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The recovery of pig iron from the Zimbabwean limonite-coal composite pellet

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1 INTRODUCTION

The iron and steel industry is experiencing an increase in the use of iron and steel commodities within societies, decarbonization pressures, depletion of high iron ore grades and high energy consumption. This necessitates scrap metal recycling, low grade ore utilization using the induction or electric arc furnace to achieve the global target of net zero CO_2 emission. The available high quality scrap metal cannot sustain the steel industry but the world has unused hematite-goethite ores. It is the aim of this research that this resource be utilized using the induction furnace to sustain the steel industry in an environmental friendly manner.

2 METHODS

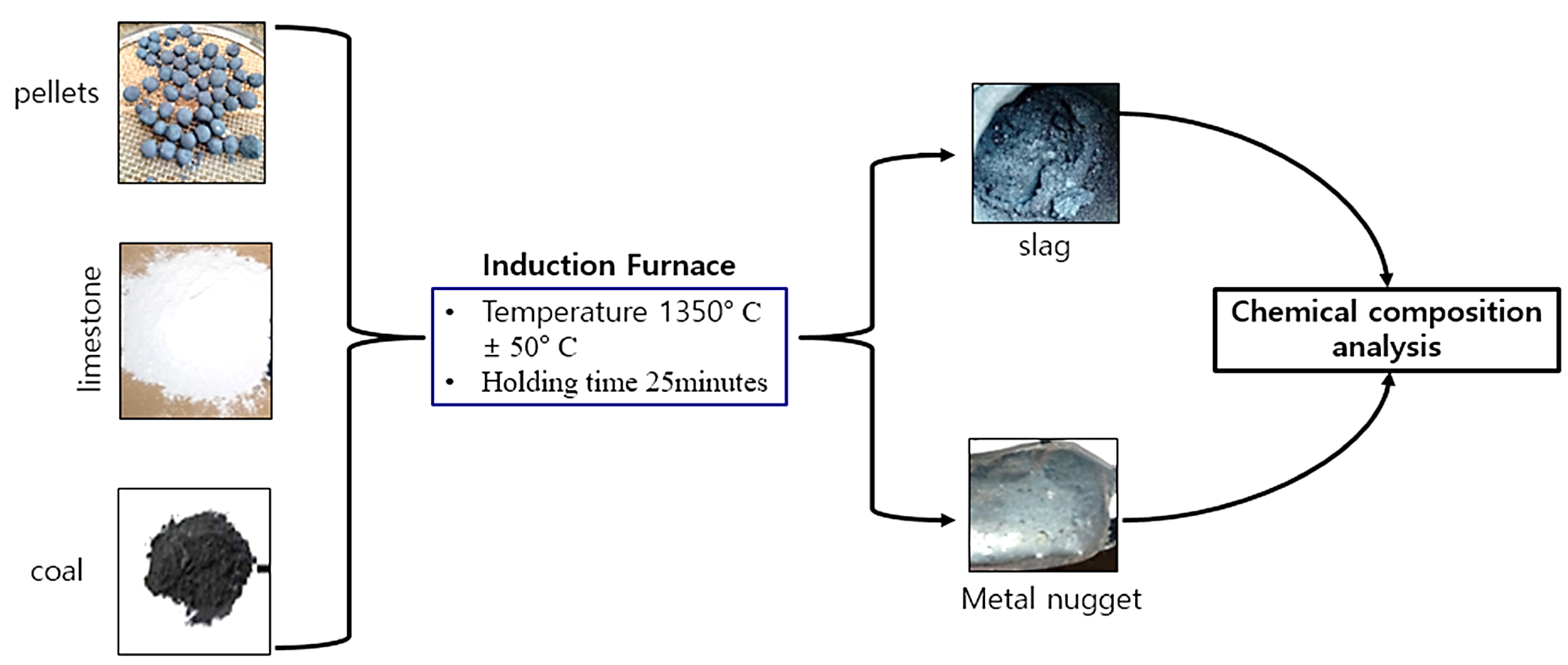

FIG 1 – Experimental process flow

3 RESULTS

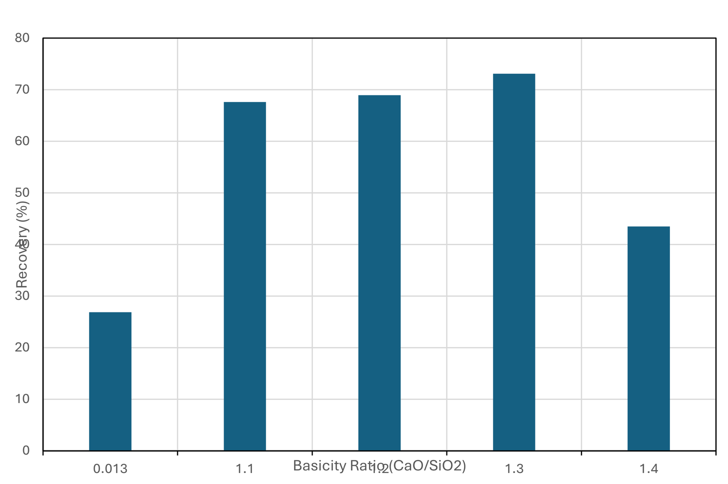

FIG 2 – Percentage metal recovery with increasing basicity

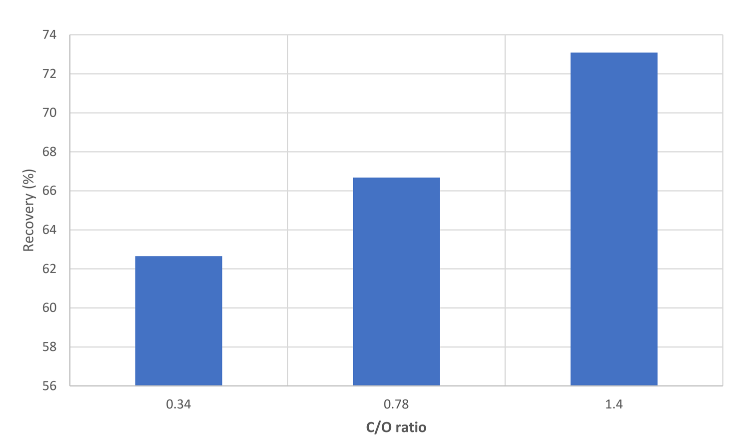

FIG 3 – Percentage metal recovery with change in C/O ratio

- Optimal slag basicity gives highest recovery of metal iron in smelting because it enhances the fluidity of slags and also suppresses the formation of highly stable compounds such as Fe2SiO4.
- The percentage metal recovery was found to increase with the increase in the C/O ratio showing an increase in the available amount of carbon for reduction and carburization, which then became sufficient for the reduction of the metal oxide.

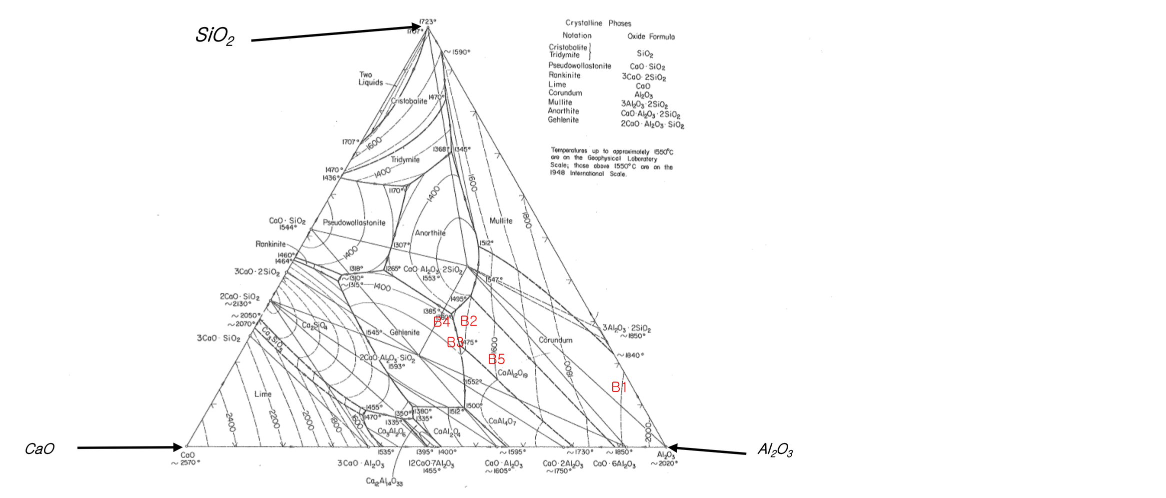

FIG 3 – CaO-Al_2O_3-SiO_2 Slags Phase Diagram, adopted from (Draper, 1976): Approximate melting temperature with increase in basicity, B1: 0.034, B2: 1.11, B3: 1.20, B4: 1.30 and B5: 1.40.

Estimated Crystalline Phases Present	Approximate Melting Temperature (ºC)	Basicity ratio (CaO/SiO_2)
$CaO\cdot 6Al_2O_3$	1850	0.013
$CaAl_{12}O_9$ and $2CaO\cdot Al_2O_3\cdot SiO_2$	1475	1.11
$2CaO\cdot Al_2O_3\cdot SiO_2$ and $CaAl_{12}O_9$	1400	1.20
$2CaO\cdot Al_2O_3\cdot SiO_2$	1380	1.30
$CaAl_{12}O_9$	1600	1.40

TABLE 1– Slag's crystalline phases and melting temperature with increasing basicity ratio

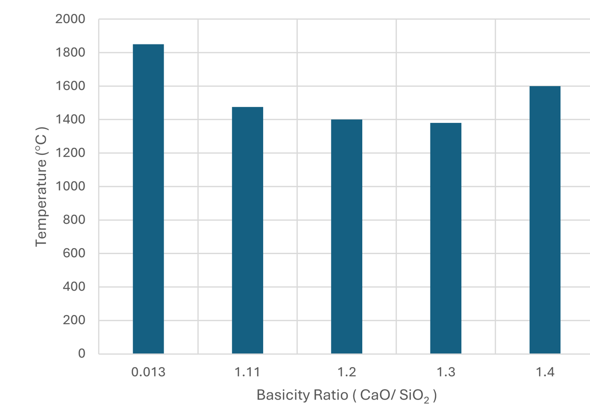

FIG 4 – Effect of basicity on melting temperature of slags

4 DISCUSSION

- Muller and Erwee (2011) stated that slag viscosity determines metal yield, and impurity removal efficiency through its determination of the slag-metal separation efficiency.
- Formed slags at the different basicity ratios do have different melting temperatures. Having furnace temperature fixed at 1350 °C with accuracy ±50 °C, it is highly likely that slags with melting temperature close to this value may have the best viscosity to allow for better slag-metal separation
- Highest recovery at basicity ratio 1.3 where the slag melting temperature was 1380 °C unlike in other basicity ratios where the slags had melting temperatures above 1400 °C.

5 CONCLUSION

Careful control of the basicity, and iron-to-carbon ratio maximised total metal recovery. The optimal basicity ratio was determined to be 1.3 and a carbon to iron ratio of 1.4 achieved a total metal recovery of 73 %. The metal recovery was closely related to the estimated slag melting temperature. The basicity ratio of 1.3 achieved the lowest slag melting temperature estimated to be around 1380 °C basing on the CaO-SiO_2-Al_2O_3 phase diagram. The recovered metal had a comparable chemical composition and microstructure to that of a product from an ITmk3 furnace

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