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Characteristics and Control of Oxide-Sulfide Complex Inclusions in D2 High-Speed Railway Wheel Steel

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The hard oxides wrapped by the plastic (Mn,Ca)S sulfides can effectively reduce the harmful effects of oxides on D2 high-speed railway wheel steel. An analysis of the composition characteristics of complex inclusions reveals that 1 to 2 μ m CaO·6Al2O3 (CA6) and CaO·2Al2O3 (CA2) serve as core, promoting the growth of (Mn,Ca)S, which contains 5 to 20 mass pct CaS and 80 to 95 mass pct MnS. This results in the formation of Al2O3–CaO + (Mn,Ca)S complex inclusions. These complex inclusions with specific composition can deform in harmony with the steel matrix under the external forces, making them ideal complex inclusions, a mathematical model is established to describe the inclusion formation during the cooling and solidification of molten steel. The results indicate that CA6 and CA2 are mainly formed during cooling and solidification, with their sizes remaining under 2 μ m. These oxides serve as the cores to promote the formation of (Mn,Ca)S in the later stages of solidification. To increase the formation of such complex inclusions and reduce the appearance of large-sized oxides, it is vital to control the contents of Al, Ca and O to 0.011 to 0.016 mass pct, 6 to 8 mass ppm and 8 to 10 mass ppm, respectively.

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