Crystallization control of $CaO-SiO_2-Al_2O_3-MgO$ system inclusion

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Keywords: crystallization, non-metallic inclusions, time temperature transformation, continuous cooling transformation

The crystallization behavior of oxide melts is commonly studied in glass ceramics, mold fluxes, and molten slags. However, there are few studies concerning the crystallization of oxide non-metallic inclusions in steel. Inclusions with high crystallization ability tend to crystalize during the soaking process before hot rolling, which can greatly decrease the deformation ability of inclusions during the rolling process. In this study, the effects of MgO and Al_2O_3 contents on the crystallization behavior of $CaO-SiO_2-Al_2O_3-MgO$ system inclusions were investigated using the sessile drop technique and thermodynamic calculations. Moreover, the effect of alkali metal oxide (Na_2O, K_2O, Li_2O) on crystallization kinetics of $CaO-SiO_2-Al_2O_3-MgO$ system inclusions were also studied. Their continuous-cooling-transformation (CCT) diagrams and time-temperature-transformation (TTT) diagrams were constructed. The results show that the increase of MgO content increases the crystallization ability of $CaO-SiO_2-Al_2O_3-MgO$ inclusions, while the increase of Al_2O_3 content has the opposite effect. To obtain low melting point plasticized $CaO-SiO_2-Al_2O_3-MgO$ ($CaO/SiO_2=1$) system inclusions, the Al_2O_3 content of the system needs to be controlled larger than 15 wt.% and the MgO content should be kept at a small amount. Addition of alkali metal oxide decrease the liquid temperature of $CaO-SiO_2-Al_2O_3-MgO$ inclusions and can suppress the crystallization process of inclusions. The degree of inhibition decreases in the order of K_2O, Na_2O, Li_2O. Also, the crystallization activation energy could semi-quantitatively characterize the crystal growth during the crystallization of inclusions. This study provides a theoretical basis for understanding the crystallization behavior of $CaO-SiO_2-Al_2O_3-MgO$ system inclusions and optimization of its compositions with the lowest crystallization ability.