Materials Processing Institute

TATA STEEL

EPSRC Engineering and Physical Sciences Research Council

WMG THE UNIVERSITY OF WARWICK

Coal Particle Swelling

With Regard to Blast Furnace Coal Injection

Introduction

- Pulverised coal is injected into the blast furnace raceway via the tuyere to reduce the demand for coke (Carpenter, 2006).
- During this process coal particles may swell to a much larger size (Yu et al. 2003).
- This work aims to further our understanding of the coal particle swelling process and how this may impact upon Blast Furnace performance.

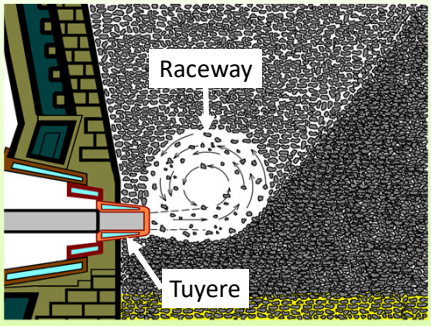
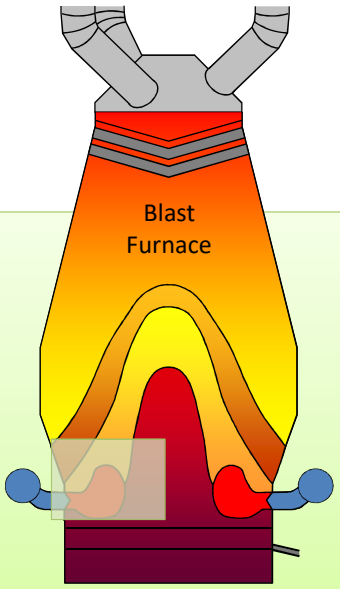
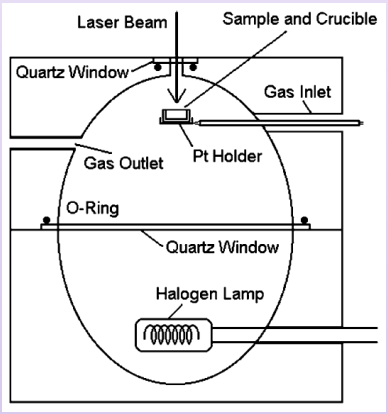


Image source: Own work on Г. Г. Ефименко, А. А. Гиммельфарб, В. Е. Левченко. Металлургия чугуна. — К.: «Вища школа», 1974. — С. 250– 254., Maarten Geerdes, Hisko Toxopeus, Cor van der Vlist. Modern Blast Furnace Ironmaking: An Introduction. — Amsterdam: IOS Press, 2009. P. 11. ISBN 978-1-60750-040-7 and J. G. Peacey, W. G. Davenport. The Iron Blast Furnace: Theory and Practice. — Pergamon Press, 1979. P. 18. ISBN 0-08-021318-5 ISBN 0-08-021258-2

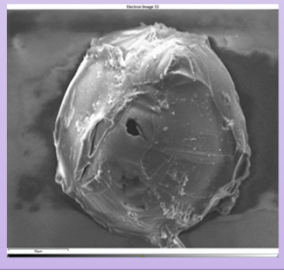


Measurement of Particle Swelling

- The High Temperature Confocal Scanning Laser Microscope (HT-CSLM) allows videos of swelling coal particles to be captured as they are heated at specified heating rates (up to 700 K/min) in a controlled atmosphere.
- Image analysis techniques enable the change in size of individual particles to be measured against temperature.

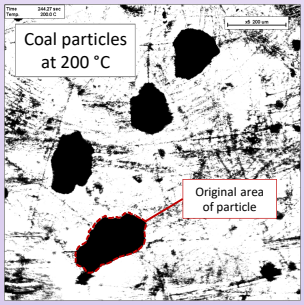


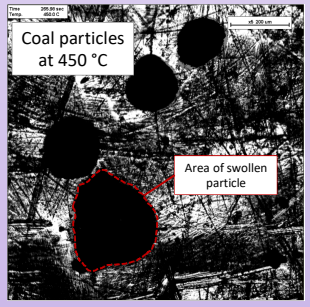
Above: High Temperature Confocal Scanning Laser Microscope (Source: Shannon et al. (2009))



Right: SEM image illustrating a swollen particle.

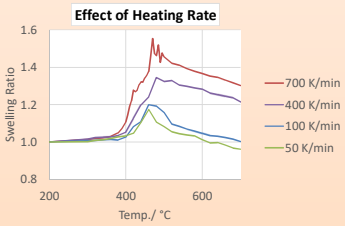
Below: Still images from HT-CSLM video demonstrating coal particle swelling.



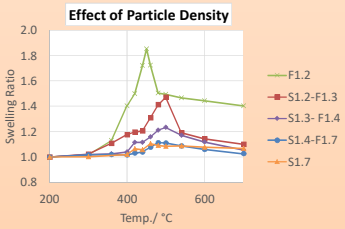


$$\text{Swelling ratio} = \frac{\text{area of swollen particle}}{\text{original area of particle}}$$

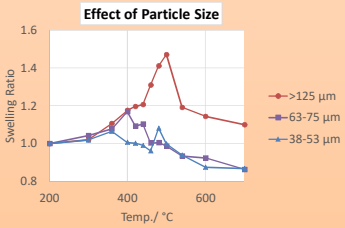
Results



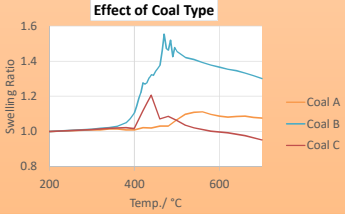
- Left: Effect of **heating rate** on swelling ratio for +125 µm particles of Coal B.
- Increasing heating rate from 50 K/min to 700 K/min increases swelling ratio.
- Attributed to increased volatile matter yield and rate of release. At lower heating rates gas can escape before internal pressure builds up. (Gale et al., 1995)



- Left: Effect of **particle density** on swelling ratio of +125 µm particles of Coal B heated at 700 K/min.
- Lighter particles swell more than denser particles.
- Lighter particles generally have more vitrinite and less mineral matter, therefore enhanced thermo-plastic properties. (Yu et al., 2003)



- Left: Effect of **particle size** on swelling ratio for S1.2-F1.3 particles of Coal B heated at 700 K/min.
- Larger particles swell more than smaller particles.
- Larger particles enable a greater build-up of internal pressure and have enhanced thermo-plasticity.



- Left: Effect of **coal type** on swelling ratio of +125 µm particles of three coals heated at 700 K/min.
- Some coals swell more than others.
- Different coals have different thermo-plastic properties due to geological age and provincialism. (Gao et al., 1997)

Project Team

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