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Influence of copper and tin on the oxidic cleanness and investigation of the agglomeration tendency of non-metallic inclusions in a medium-carbon steel

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The European Green Deal and its consequences represent a disruptive change in steelmaking as the iron and steel industry contributes up to 7 % of total European greenhouse gas emissions. The goal to reach CO2-neutrality until 2050 requires a variety of new technologies such as direct reduction using hydrogen. Since the availability of both facilities as well as green hydrogen will not be sufficient, more established processes such as remelting of steel scraps in Electric Arc Furnaces (EAFs) are required as well. Therefore, it is essential to increase the recycling rate of steel which means that also lower quality secondary resources must be used which contain higher tramp element contents. These elements impact steels in various ways by, for example, affecting phase transformations or leading to hot shortness.
The research on tramp elements in steel until now has mainly focused on hot shortness or scaling during continuous casting and hot working while knowledge on interactions between tramp elements and non-metallic inclusions (NMIs) is still limited. The presence of copper and tin lowers the surface tension of steel melts. The authors have shown that this leads to an increase in nucleation of NMIs and changes wetting behavior, in turn affecting separation of NMIs into the slag as well as clogging. The first part of this study considers the effect of tramp elements on the agglomeration behavior of NMIs which is also influenced by surface tension and wetting behavior. Therefore, the movement of NMIs on the interface between steel and argon is tracked using High-Temperature Confocal Scanning Laser Microscopy (HT-CSLM). The attraction forces are calculated using the acceleration and the calculated mass depending on the chemistry analyzed by Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM/EDS).
Furthermore, the behavior of NMIs on steel/slag interfaces is analyzed. for which a newly invented set-up for the observations of the interface through a liquid slag in the HT-CSLM is used. Therefore, larger synthetic spheres made of zirconia, silica, and alumina are added to the steel resembling different NMIs. These larger NMIs can be tracked even through the slag layer enabling the observation of agglomeration and repulsion as well as dissolution of NMIs when in contact with both steel and slag. The comparison of NMI movement in steels with and without tramp elements will provide valuable insights to retain or even improve the cleanness of steels made by remelting of low-quality scrap in EAFs.

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