Swansea University Prifysgol Abertawe
Cronfa Gymdeithasol Ewrop European Social Fund
The M2A project has been supported by the European Social Fund through the Welsh Government
UKRI Engineering and Physical Sciences Research Council

Use of Sinter Pot Pilot Facility to Optimise Sinter Plant Performance

Figure 1: Set-up of the pilot pot facility in Tata Steel

Introduction

The sinter pot (Figure 1) is a small version of the sinter strand as shown in Figure 2. Similar to the strand; iron ores, fluxes and fuels are mixed to produce a green blend which is then ignited at high temperatures of around 1200°C to form iron ore sinter. The pilot pot shown is fully validated against the industrial scale process in terms of quality metrics. The sinter pot is beneficial as it allows sinter qualities to be evaluated in line with required demands for use at higher rates with the blast furnace without the need to run expensive plant-based trials. A pilot pot trial which is only 6.5kg can ensure that the blend has the required quality to be able to potentially save financially and environmentally on producing a blend which does not meet the quality requirement for the blast furnace. The blast furnace is what ultimately produces the molten iron, therefore having the correct quality (good strength, reducibility and chemistry) of sinter which makes up most of the burden material is pivotal in allowing the overall steelmaking process to progress successfully .

Figure 2: Sinter strand on the industrial scale (Vizag,2013)

Effect of basicity changes on sinter quality, focussing on SFCA formation

Sinter basicity (B2) (defined by the CaO/SiO_2 ratio) is typically controlled by dosing the sinter raw material feed with limestone. The motivation for understanding more about this effect is two-fold: Firstly, there is an industrial imperative to optimise this ratio as it has an effect on key sinter quality parameters such as strength and degradation index. Secondly, there is an academic objective of greater understanding the mineralogical changes as a function of B2, particularly on the SFCA phases, which is a phase known to influence the mechanical strength, reduction degradation as well as the reducibility, which are all parameters required by the blast furnace (Chen, 2019). There are many articles on how the basicity effects the iron ore sinter parameters and consequential productivity, such as RDI, reducibility index, tumbler index and many more. However, there is limited literature on what phases are formed, quantification of these phases and how they contribute to the quality of iron ore sinter. In this case, 'quality' is referred to the physical, chemical, and metallurgical properties of the iron ore sinter. With the help of x-ray diffraction (XRD), x- ray fluorescence (XRF), reduction degradation index (RDI) and an AI driven application called Intellesis, which I used to train my optical microscopy pictures to produce images where each mineralogy is labelled according to the colour, appearance, and morphology. For each sample numerous images were taken for phase analysis. Below shows the investigation of how the sinter is observed visually when the basicity is changed. In addition to this, quantitative analysis of the different mineralogy, and chemistry in the iron ore sinter at different basicities is shown.

Results

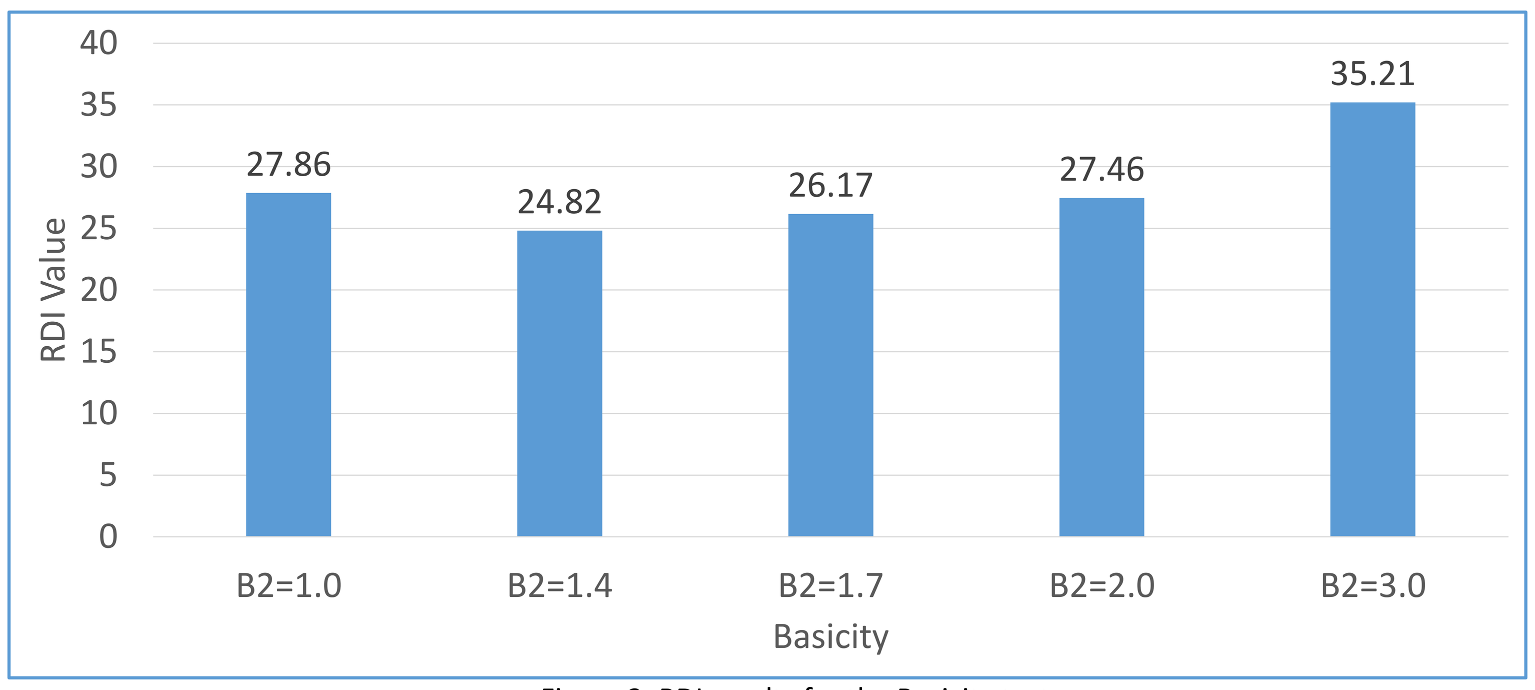

Figure 3: RDI results for the Basicity test

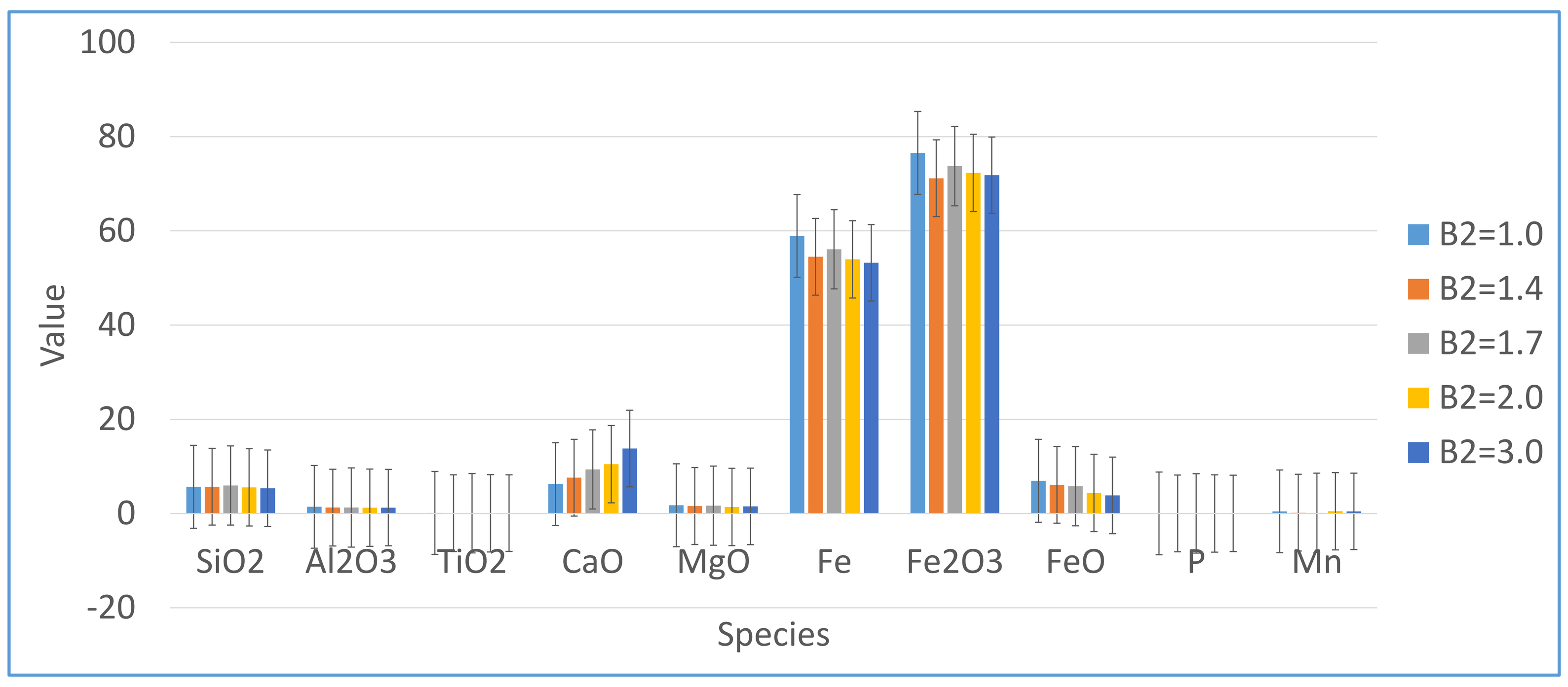

Figure 4: XRF results for the Basicity test

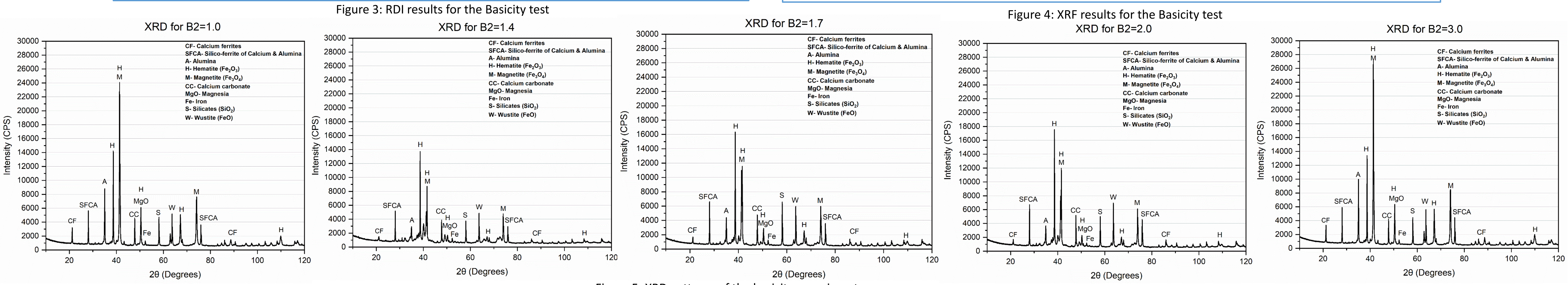

Figure 5: XRD patterns of the basicity experiment

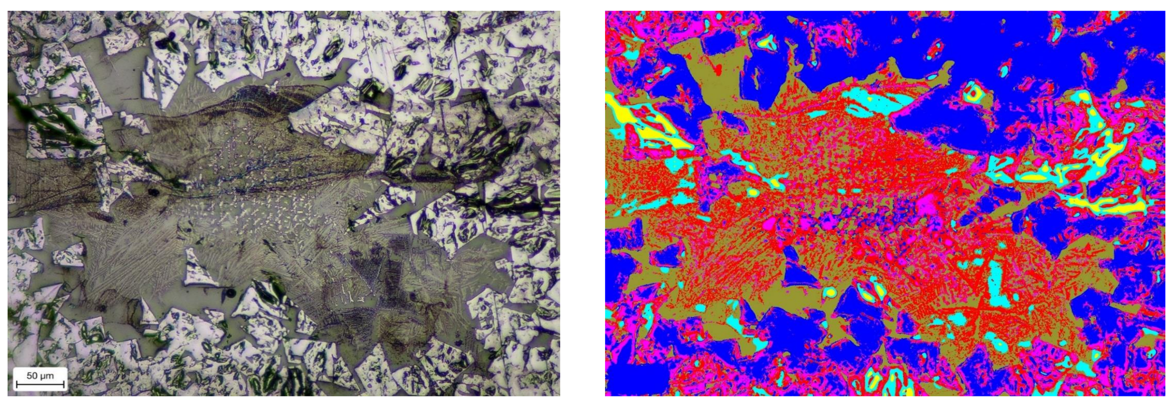

Figure 6: Optical microscopy (left) and corresponding Intellesis (left) images of B2=1.0

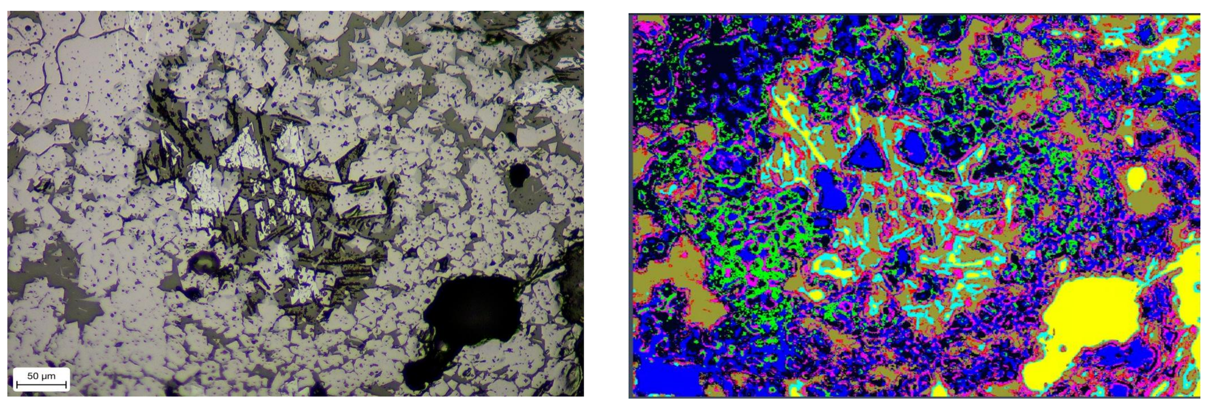

Figure 7: Optical microscopy (left) and corresponding Intellesis (left) images of B2=1.4

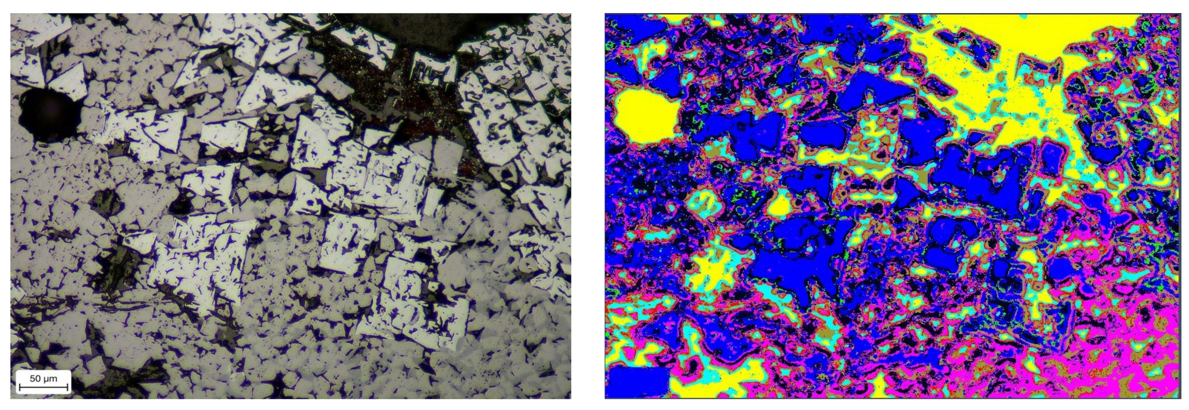

Figure 8: Optical microscopy (left) and corresponding Intellesis (left) images of B2=1.7

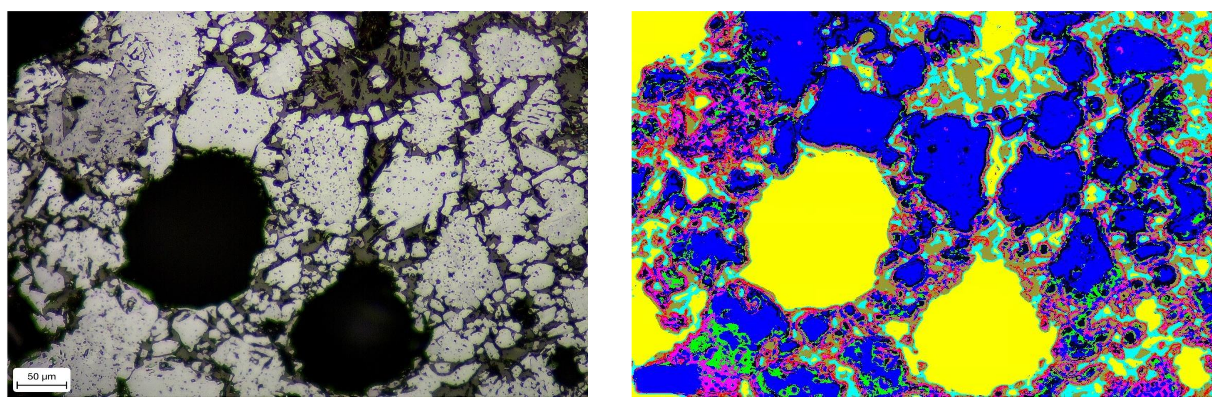

Figure 9: Optical microscopy (left) and corresponding Intellesis (left) images of B2=2.0

Key
SFCA- (olive)
Primary Hematite- (blue)
Pores- (yellow)
Dicalcium Silicate- (red)
Secondary Hematite- (dark blue)
Magnetite-(purple)
Larnite- (cyan)
SFCA-I- (green)

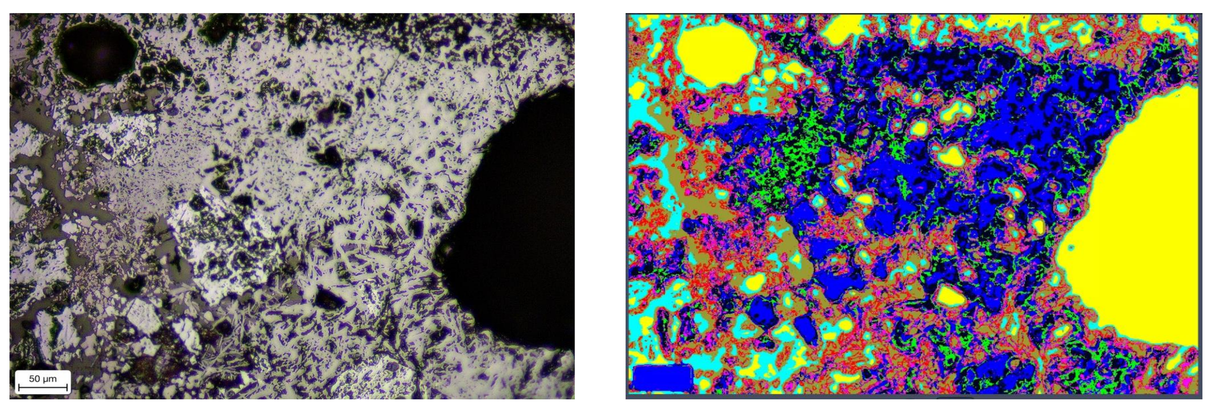

Figure 10: Optical microscopy (left) and corresponding Intellesis (left) images of B2=3.0

Table 1: Average mineralogy based on data collected via Intellesis for the basicity test

Blend/Phase (%)	SFCA	Primary Hematite	Pores	Dicalcium Silicate	Secondary Hematite	Magnetite	Larnite	SFCA-I	Total	Total SFCA (average)
B2=1.0	34.47	26.69	1.65	10.88	11.38	8.95	2.38	3.60	100	38.07
B2=1.4	23.47	16.08	2.63	6.58	27.01	13.96	4.65	5.62	100	29.10
B2=1.7	18.88	17.29	11.75	5.39	21.12	15.39	5.88	4.30	100	23.18
B2=2.0	14.67	29.40	14.62	5.81	9.99	8.21	12.15	5.15	100	19.82
B2=3.0	16.60	24.78	18.36	8.16	11.18	8.47	7.66	4.79	100	21.39

References
Chen C, Lu L, Jiao K. Thermodynamic modelling of iron ore sintering reactions. Minerals. 2019;9(6):1-13. doi:10.3390/min9060361
Infrastructure. Available at: https://www.vizagsteel.com/code/infrastr/sp.asp (Accessed: February 1, 2023).

Conclusions

1. XRF data confirms for this test that the chemistry agreed with what would be expected for an experiment with increasing basicity.

2. XRD data shows confirmation of the presence of SFCA in each blend. With the highest intensity shown in the region when the basicity was B2=1.4, 1.7 and 2.0. This shows operating in this region is beneficial as we know SFCA's are known to influence the mechanical strength, reduction degradation as well as the reducibility.

3. RDI tests show that B2=1.4 has the lowest RDI value at 24.82 compared to the rest of the basicities. Therefore operating at this basicity (approximately) will help to understand the mineralogical features of sinter that contribute to achieving sinter of the correct optimised quality for a given blast furnace burden.

4. The Intellesis analysis makes it very clear to visually see the different mineralogy contained within each blend. As it can be seen from the images, SFCA denoted by the olive colour and SFCA-I denoted by the green colour can be seen to be most prominent in Figure 7 which is for B2=1.4. This may be reason to suggest the strength that is shown in the sinter through the RDI value obtained coincides with this observation, proving the benefit of using Intellesis.