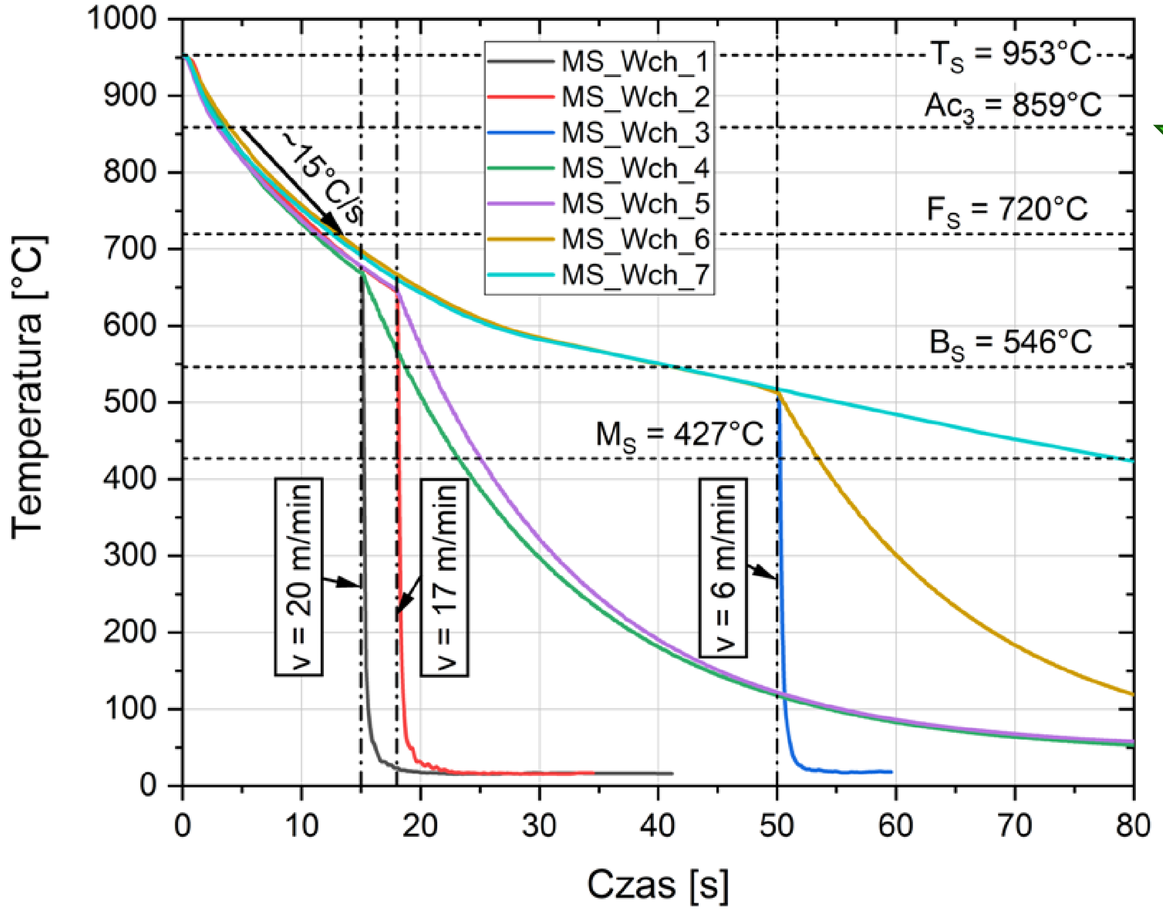
The core innovation was integrating high-frequency electric resistance welding with rapid induction heating and controlled cooling. This enabled us to shape the final microstructure directly in-line during pipe production.

HF-ERW & HT Processes Development

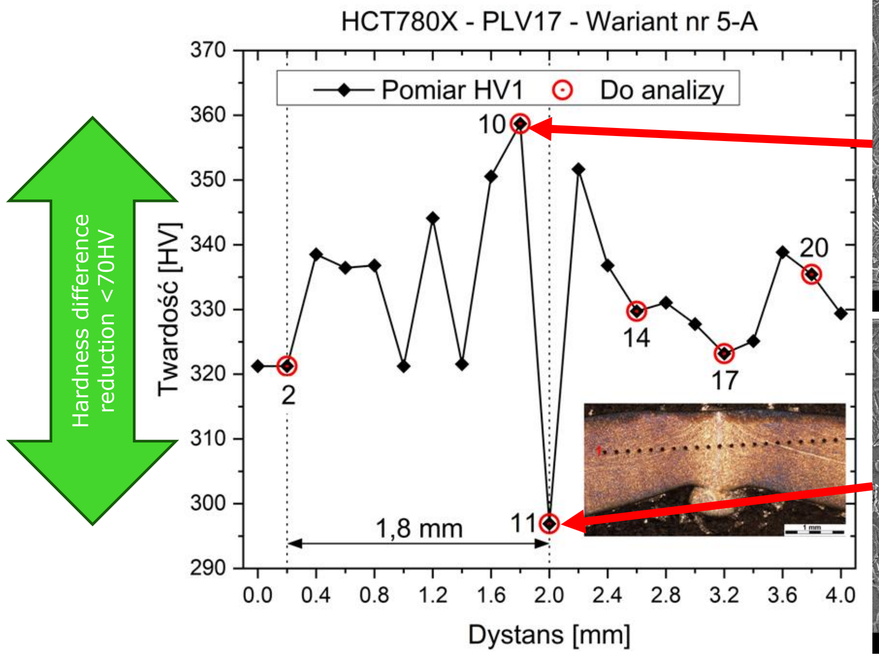
Line speed	v = 0.1 m/s (6 m/min)			
LSV6	Welding system	Cutting system + Break points	Heat treatment system	
			Annealing module	Cooling module
System length	~0.1 m	~2 m	4.5 m	5 m
System time	1 s	20 s	**45 s**	50 s
			95 s	
		115 s		
Overall process time	**116 s**			

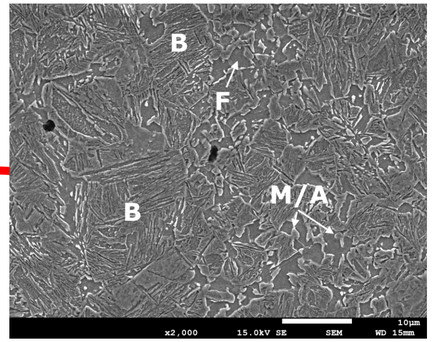
The optimized heat treatment cycle includes heating rates up to ~3000°C/s and cooling between 1 and 50°C/s. The pilot line was designed with a 9.5-meter module and supports production speeds from 6 to 20 meters per minute.

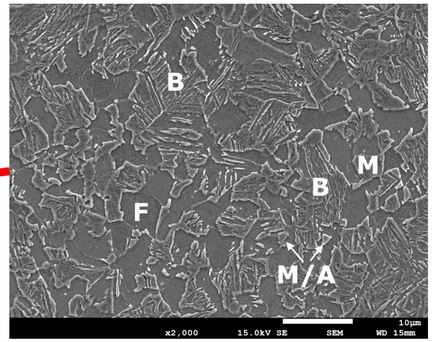
Technological Achievements

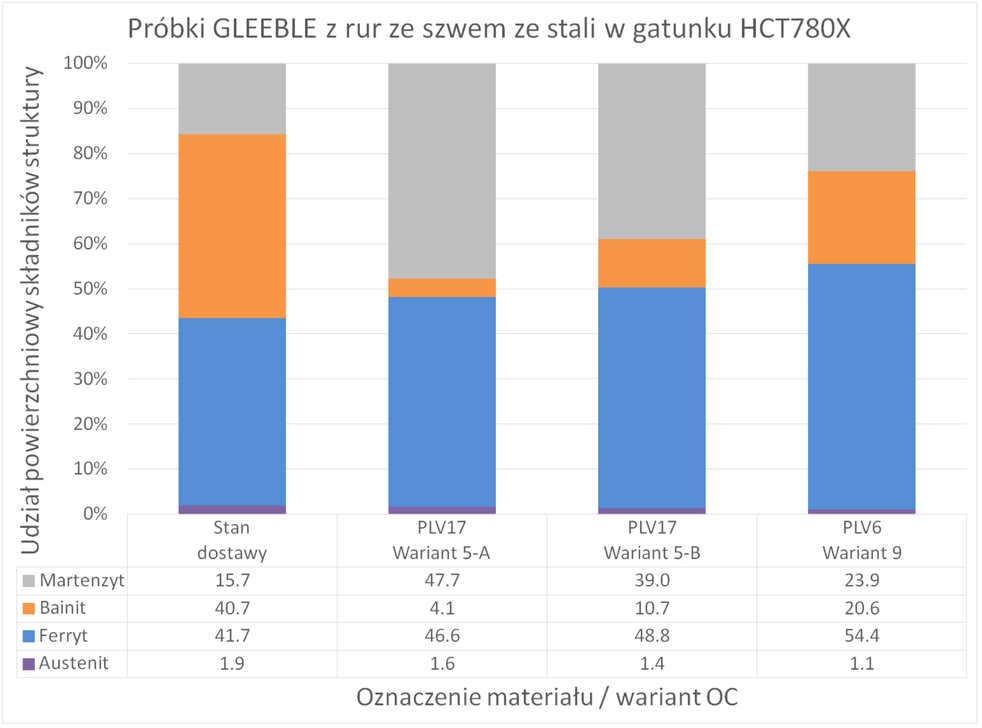


Hardness difference reduction < 70HV



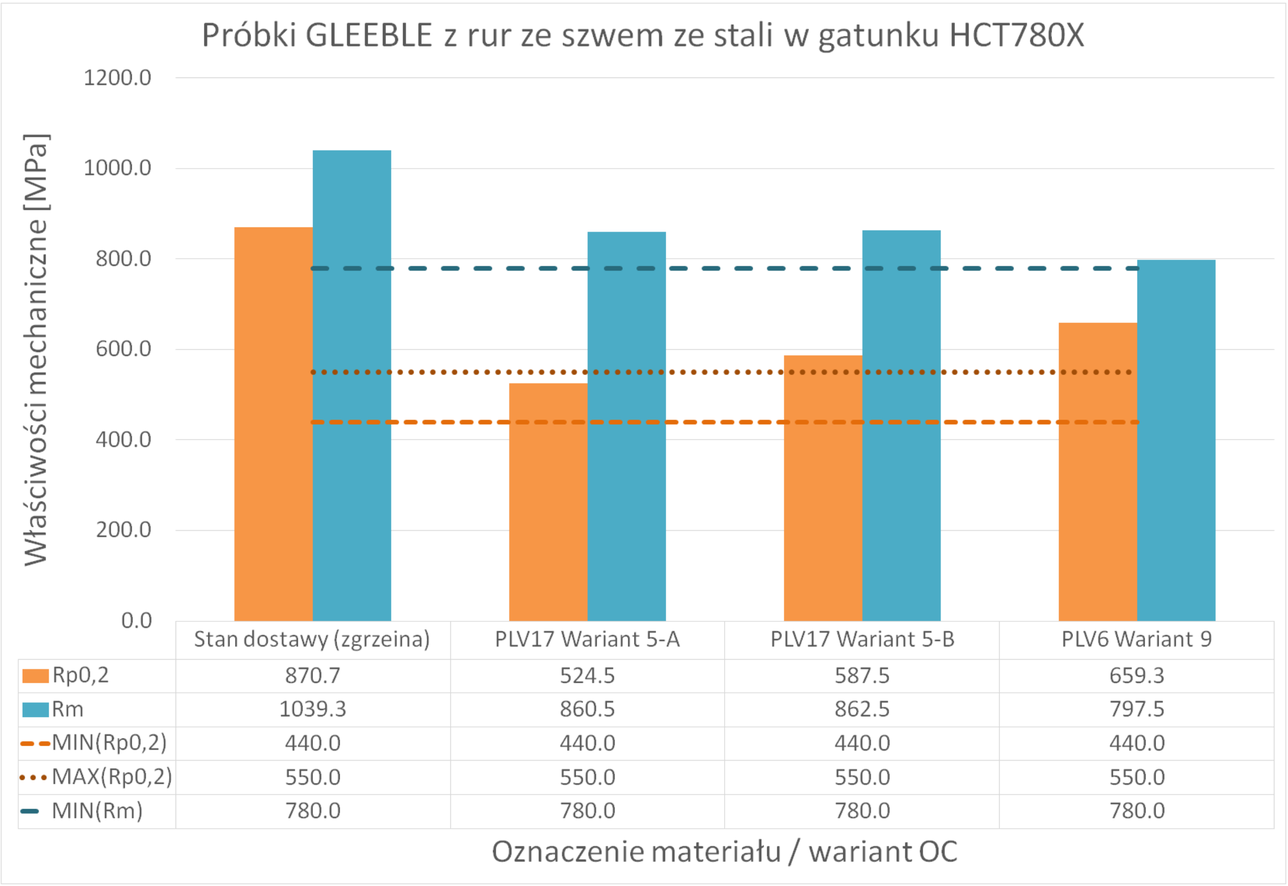


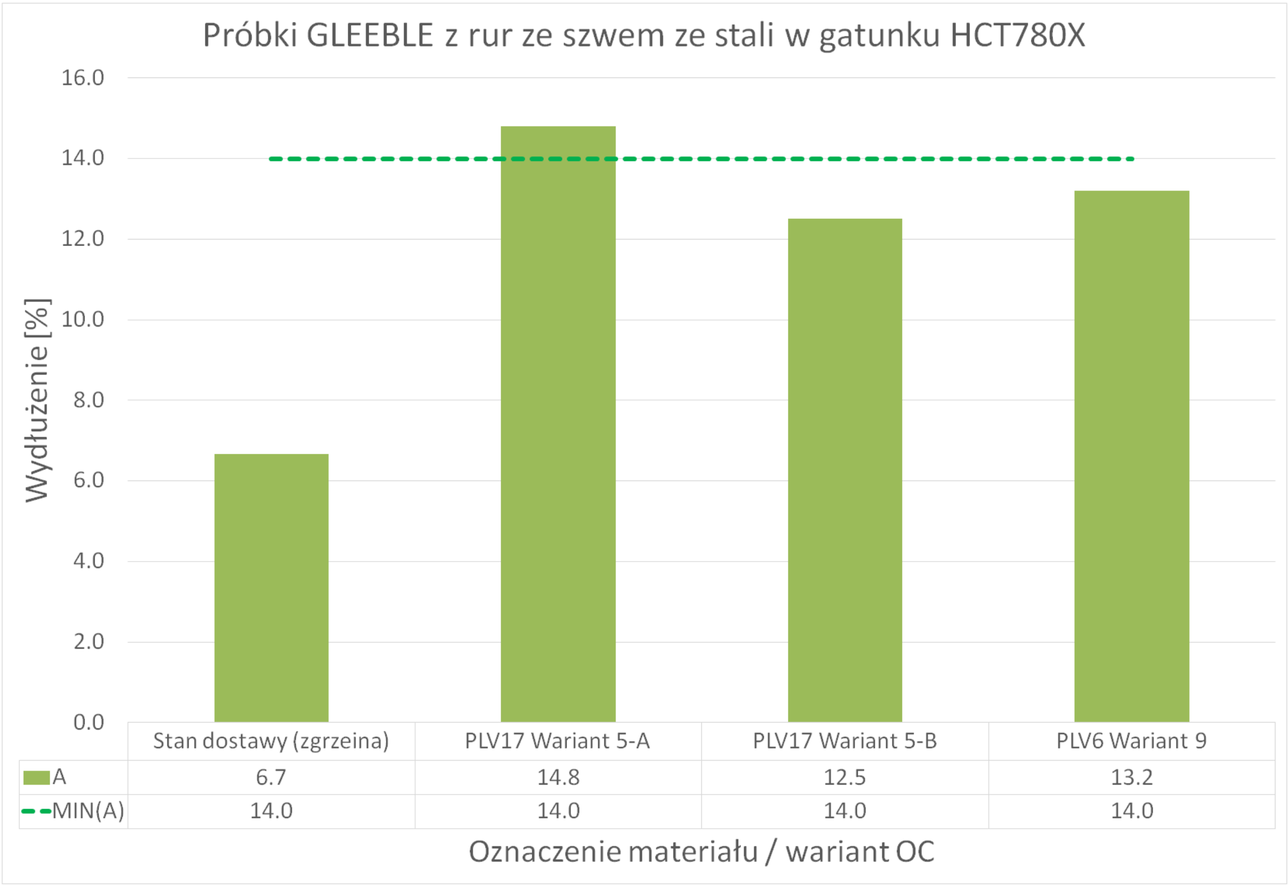




	Stan dostawy	PLV17 Wariant 5-A	PLV17 Wariant 5-B	PLV6 Wariant 9
Martenzyt	15.7	47.7	39.0	23.9
Bainit	40.7	4.1	10.7	20.6
Ferryt	41.7	46.6	48.8	54.4
Austenit	1.9	1.6	1.4	1.1

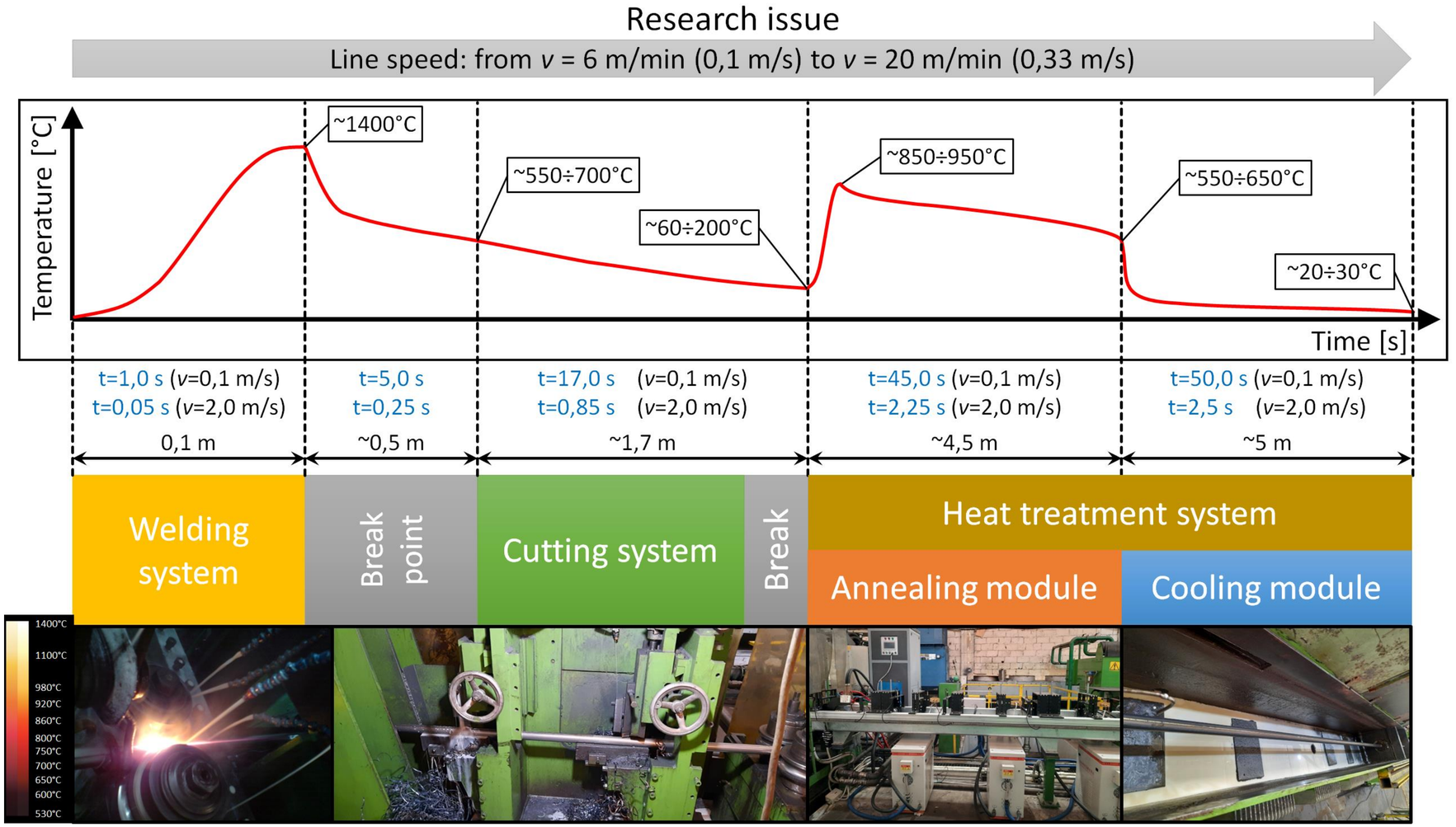
Technological Achievements





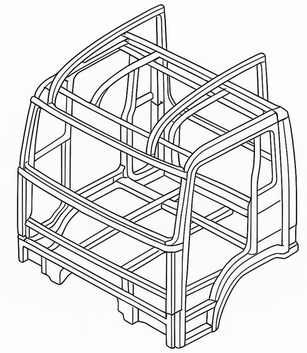
All six steel grades tested met target mechanical properties. For instance, HCT780X pipes achieved yield strength of 520–870 MPa and tensile strength above 790 MPa - suitable for demanding applications.

Industrial Readiness and Applications



A full pilot line was built and tested, demonstrating the process at scale. The setup is compact, efficient, and adaptable for use with multiple pipe dimensions and steel grades.

Industrial Readiness and Applications



These pipes are ready to support lightweight design in vehicles, construction elements, and appliances - delivering both performance and processing advantages such as easier cutting and forming.

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Conclusions and Outlook

- Innovative in-line HF-ERW + heat treatment process successfully developed
- Targeted properties achieved for all six CP and DP steel grades
- Pilot line built and validated under semi-industrial conditions
- Ready for industrial implementation in lightweight applications
- Potential for further scaling and adaptation to other steel grades

THANK YOU FOR YOUR ATTENTION

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