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REFINING OF REGOLITH DERIVED FERROSILICON ALLOYS FOR THE LUNAR STEEL PRODUCTION

Abstract

NASA and other space agencies are making plans for the sustainable lunar habitat which will require in-situ utilization of lunar resource. High temperature regolith processing techniques such as molten regolith electrolysis and carbothermal reduction are being developed to extract oxygen from the lunar soil. However, these processes also produce Fe-Si alloys as a metallic by product. The higher Si content (about 10 wt.%) in these Fe-Si alloys makes them brittle and unsuitable for lunar applications. To address this issue, the removal of silicon through direct oxygen injection is being explored as a novel approach to reduce the silicon content below 1 wt.%, thereby enhancing the suitability of these alloys for lunar applications. FactSage 8.2 thermodynamic modelling software has been used to predict the optimal temperature, oxygen requirements, product compositions, and the role of flux (CaO) in Fe-Si alloy refining. Equilibrium calculations predicted that the direct injection of oxygen gas is crucial for efficient slag separation during the refining process, 15 wt.% oxygen is required for the refining of Fe91Si9 alloy. The thermodynamic modelling suggests that adding CaO facilitates early slag formation, thereby lowering the oxygen requirement. Refining of Fe91Si9 alloy at 1600 C with 10 wt.% O2 and 9 wt.% CaO is predicted to recover 99.4 % of Fe from Fe91Si9 alloy. The Si content in the liquid Fe at this oxygen level is about 0.6 wt.%, making it suitable for lunar steel production. The experimental work for this project is ongoing at the High Temperature Processing Lab at Swinburne University in Melbourne, with preliminary results validating the predicted modelling outcomes. This work advances thermal processing methods for lunar resource utilization, providing a pathway to produce high-quality iron and steel from lunar regolith. It also aligns with Earth's electrical steel recycling technologies, demonstrating the potential for cross-application in both lunar and terrestrial contexts. Refining Fe-Si alloys into lunar steel has the potential to revolutionize lunar manufacturing and facilitate a sustainable human presence on the Moon.