Investigation of Coals for Blast Furnace Injection

The injection of coal into blast furnaces increases their productivity, reduces coke consumption, improves process control and is less energy intensive than all-coke operations. For maximum efficiency, the characteristics of the injected coal must be carefully matched to the operation of the blast furnace.

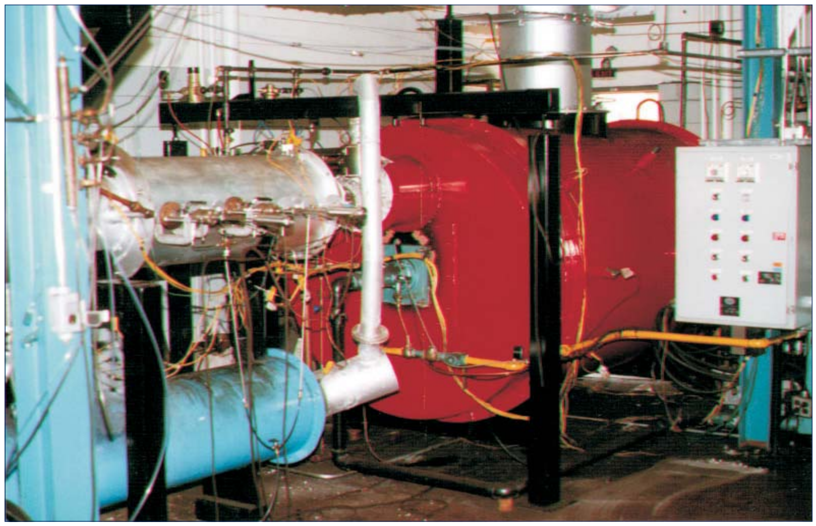

Fig. 1: Reactor in CETC's Coal Injection Pilot Plant

Coal properties affect coal burn out, raceway cooling and the amount of coke that can be replaced by injected coal. Carbon, hydrogen, oxygen and volatile matter contents are major determinants of these properties. So, too, are the amount, composition and fusion temperature of the ash.

Studies at the CANMET Energy Technology Centre have shown that many Canadian coals with medium to low volatile matter contents have excellent characteristics for blast furnace injection.

The most suitable coals show good combustibility, have reactive chars and exert minimal cooling on the raceway. Coals which exhibit low cooling effects can be injected in large quantities with little or no compensatory increases in blast temperature.

Services

The laboratory capabilities at the CANMET Energy Technology Centre are unique in North America, if not the world. We conduct and provide, in confidence:

Modelling and Simulation Studies

- optimization of the blast furnace process; and
- evaluation of the suitability of coals for blast furnace injection.

Energy Technologies for High Temperature Processes

Experimental, Pilot Plant Studies

- evaluation of coal burn out under simulated blast furnace conditions; and
- evaluation of char/coke reactivity under simulated raceway conditions (1800°C using thermogravimetric analysis).

Clients receive advice and recommend-ations on process improvements based upon our results.

> *Experience shows that coal producers and blast furnace operators need results from the above-mentioned studies respectively to market and select coals for injection.*

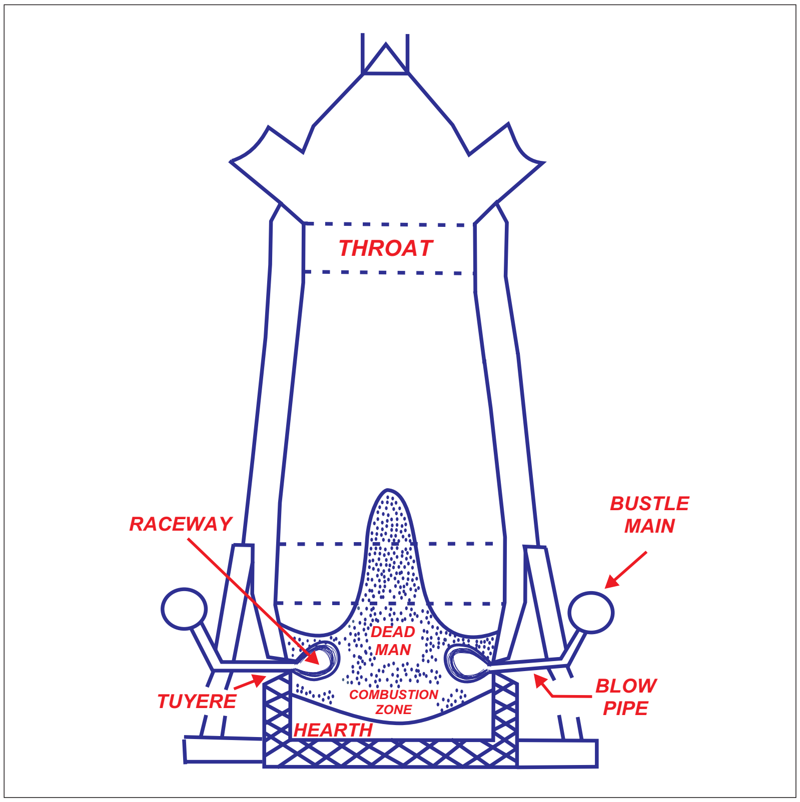

Fig. 2: Schematic of Blast Furnace and Referenced Features

Combustibility

Figure 1 shows the reactor in CETC's coal injection pilot plant facility. It simulates blowpipe-tuyere conditions in operating blast furnaces, using:

- blast temperatures up to 900°C;
- adjustable flow pattern geometries;
- hot air velocities up to 150 m/s;
- coal injection velocities up to 30 m/s;
- residence times up to 20 ms; and
- oxygen concentrations up to 30% in the blast to simulate the most advanced blast furnace operation.

Sampling is conducted at intermediate and final stages. Extracted samples are analyzed using:

- chemical analysis;
- thermogravimetric analysis (TGA);
- scanning electron microscopy; and
- optical microscopic analysis.

Char reactivity is evaluated and compared to that of coke using TGA under simulated raceway conditions of 1800°C and gas compositions of:

a) CO_2 10%; O_2 2%; N_2 88%

b) CO_2 10%; O_2 5%; N_2 85%

Modelling and Simulation

CETC has developed three blast furnace computer models for use in studies for clients.

1 — Blast Furnace Injection Simulator

This model is used to predict the cooling effect and coke replacement properties of coals and the response of the blast furnace to the injection of auxiliary fuels.

The model assumes steady-state conditions and simulates the complex interplay of chemical and physical processes in the tuyere and raceway. It relies on the principle of conservation of mass and energy.

Carbon, oxygen and iron are checked using mass balance equations, and enthalpy balance equations are used to account for energy in the combustion zone and the hearth of the furnace.

The model determines:

- coke rate;
- top gas composition;
- raceway adiabatic flame temperature (RAFT);
- coke replacement ratio (ratio of the mass of coke displaced to the mass of coal injected);
- permissible amount of injected coal as a function of change in RAFT (kg/100°C);
- permissible injection rate at constant RAFT relative to those for natural gas and oil; and
- change in RAFT per unit quantity of injectant (°C/kg).

2 — Blast Furnace Process Model

This model is used to predict the impact of changes on blast furnace operations. Input parameters, such as injection of auxiliary fuel, oxygen enrichment, blast parameters and charge materials, can be varied. It is a useful tool in strategic decision-making.

This steady-state model is based upon energy balances conducted for the raceway and the lower zone of the furnace, and mass balances for carbon, oxygen, hydrogen, nitrogen and iron.

Outputs from the model include:

- blast volume;
- volume and composition of shaft and top gas;
- production of hot metal and slag;
- flame temperature (RAFT);
- reduction of wustite;
- solution loss reaction;
- ratio of direct and indirect reduction of iron oxides;
- energy needed and provided

3 — Dynamic Model

This model is primarily a research tool. Its output supplements that of the Blast Furnace Process Model by providing time-dependent information. It is based on the kinetics of indirect reduction and heat transfer in the shaft.

CETC's R&D capabilities are available for use on a "Fee-for-service basis."

For further information, please contact:

CANMET Energy Technology Centre
Natural Resources Canada
1 Haanel Drive
Nepean, Ontario
Canada K1A 1M1

Wes Hutny, PhD
Research Scientist
Tel: (613) 996-3968
Fax: (613) 995-9728
E-Mail: whutny@nrcan.gc.ca

Or Visit our Web Site at:
www.cetc-ctec.gc.ca