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Editorial

The Importance of Structure and Corrosion Resistance of Steels/Alloys

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Steels/alloys are widely used in various aspects of human society, such as transportation and construction, machinery manufacturing, oil, chemical, petrochemical, marine, and nuclear power industries, etc., due to their outstanding properties and processing performances. They have become the necessary materials for the development of modern society. Steels/alloys have played an important role in scientific and technological progress, economic development, and living quality improvement. With the development of society and technology, more strength and toughness, corrosion resistance, and green fabrication steels/alloys are one of the most important research topics and developing directions of high-performance metallic materials.

Most steels/alloys are exposed to natural environments such as atmosphere, soil, and ocean, or artificial environments of high pressure and temperature, acid and alkali, and fluid. They suffer static, impact, vibrating, or periodic cycle loads, and moreover, they easily lose extranuclear electrons and corrode in some environments. Therefore, mechanical properties, including strength, ductility, toughness, and corrosion resistance, including localized corrosions and general corrosions, are the two most important properties of steels/alloys. Alloying is one of the most effective strategies for strengthening, toughening, and improving corrosion resistance because the structure or microstructures of metals are optimized and modified during alloying.

The structures or microstructures of steels/alloys bear loads directly; therefore, the type, morphology, size, amount, distribution, and internal defects depend on the composition and processing of steels/alloys that affect the mechanical properties and corrosion resistance inevitably. The optimization of structures and microstructures is the modification of the above characteristics based on steels/alloys' high performance. The dual-phase (DP) or multiple-phase (MP) structures with high strength and toughness simultaneously can be obtained by the regulation of the type of microstructures, for example, high-entropy dual-phase alloys [1], ferrite–martensite dual-phase steel [2], ferrite–austenite stainless steel [3,4] and ferrite–martensite–austenite complex phases steel [5], etc. High strength and ductility are also achieved by the modification of the size and morphology of microstructures. Gradient nano-grained alloys [6], heterogeneous lamella structure metals [7], ultra-fine grained steels [8,9], and bimodal grains alloys [10], etc., possess different sizes and morphological grains or structures that present with excellent high strength and ductility. The number and distribution of phases are also the main factors for the mechanical properties of steels/alloys [11]. For instance, the content and distribution of retained austenite in transformation-induced plasticity (TRIP) or quenching and partitioning (Q&P) steels affect the ductility and toughness of steels directly [12]. Moreover, the amount of precipitates is one of the most important factors for the strengthening of precipitated strengthening steels/alloys [13,14], such as the outstanding strength and ductility that have been achieved simultaneously in maraging steels steel by high-density nanoprecipitation with minimal lattice misfit [15]. In addition to the above strategies of microstructural modification, the optimal design of defects in structures, such as dislocations density, lattice distortion, solid solution atomic concentration, etc., is another significant method of improving the mechanical properties too. For instance, high dislocation density brought about the large ductility and high strength combination in deformed and partitioned steels [16]. The strength and ductility are enhanced simultaneously in high-entropy alloys via ordered interstitial oxygen complexes [17]. Recently, some works verified that composition undulation and chemical short-range ordering could lead to high strength with good ductility in alloys [18–20].

Corrosion resistance is another very important property of steels/alloys during their service life. The importance of corrosion resistance is more and more remarkable with the demand for low carbon emissions and environmental protection. The improvement of corrosion resistance not only prolongs the service life and reduces the full-cycle costs of steels/alloys but can also save energy, decrease consumption, and protect the environment. The thermodynamics and dynamics of corrosion should be considered when we carry out research on the corrosion of steels/alloys. The two aspects are both related to the alloying process and will be inevitably combined with structures or microstructures. The addition of Ni and Cu into an Fe matrix forming Fe–Ni and Fe–Cu solid solution alloys will increase corrosion potential and improve corrosion resistance; this belongs to the thermodynamics strategy. However, the dynamics strategy, forming passive films on the surface of steels/alloys, is a more effective and practical method of improving corrosion resistance due to its low cost, convenient production, and is not or less harmful to the mechanical properties. For example, widely used weathering steels, in which Cu, P, Cr, Ni, and Si are added as alloying elements present with good resistance to atmospheric corrosion owing to their formation in low, aggressive atmospheres of the compact and well-adhering corrosion product layer (rusting coat), known as patina [21,22]. Nevertheless, this rusting coat will not be protective in environments with high atmospheric salinity or acid-harsh corrosive environments, especially those containing Cl^- [22]. In these conditions, for obtaining good corrosion resistance, thin, dense, and stable passive films on the surface of steels/alloys are needed to form by adding enough Cr, Ni, etc., elements to satisfy the criterion of the n/8 (Tammann) law, such as popular stainless steels with over 13 wt% Cr content, which possess excellent resistance to acid and alkali corrosion. Although more and more high-corrosion-resistant steels/alloys are being researched and developed, there are lots of explorative works that are needed for the development of metals. For example, how to enhance the strength and ductility and corrosion resistance of steels/alloys simultaneously? Most strengthening methods will degrade corrosion resistance generally; for instance, conventional, precipitated strengthening can bring massive high-energy phase boundaries, which can easily induce the localized corrosion of steels/alloys.

To sum up, structure and corrosion resistance are very important for steels/alloys, which are necessary pillars for the development of industries and technology. Moreover, there is a relationship between them; corrosion resistance also depends on the structure to some extent. In order to develop and create higher-performance metallic materials, the structure and corrosion resistance of steels/alloys should be given more attention. It is time to generate more work and effort on the research of structure and corrosion resistance. This Special Issue will provide a platform for communication about these topics.

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