Solar Processing of Iron Ores

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ABSTRACT

The use of concentrated solar flux for high temperature metallurgical applications is a well-researched area with several reported literatures on solar calcination and metal oxide reduction. This paper presents two such processes with potential to reduce the carbon footprint from ironmaking through using concentrated solar flux. The first process involves solar flux incorporation to the already established lime-magnetite pellet (LMP) route of magnetite ore agglomeration. The second process is a hybrid solar-smelting route for iron ore-coal composite pellets that utilises solar flux to provide process heat. Both the concepts of solar agglomeration and solar smelting process were investigated using solar simulator-hybrid reactor setup at Swinburne University of Technology. Results from solar agglomeration experiments at 950 °C suggested no change in the reaction mechanism of the LMPs under solar irradiation compared to electrical heating. The percentage and morphology of the primary phases (mainly $CaFe_3O_5$) appeared similar for both solar and electric heated LMPs. The solar-reduction of magnetite concentrate-lignite coal composite pellets at 1130 °C resulted in a maximum metallisation of 55 % after 1.5 hrs of reaction. Mass and energy balance analysis of the solar agglomeration process was conducted for estimation of the emission reduction and the solar flux requirement at various percentages of fossil fuel to solar flux substitution. The preliminary economics of the solar-agglomeration process was also investigated which suggested the capital cost of a 2 Mtpa plant between AU$165 M and AU$142 M assuming a solar reactor thermal efficiency of 50% and 80%, respectively. The respective payback period was likely to be 15 to 20 years and 7 to 9 years. At current achievable reactor efficiencies of about 50%, a solar-agglomeration process is not economically attractive. However, with further development in reactor design, heliostat cost reductions and improvements in thermal storage performance, a solar-based LMP process could potentially be commercialised.