NEXT Competence Centre | Associated project: RECaSt | Master thesis

Microstructure-Property Correlation in Non-Homogeneous Duplex Stainless Steels to Advance Resource-Efficient Casting Technologies

Background

Duplex stainless steels (DSS) are a class of corrosion-resistant alloys characterized by a dual phase microstructure consisting of approximately equal proportions of austenite (γ, FCC) and ferrite (α, BCC). This dual-phase balance imparts a unique combination of high strength, toughness, and excellent resistance to localized corrosion, making DSS attractive for applications in aggressive environments such as chemical processing, oil and gas, and marine systems. Although mechanical properties of DSS are highly sensitive to microstructural features, such as phase balance and morphology, which are in turn governed by the solidification path and subsequent heat treatments, the microstructure-property correlation in as-cast steel remains highly unexplored.

In as-cast DSS, solidification typically favors a ferritic primary structure, followed by partial transformation to austenite upon cooling. The final γ/α phase balance, morphology, and distribution directly influence mechanical performance: ferrite contributes to high yield strength, while austenite enhances ductility and toughness. Furthermore, secondary phases such as sigma (σ) or chi (χ), which can precipitate during improper cooling or high-temperature exposure, embrittle the alloy and drastically impair corrosion resistance. At the moment, the traditional tools such as composition guidelines and heat treatment standards no longer meet the demands of energy efficiency and material conservation. Therefore, this project recognizes the need for a transition in steel casting and focuses on advancing cast steel technology to enable more durable and resource-efficient components through modernized design concepts and resource-efficient production.

Central to this initiative is microstructure-based design, rather than chemical composition design, relying on the structure–property correlation, a concept well-established in wrought materials but underexplored in cast steels. The project will focus on various typical microstructures in DSS and explores how they affect the underlying deformation mechanisms, by using lab-scale microstructural and mechanical properties characterization and potentially also by investigating phase fraction and stress partitioning using synchrotron large scale infrastructures through NEXT competence center.

Aims and objectives

This Master thesis project aims at developing microstructure-property correlation in as-cast and heat treated duplex stainless steels to reveal deformation micro-mechanisms in non-homogeneous structures. This is an extremely useful approach for designing as-cast components with improved durability as well as novel energy-efficient heat treatment procedures.

Project plan and timeline

The project includes heat treatment and characterization of cast DSS. The project requires microstructural characterization (SEM, EBSD) and mechanical testing (hardness, tensile test). This will be further complemented by using lab-scale and synchrotron XRD for phase analysis and stress partitioning. This is an excellent opportunity to gain hands-on experience with several material characterization techniques.

Activity	2025				
	Month 1	Month 2	Month 3	Month 4	Month 5
1. Literature survey and detailed plan					
2. Sample preparation					
3. Microstructural characterization					
4. Mechanical testing					
5. X-ray measurements					
6. Analysis					
7. Reporting					
8. Visits to foundries			*		

Starting date: January 2026 or as agreed.
Duration: 5 months
Location: KTH and visit/-s to partner/-s (Österby Gjuteri AB and TRATON SE)
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