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Biochar application for sustainable ironmaking using electric smelting furnace

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In order to help reduce the emissions from the global steel industry, many operators are looking to adopt the Electric Smelting Furnace (ESF), and utilising biocarbon as a substitute for fossil carbon to produce pig iron. The ESF can be operated using renewable electricity, and has the capability to treat low grade iron ore, making the ESF favoured in areas where low grade iron ore is abundant. In this study, an ESF process was modelled using Aspen Plus to understand the effect of biochar with varying chemical compositions on the smelting processes and product yield. When biochar with higher fixed carbon (86-92 wt%) was used in the ESF, hot metal production increased by 1.3-1.6 % compared to the biochar with lower fixed carbon (50 wt%), with molten iron in the hot metal ranging between 97.2-97.4%. Total hot metal of 847.5 kg and 849.6 kg were projected to be obtained from smelting 1000 kg of direct reduced iron with about 92 kg of the biochar with fixed carbon contents of 86% and 92%, respectively. More offgas (61.8 kg), mainly composed of CO, was generated from the lower fixed carbon scenario, compared to 34.5-41 kg of the offgas from the higher fixed carbon scenarios. Other components of biochar, such as oxygen and hydrogen, contributed to the higher offgas of the lower fixed carbon scenario. Although decomposition of the low carbon biochar required less energy, initiating the reactions in the furnace with dissolved carbon required higher energy. When the modelling results using biochar were compared to the furnace operation using fossil carbon, the fraction of molten iron in the hot metal remined unchanged, while offgas production decreased from 41 kg to 24.8 kg. The furnace was operated at 1600 ℃, which consumed about 728 kWh electricity for producing 1 tonne of hot metal (HM). Emissions from the use of 2024 Australian grid electricity with 45% coal, 17.2% natural gas, 1.7% oil, 36.1% renewables were estimated to be 417.9 kg CO2 eq/t HM, which could be reduced to 11.8 kg CO2 eq/t HM by using wind electricity.

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