

2010

Some comments on the study of metallurgical coke and its use in the iron blast furnace: understanding process fundamentals through laboratory studies

Brian J. Monaghan

University of Wollongong, monaghan@uow.edu.au

Michael Chapman

mwc03@uow.edu.au

Sharon A. Nightingale

University of Wollongong, sharon_nightingale@uow.edu.au

John G. Mathieson

BlueScope Steel, John.Mathieson@bluescopesteel.com

Robert Nightingale

Publication Details

Monaghan, BJ, Chapman, M, Nightingale, SA, Mathieson, JG & Nightingale, R, Some comments on the study of metallurgical coke and its use in the iron blast furnace: understanding process fundamentals through laboratory studies, High Temperature Processing Symposium 2010, p 41-42, Melbourne, Australia: Swinburne University of Technology.

SOME COMMENTS ON THE STUDY OF METALLURGICAL COKE AND ITS USE IN THE IRON BLAST FURNACE: UNDERSTANDING PROCESS FUNDAMENTALS THROUGH LABORATORY STUDIES

B.J. Monaghan¹, M.W. Chapman^{1,2}, S.A. Nightingale¹, J.G. Mathieson² and R.J. Nightingale²

¹PYROmetallurgical Research Group, University of Wollongong, NSW 2522, Australia

²BlueScope Steel Limited, P. O. Box 202, Port Kembla, NSW 2505, Australia

Keywords: ironmaking, coke, coke analogue

Much of the recent experimental work carried out at by the PYROmetallurgical group at the University of Wollongong has focussed on understanding coke behaviour in the lower zone of the blast furnace. This work has had both fundamental and applied elements and has been carried out with a view to improving coke utilization in the blast furnace and ultimately reducing greenhouse gas emissions. Brief details of the some of this research are given below.

Mineral Layer Effects on Coke dissolution in Iron

An experimental study of the effect of a mineral layer formation on coke dissolution kinetics in liquid iron has been carried out. The system studied was designed to in part replicate the relatively quiescent conditions in the deadman area of a blast furnace. In this investigation a clear relation between the kinetics of coke dissolution and the morphology of the layer formed on the coke was established [1]. Experimental findings are shown below in Fig. 1 and Fig. 2 for the predominant phases at the coke-iron interface and first order rate plots respectively. The change of slope shown in Fig.2's first order rate plots represents a slowing of the rate of coke dissolution.

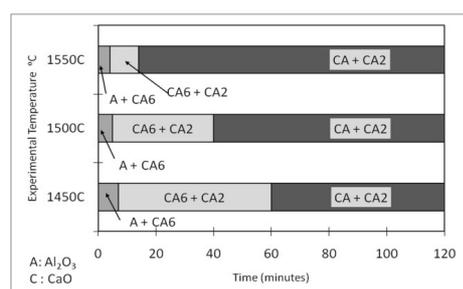


Fig. 1. Predominant mineral matter phase(s) at the coke-metal interface verses experimental time.

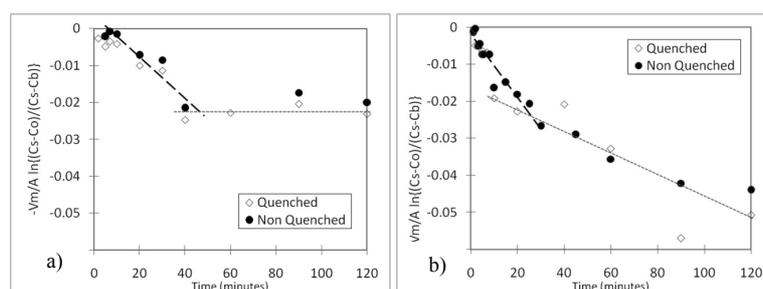


Fig. 2. First order mass transfer control plots for a) 1500°C and b) 1550°C.

Though not shown in Fig.2, similar results were found for coke dissolution at 1450°C. The change of slope is coincident with the appearance of the more dense CA (CaO.Al₂O₃) phase noted in Fig. 1. This finding is considered evidence of a reaction blocking mechanism slowing the dissolution kinetics, where the formation of a dense layer reduces the contact between the coke and liquid iron.

Deadman Coke Fines and Their Sources

There was some ambiguity as to the source of coke fines (generally less than 8mm but 1 to 4 mm in this study) found in deadman area of a blast furnace [2]. To identify the source of these coke fines tuyere probe samples were obtained from both the deadman and raceway areas of the blast furnace (see Fig.3 .) Using measurements of L_C , it was established that some of the fines found in the deadman area of a blast furnace were not simply the degradation products of the lump coke in this area. The coke fines had a higher L_C than the coke lump and therefore had experienced a higher temperature than the associated coke lump. Fig. 4 shows typical L_C measurements for the tuyere probe coke samples. This finding has been interpreted as indicating that at least some of the coke fines are being blown into the deadman area (lower temperature region) from the raceway by the high velocity hot blast.

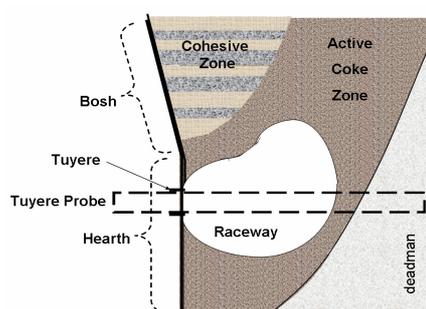


Fig.3. Schematic showing the tuyere probe and key zones in the lower zone of the blast furnace.

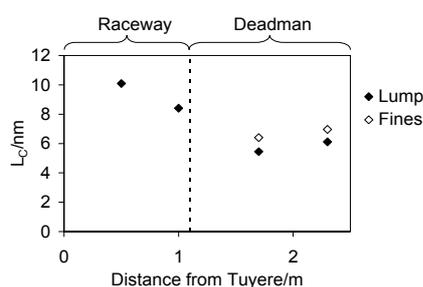


Fig.4. L_C measurements for the tuyere probe coke samples 12/02.

The Development of a Coke Analogue for the Study of Important Coke Reaction Phenomena

Industrial coke is not an ideal laboratory reagent. It has inherent heterogeneity problems with respect to oxide phase composition and phase dispersion not to mention coke porosity variability that often mask or complicate the coke reaction behaviour that is of interest in the metallurgical industries. To overcome this heterogeneity problem an idealised coke analogue material has been developed in which the mineral phase's composition, morphology and dispersion and the overall porosity can be controlled. Details of the analogue are given and its abilities to represent coke are assessed and discussed. It is envisaged that this coke analogue material will have much to offer in future studies of coke reaction behaviour, particularly in areas where mineralogy of the coke ash is considered to affect coke reactivity. There may also be coal applications of this analogue that are of interest to the power generation industries that have similar heterogeneity problems to coke when trying to understand coal reaction behaviour.

References

- [1] M.W. Chapman, B.J. Monaghan, S.A. Nightingale, J.G. Mathieson, and R.J. Nightingale, Formation of a Mineral Layer During Coke Dissolution into Liquid Iron and its Influence on the Kinetics of Coke Dissolution Rate, *Metallurgical and Materials Transactions B*, **39B**, 418-430, 2008.
- [2] B.J. Monaghan, R. Nightingale, V. Daly and E. Fitzpatrick, Determination of the Thermal Histories of Coke in a Blast Furnace Through X-ray Analysis, *Ironmaking and Steelmaking*, **35**, 38-42, 2008.