June 2010
PF 10-07

Profiles

Injection of coal and waste plastics in blast furnaces

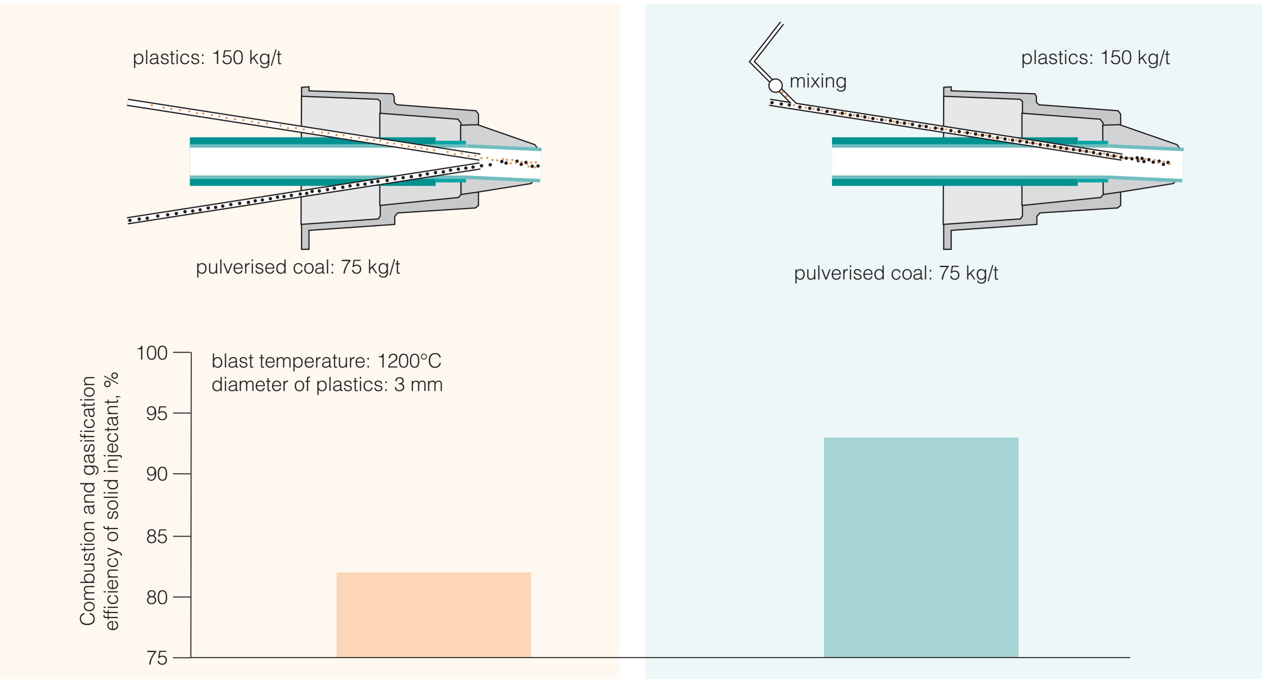
'The co-injection of coal and waste plastics reduces the overall CO_2 emissions'

'The cost of collection and treatment may limit the use of waste plastics'

'Interactions between coal and waste plastics can improve combustion efficiency'

Waste plastics are being produced in ever increasing quantities due to the growth in the use of plastic products. The majority of this material is currently being landfilled or incinerated. Unfortunately, the synthetic polymers in the plastics do not readily degrade and leaching of toxic elements from the landfill can occur. Combustion of waste plastics can generate environmentally hazardous pollutants, such as dioxins/furans, as well as undesirable carbon dioxide. Consequently, cost effective ways of recycling the increasing amounts of generated waste plastics are required, preferably by turning them into marketable commodities. One way of achieving this is by injecting them with coal into blast furnaces (BFs).

Pulverised coal injection (PCI) is a well established technology practised in most, if not all, countries operating coke-based BFs. However, the injection of waste plastics, either as a separate injectant or co-injected with coal, is practised only in a few BFs in Japan and Europe. A factor restricting the utilisation of waste plastics is the cost of their collection and treatment. BF operators need a reliable supply of consistent quantity and quality, and at a suitable cost. This requires an effective and efficient collection system for obtaining waste plastics from the widely distributed waste streams coming from households, industry and agriculture. The majority of waste plastics that are injected originate from packaging and container wastes. The wastes are highly heterogeneous, consisting of different types of plastics, as well as contaminants. Chlorine content is of concern due to its corrosive effects and consequently needs to be removed from the waste plastics. Both the BFs in Linz, Austria, and Salzgitter, Germany, which recently started to inject waste plastics (albeit with heavy and not coal), are sourcing the material from waste treatment plants not owned by them. This includes automobile shredder residues in the case of the Linz BF.



Effect of simultaneous injection on combustion and gasification efficiency

This compares to the situation in Japan where commercial injection of waste plastics began in 1996. Here the waste plastics are treated on site by the steel company (or a subsidiary company).

The substitution of coke by the coal and waste plastic injectants is limited to a maximum of around 40% since the injectants are unable to give the physical support for iron ore provided by coke. The composition and properties of the injectants influence the operation, stability and productivity of a BF, the quality of the hot metal product, and the offgas composition. The choice of injectant is plant specific due to differences in BF design and operating conditions. Selecting coals for injection is a complicated process that often involves compromises. In general, coals with less ash, moisture, sulphur and alkali are favoured. Coals are commonly blended to meet the requisite specification. Blending can optimise the relative strengths of the constituent coals, diluting unfavourable properties, and lower raw material costs since cheaper coals can be incorporated. The quality of the blend should be consistent to ensure stable BF operation. However, blending different types of coal, such as low and high volatile coals, can lead to problems. The blends may not behave as an average of their components, but may be affected disproportionately by one coal with problem characteristics. For mixed waste plastics, low chlorine, moisture, ash and sulphur contents are preferred. Most types of coal and waste plastics can be utilised at low injection rates. However, as injection rates increase more complex characteristics, such as combustibility, char reactivity and flow properties, influence their selection.

The combustibility of the injectants is particularly important because of the affect on furnace permeability. Utilising injectants with a high burnout and optimising operating conditions, such as blast temperature and oxygen enrichment, can improve combustion efficiency. Interactions between coal and wastes plastics can be exploited to improve their combustion efficiency. JFE, for instance, achieved this by co-injecting the materials through the same lance, causing the smaller coal (75 µm) particles to adhere to the surface of the larger plastic particle (3 mm). This resulted in the generated heat from the combustion of coal being supplied directly to the plastic particles, accelerating their combustion. Furthermore, the residence time of the coal in the high temperature area is prolonged, improving its combustibility. The coal and waste plastics are mixed in the piping (*see figure*) just before the injection lance to avoid potential blockage problems.

The co-injection of coal and waste plastics reduces the overall CO_2 emissions from the ironmaking process. PCI decreases the need for coke and hence energy consumption and CO_2 emissions from the coking plant. Injecting waste plastics further lowers CO_2 emissions (by about 30% in comparison to the use of coke and/or coal) due to their higher hydrogen content. There is less CO_2 produced from the combustion and reduction processes, and a lower heat demand by the direct reduction, solution loss and silicon transfer reactions. Small modifications to the offgas scrubbers keep emission levels comparable to operation without plastics. Concerns over emissions of dioxins and furans from the waste plastics have proved groundless since they are negligible.

The report concludes that the injection of coal and waste plastics can help BF operators maximise productivity, whilst reducing costs and minimising environmental impacts. With their higher utilisation efficiency (around 80%), waste plastics can be employed more efficiently in BFs than in plants which directly combust these materials to generate heat or electricity. Moreover, with the increasing amounts of waste plastics being generated, there is potentially a large market for appropriately treated waste plastics of which BF operators can take advantage.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

Injection of coal and waste plastics in blast furnaces
Anne Carpenter
CCC/166, ISBN 978-92-9029-486-3, 58 pp, March 2010,
£255*/£85†/£42.50‡

* non-member countries
† member countries
‡ educational establishments within member countries

IEA CLEAN COAL CENTRE

Gemini House
10-18 Putney Hill
London SW15 6AA
United Kingdom

Tel: +44 (0)20 8780 2111
Fax: +44 (0)20 8780 1746
e-mail: mail@iea-coal.org
> **Internet:** www.iea-coal.org