PhD Offer

Texture developement during bainitc transformatin under stress in pipeline steel

Duration : 36 months

Type of contract : CIFRE

Start date: October 2025

Workplace: Vallourec / Laboratoire Institut Jean Lamour Nancy

Proportion of work: Full time

Desired level of education : Master's degree in mechanical engr., physics or materials science

Context

Vallourec provides premium tubular solutions for the energy sectors, including oil and gas, as well as emerging energy fields such as geothermal, hydrogen, and carbon capture, utilization, and storage (CCUS) technologies. With 15,000 employees across 20 countries, Vallourec combines a global reach with a strong local presence to meet the needs of its clients.

In line pipe applications, microalloyed low-carbon steels are essential due to their high strength, improved toughness and weldability. As the industry shifts towards larger diameter pipelines and higher operating pressures, there is an increasing demand for stronger steel grades like X70 and X80. These higher strength steels enable thinner walls, resulting in lower material and transportation costs. However, achieving the required toughness in these steels remains a challenge.

A key factor affecting toughness is the bainitic microstructure formed during the cooling process. The stress induced by thermal gradients in the pipeline wall during quenching may affect the bainitic transformation and the resulting texture, which in turn impacts the steel's performance. Understanding this interaction is important for designing steels with superior properties.

Objective

This PhD project aims to explore the complex interplay between bainitic transformation and the stress generated by thermal gradients during cooling. The goal is to understand how the generated stress affects the bainitic transformation and the variant selection, and how these factors can affect the steel's toughness. Ultimately, the project aims to support the development of next-generation pipeline steels with superior performance.

Research Plan

The research plan for this PhD project focuses on understanding the interaction between stress and microstructural evolution during the cooling of high-strength steels. Advanced experimental techniques will be used, including dilatometry to monitor transformation kinetics during complex thermo-mechanical treatments and high-energy X-ray diffraction (HEXRD) to quantify phase fractions in real-time. Electron Backscatter Diffraction (EBSD) will be used to analyze the bainitic microstructure and variant selection under applied stress.

The study will investigate two scenarios: the effect of stress or strain on bainitic transformation under isothermal conditions, where temperature remains constant, allowing the isolation of stress and strain effects on the transformation process. Second, the effect of stress and strain during non-isothermal cooling, where varying cooling rates introduce more complex conditions that better reflect industrial processes. These results will be compared with real-world pipeline quenching, considering through-thickness variations in cooling rates.

The experimental results obtained during this PhD project will be validated and compared with modeling predictions. The kinetics of the bainitic transformation will be assessed against classical diffusional models available in the literature. Additionally, the final texture and variant selection observed in the bainitic microstructure will be analyzed using a newly developed model that uses cellular automaton simulations to predict bainite variant selection. This integration of experimental and modeling approaches will offer a comprehensive understanding of the transformation mechanisms and their impact on material properties, bridging theoretical predictions with practical outcomes.

Your Tasks

- Conduct advanced experimental research to explore the interplay between bainitic transformations, thermal gradients, and stress in high-strength steels.
- Use advanced techniques such as dilatometry, high-energy X-ray diffraction (HEXRD), and electron backscatter diffraction (EBSD) to analyze microstructural evolution.
- Design and execute thermo-mechanical experiments using dilatometry to simulate industrial cooling and quenching conditions.
- Perform real-time phase quantification during transformations using high-energy X-ray diffraction.
- Conduct detailed microstructural and texture analysis using EBSD to assess variant selection and its correlation with stress.
- Develop and refine experimental protocols to replicate industrial thermal and mechanical stresses.
- Analyze data to establish a position-dependent profile of microstructural evolution across pipeline wall thicknesses.
- Compare experimental results with classical diffusional models to evaluate the kinetics of bainitic transformation.
- Collaborate with Vallourec’s research team to translate experimental findings into practical recommendations for steel production.
- Document and publish research findings in scientific journals and present results at conferences.

Your Profile

- A Master’s degree in materials science, metallurgy, mechanical engineering, or a related field.

- Strong interest in phase transformations, microstructural analysis, and materials characterization.
- Familiarity with thermo-mechanical treatments and their impact on material properties is preferred.
- Ability to think critically and solve complex problems independently, while also being a collaborative team player.
- Strong computational and problem-solving skills.

About Institut Jean Lamour

The Institute Jean Lamour (IJL) is a joint research unit of CNRS and Université de Lorraine. Focused on materials and processes science and engineering, it covers: materials, metallurgy, plasmas, surfaces, nanomaterials and electronics. It regroups 183 researchers/lecturers, 91 engineers/technicians/administrative staff, 150 doctoral students and 25 post-doctoral fellows. Partnerships exist with 150 companies and our research groups collaborate with more than 30 countries throughout the world. Its exceptional instrumental platforms are spread over 4 sites; the main one is located on Artem campus in Nancy.

To apply

For those interested, please send detailed CV and motivation letter to :

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