STUDY OF INTERGRANULAR CORROSION IN AUSTENITIC STEELS

Atakhonova Sayyora Koraboyevna

Associate Professor, Andijan State Technical Institute

Email: ataxonova.sayyora@mail.ru

Kholdarova Maftuna Rustamjon qizi

Master's Student, 1st Year, Andijan State Technical Institute

Annotation: Intergranular corrosion of austenitic steels depends on their chemical composition, heat treatment processes, and operating conditions. This type of corrosion occurs due to the interaction of chromium and carbon in the steel, leading to the accumulation of chromium carbides at grain boundaries. As a result, the regions surrounding the grains become depleted of chromium, making them more susceptible to corrosion. This process negatively affects the mechanical properties of the steel, reducing its strength. To minimize intergranular corrosion, it is recommended to add stabilizing elements, optimize heat treatment, and apply electrochemical protection methods.

Keywords: Austenitic steel, intergranular corrosion, chromium carbide, heat treatment, electrochemical protection, chromium depletion, steel strength, mechanical properties, chemical composition, operating conditions, corrosion, steel degradation, metallurgy, protective coatings, stabilizing elements, high-temperature effects, corrosion resistance, chromium-carbon interaction, grain boundaries, industrial materials.

1. Introduction

Austenitic steels are widely used in various industries due to their high mechanical strength, corrosion resistance, and thermal stability. However, their susceptibility to intergranular corrosion during operation remains a significant issue. Intergranular corrosion primarily occurs when chromium and carbon in the steel interact, leading to the precipitation of chromium carbides at grain boundaries. This process depletes the grain boundaries of chromium, making the material more vulnerable to corrosion[4]. Consequently, the mechanical properties of the steel deteriorate, reducing its durability and service life. This problem is particularly severe in chemically aggressive environments and at high temperatures. To mitigate intergranular corrosion, the addition of stabilizing elements, optimal heat treatment, and electrochemical protection methods are effective solutions. This study focuses on examining the mechanism of intergranular corrosion in austenitic steels, exploring preventive measures, and analyzing the impact of this process on the steel's operational properties[5].

2. Research and Analysis

To study the intergranular corrosion of austenitic steels, experimental and analytical methods were used. The corrosion formation mechanism, contributing factors, and prevention methods were analyzed. Steel samples underwent heat treatment at high temperatures, and their corrosion resistance in different environments was tested. It was found that the accumulation of chromium carbides at grain boundaries leads to chromium depletion, accelerating the corrosion process. Electrochemical analysis methods were employed to study the corrosion rate and electrochemical properties of the steel[6].

The results showed that the addition of stabilizing elements, such as titanium and niobium, prevents chromium carbide formation and reduces the risk of intergranular corrosion. Additionally, optimal heat treatment conditions were identified, with rapid cooling from 1050–1100°C significantly improving corrosion resistance. The findings indicate that minimizing intergranular corrosion requires the use of stabilized steels and carefully controlled heat treatment processes. This approach enhances the service life and operational performance of austenitic steels[7].

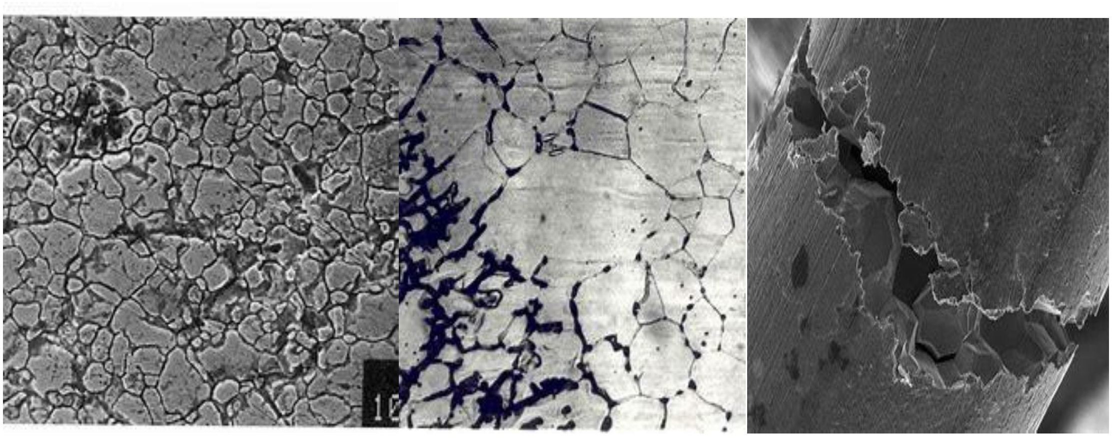

Figure 1. Intergranular corrosion in austenitic steels

3. Results and Discussion

The study results confirm that intergranular corrosion in austenitic steels mainly occurs due to the accumulation of chromium carbides at grain boundaries. This phenomenon significantly reduces the corrosion resistance and negatively affects the mechanical properties of the steel. The research demonstrated that adding stabilizing elements, such as titanium and niobium, effectively reduces corrosion risks. Furthermore, optimal heat treatment—rapid cooling from 1050–1100°C—was identified as an efficient method to prevent chromium depletion at grain boundaries. Electrochemical analysis also indicated that enhancing the steel's passivation capability improves its corrosion resistance[8].

Table 1

Intergranular Corrosion of Austenitic Steels

Factor	Effect	Prevention Method
Carbide	Forms corrosion sites at grain	Optimal heat treatment and

precipitation	boundaries	addition of alloying elements
Heat treatment temperature	Increases intergranular corrosion at 550–850°C	Controlled thermal processing
Chemical composition	High carbon content increases corrosion susceptibility	Use of low-carbon or stabilized steel
Aggressive environment	High humidity and chloride ions accelerate corrosion	Application of protective coatings and inhibitors
Service life	Corrosion leads to material degradation over time	Regular maintenance and monitoring

4. Conclusion

Intergranular corrosion of austenitic steels can be a significant issue depending on their operating conditions. This study examined the causes of corrosion, its impact on the metal's microstructure, and preventive measures. The results indicate that carbide precipitation at grain boundaries increases susceptibility to corrosion. This process can be controlled through heat treatment and the addition of alloying elements. Furthermore, optimizing the chemical composition and heat treatment improves corrosion resistance. The findings contribute to extending the service life of austenitic steels in industrial applications and preventing corrosion-related degradation.

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