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Editorial

Microstructure, Fatigue, Wear Properties of Steels

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Citation: Long, X.; Zhang, Y.; Liu, W.; Zhang, Z.; Zhu, R. Microstructure, Fatigue, Wear Properties of Steels. *Coatings* **2022**, *12*, 1818. https://doi.org/10.3390/coatings12121818

Received: 23 November 2022
Accepted: 24 November 2022
Published: 25 November 2022

Green manufacturing is a hot topic in the manufacturing industry. Steel manufacturing produces carbon emissions; to achieve "green steel", it is a reasonable means to improve the service performance of steel and reduce production time. Microstructure regulation has proven effective at realizing a high service life of steel. From the perspective of bainitic steel, it accelerates bainite transformation, improves comprehensive properties, and possesses excellent service properties, including wear and fatigue properties.

Presently, it is an important way to provide an effective nucleation interface or location to accelerate bainite transformation [1–3]. It is feasible to form pre-ferrite, pre-martensite and pre-second-phase particles. The study [4] illustrates that the control of heat treatment in the high-temperature zone will form ferrite at the austenite grain boundary. This step accelerates the formation kinetics of bainite, which is mainly due to the increase in the density of bainite nucleation points. The bainite ferrite can be nucleated at the austenite/austenite interface at the initial nucleation point, or at the austenite/ferrite interface at the secondary nucleation point [5]. However, some literature reports that the formation of some ferrites will increase the carbon content in the remaining austenite, which may prolong the transformation time. This is also the contradiction of current research [6]. Quidor et al. [7] believe that when the proportion of ferrite is small, the carbon distribution has no significant effect on the reduction of driving force for bainite formation. One of the strategies for high bainite formation rate is to form part of martensite before bainite formation. Kawata et al. [8] found that the bainite transformation of austenite martensite duplex structure is faster than that of single-phase austenite in Fe-0.2C-8Ni alloy pre-forming martensite, and they believed that the acceleration of bainite transformation is caused by the increase in nucleation position at the martensite/austenite interface. It is speculated that the dislocation released into austenite through martensite transformation is helpful for bainite nucleation. Gong and Smanio et al. [9,10] believed that the introduction of a small amount of martensite volume fraction can accelerate the transformation of bainite. At the same time, the bainite lath shows almost the same orientation as the adjacent existing martensite plates. The dislocations introduced in austenite are the companion variant selection of auxiliary bainite transformation, and the bainite nucleation point increases [9]. The researchers also analyzed the crystal characteristics of pre-martensite and bainite [11]. The precipitation of the second phase is also one of the methods used to effectively increase the nucleation interface. Taking alloy element V as an example, it is a strong carbonitride-forming element. Adding V in the continuous cooling process can broaden the bainite transformation zone [12]. Bainitic ferrite can nucleate at the position with low carbon concentration near the VC/austenite interface. Due to the different thermal expansion coefficients of VC and austenite, the strain field and dislocation field are generated, which reduces the barrier to bainite ferrite nucleation [13]. Ravi et al. [14] have shown that the nucleation ability of bainite is affected by the interface energy between precipitates and matrix. Before isothermal treatment of bainite, small VC particles accelerate the initial transformation and shorten the incubation period [15]. These research methods accelerate the transformation, but also affect the microstructure. This is one of the research directions.

The change in microstructure will affect the properties of steel. In bainitic steel, the quantity, morphology and size of bainitic ferrite and retained austenite affect the wear and fatigue. Research shows that the wear rate increases at a higher transformation temperature and retains austenite content [16]. For the microstructure with higher stability of retained austenite, the improvement of toughness and TRIP effect are conducive to improving the wear resistance of materials [17]. Chang et al. [18] found that carbide-free bainitic steel has excellent wear resistance, because plastic deformation induced by deformation can effectively improve the material plasticity and further improve the wear resistance. Many studies have shown that high-carbon, low-temperature carbide-free bainite steel has high wear resistance and is closely related to the bainite transformation temperature [19,20]. Microstructure also plays an important role in fatigue testing. Shendy et al. [21] found that thinner bainite ferrite thickness, higher carbon content of retained austenite, larger volume fraction of bainite ferrite content and lower volume fraction of massive retained austenite can improve the fatigue strength of materials. It was also found that in the interior of retained austenite, due to its lower carbon content and stability, shear strain and secondary cracks are likely to occur in the center of the blocky retained austenite [21]. Solano Alvarez and Bhadeshia et al. [22,23] carried out a rolling contact fatigue test on low-temperature bainite and found that microcracks occur at the interface of martensite and bainite formed by strain-induced transformation of retained austenite. The film-retained austenite shows high stability under rolling contact fatigue conditions because of its high carbon content and small scale [24,25]. Qian et al. [26] further studied the substructure in the process of cyclic deformation and believed that the dislocation evolution of carbide-free bainitic steel was the main reason for the first cycle of cyclic hardening. Marinelli et al. [27] found that if the degree of orientation dislocation between two different crystallographic bainite blocks is large, the crack growth is prevented at the boundary on both sides. Conversely, if there is no change in the active slip plane between the bainite blocks, microcrack growth will occur inside the bainite ferrite lath of the adjacent blocks.

In conclusion, the behavior of wear and fatigue is an important research direction in relation to bainitic steel. When applied to practical engineering components, its service conditions and working environment are important factors affecting the life of bainitic steel. This Special Issue of *Coatings* collects original research articles and review papers. Contributions will focus on the microstructure and property control of steel, as well as service properties. It will emphasize the potential of the covered subject in addressing these important societal challenges.

Funding: The authors acknowledge financial support from the National Natural Science Foundation of China (No. 52001275), the Natural Science Foundation of Hebei Province (E2020203084).

Conflicts of Interest: The authors declare no conflict of interest.

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