Seminar

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Institute for Plasma Research

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Title: High strength and ductile mixed phase steels from Modified 9Cr-1Mo steel with enhanced wear and corrosion resistance

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Date: 12^{th} July 2024 (Friday)

Time: 03:30 PM

Venue: Seminar Hall, IPR

Abstract

During my Ph.D. research, I focused on the enhancement of mechanical and corrosion properties of modified 9Cr-1Mo steel, which is a critical material for high-temperature applications in power plants and other industrial sectors. The motivation for this work stems from the growing demand for materials that can withstand extreme conditions while maintaining structural integrity and longevity. Previous studies have highlighted the potential of heat treatment processes in improving the microstructure and mechanical properties of steels. However, there is limited research on optimizing these processes for modified 9Cr-1Mo steel, particularly through austempering at varying temperatures. By leveraging advanced microscopy techniques and mechanical testing, my research bridges this gap, offering new insights into the role of smart heat treatment in achieving a superior combination of strength, ductility, wear resistance, and corrosion resistance. This work not only contributes to the existing body of literature but also provides practical solutions for enhancing the performance of materials used in demanding environments.

In the first study, we explored the enhancement of mechanical properties by tuning the process parameters of modified 9Cr–1Mo steel. By transforming its microstructure into bainitic form at isothermal temperatures of 460 °C for varying durations post-austenitization at 1000 °C for an hour, we produced two sets of austempered samples. One set was water quenched (Set-I), and the other air-cooled (Set-II). The microstructural characterization was performed using optical and scanning electron microscopy (SEM). The Vickers hardness and tensile strength of the heat-treated samples showed a dramatic increase compared to the as-received tempered martensitic steel, achieving an excellent combination of strength and ductility.

Further investigations aimed to enhance the mechanical properties of modified 9Cr-1Mo steel by preparing two sets of samples (Set-III and Set-IV), austempered at 460°C and 480°C respectively, followed by water quenching. Subsequent tempering at 760°C for varying durations revealed significant impacts on the microstructure and mechanical properties. The study demonstrated that an austempering temperature of 460°C resulted in superior mechanical properties, including improved ductility, tensile toughness, and hardness.

We also characterized the wear properties of the dual-phase (bainitic and martensitic) steel developed through smart heat treatment. Group-I (Set-I and Set-II samples) and Group-II (Set-

III and Set-IV samples) were analyzed, with Group-II exhibiting superior wear resistance. The wear performance was significantly better than the as-received sample, highlighting the correlation between heat treatment, precipitated carbides, applied load, and wear properties.

The corrosion properties of the dual-phase steel were evaluated, showing that samples from Group-I and Group-II had better corrosion resistance than the as-received sample. Notably, Group-II samples austempered at lower temperatures (460°C) displayed lower corrosion rates, with the corrosion morphology indicating lesser attack compared to higher austempering temperatures (480°C).

These findings underline the potential of smart heat treatment techniques in significantly enhancing the mechanical and corrosion properties of modified 9Cr-1Mo steel, making it suitable for various high-temperature-performance applications.