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Numerical analysis of stress-induced and concentration-dependent carbon diffusion in low-temperature surface carburization of austenitic stainless steel

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ABSTRACT

A kinetic model based on stress-induced and concentration-dependent carbon diffusion was developed for simulating the carbon concentration-depth profile of carburized austenitic stainless steel. The model considers that the stress induced by diffusion of the dissolved carbon atoms can affect the diffusion behavior in turn and the diffusivity of carbon is dependent on carbon concentration. In order to check the validity of the model, 316L austenitic stainless steel was treated by low-temperature surface carburization at 470°C for different times, and the carbon concentration along the depth direction was measured by scanning electron probe micro-analyzer (EPMA). The results show that in carburized 316L austenitic stainless steel, the predicted carbon concentration-depth profile based on stress-induced and concentration-dependent carbon diffusion model is in good agreement with experimental results, which indicates that the stress and concentration-dependent diffusivity play an important role in carbon diffusion. As a result of carburization, large compressive residual stress is generated and gradiently distributes in the carburized layer; meanwhile, the diffusion of carbon atoms can be accelerated by stress. Although the carbon diffusion is dominated by concentration gradient, the stress gradient as the next driving force cannot be ignored during low-temperature surface carburization. The proposed model can only be used to describe the carbon diffusion in austenitic stainless steel during low-temperature surface carburization without obvious carbides precipitation.

KEYWORDS: austenitic stainless steel, low-temperature surface carburization, carbon diffusion, stress-induced diffusion, concentration-dependent diffusivity