CHEMICAL ECONOMICS - COAL, IRON AND STEEL

In 1911 the Broken Hill Proprietary Company decided to build a steelworks at Newcastle using coal from the Hunter Valley in NSW. Iron ore was shipped from the Iron Knob mine near Whyalla in South Australia. The advent of the First World War isolated Australia from the steel supplies from Britain and this made the new steelworks an extremely profitable operation.

The success of this operation spurred the Australian Iron and Steel Company (AIS) to build a steelworks at Port Kembla using coal from near Wollongong and iron ore from South Australia. The works started operation in 1928. Unfortunately for this enterprise the depression of the 1930s resulted in its demise and purchase by BHP in 1935. Again isolation from the Empire during the Second World War resulted in the two steelworks becoming extremely profitable for BHP. Pressure by the South Australian government encouraged BHP to build another steelworks at Whyalla which was opened in 1941.

During the 1950s iron ore resources at Cockatoo Island and later the enormous reserves of the Pilbara were discovered and one of the conditions of exploiting these resources for export was that a steelworks be built in Western Australia. A steelworks was built by BHP at Kwinana south of Perth, which from the 1960s to 1984 was fed by its own blast-furnace.

BHP ran the three remaining steelworks until 1999 when the Newcastle steel works required major investment which could not be justified by the company.

All of these facilities produced steel by reducing iron ore with coal (as coke) followed by oxidation of excess carbon in the iron by the Basic Oxygen Process (BOS a successor to the Bessemer process). This was one of the key technologies of the industrial revolution and still dominates the production of steel around the world.

The production of steel involves three large unit operations - the blast furnace, a coke oven and the BOS (Bessemer) converter.

The blast furnace is a very tall structure which takes a charge of coke, iron ore and limestone (as flux) into the top of the furnace. Hot air is blown (blasted) into the bottom of the furnace and causes partial combustion of the coke to carbon monoxide. As the combustion gases rise through the furnace against the descending solids, the iron ore is heated and reduced to molten metal. Ash in the coke and non ferrous ore is converted into a molten slag. The molten iron with a top layer of slag collects below the air injection zone in the furnace from which the iron (pig iron) and the slag are drawn-off as liquids. Hot and still combustible gases are drawn off from the top of furnace: Figure 1.

One of the major advantages of a blast-furnace is that poor quality metal scrap and some other intractable wastes can be added with the feed. Most tramp metals which otherwise would contaminate the steel, are removed in the slag.

In the Bessemer converter, oxygen is blown through the molten iron which reduces the carbon content of the iron to produce steel.

The other main unit operation is the coke oven. This has the duty to produce coke from coal. The coal is charged to a narrow vessel which is heated externally by burning coke oven gases and excess blast furnace gas. Heating the coal drives-off volatile matter leaving behind incandescent coke. This is pushed out of the coke oven and falls into a rail car ready for charging into the blast-furnace. Coke production is a batch process and the coke ovens are held in batteries of one hundred or more ovens to ensure a continuous supply of coke.

The raw coke oven gas is passed through condensers which condense coal tar and an aqueous phase (known as ammoniacal liquor) and produce a coke oven gas used to fuel the coke oven operation. The liquids are worked up separately (often by other companies) to produce a wide range of coal chemical products. In Australia, coal tar liquids are separated at the Koppers (Koppers Carbon Materials and Chemicals Pty. Ltd.) works near Newcastle.

The three principal unit operations give the photographer some of the best images of the industrial landscape - blast-furnace tapping of hot metal, steel production when oxygen is blown through the molten metal, and the coke oven when incandescent coke is pushed out of the oven.

They also have some of the moreintractable pollution issues in industry. Coal and blast furnace and downstream operations produce large quantities of slag and dust which often affects the surrounding neighbourhoods, whilst coke ovens, especially older plant, are sources of discharges of poly-nuclear aromatics and benzene to the environment.

Steel production economics benefits from the economies of scale. Blast furnaces are now built with internal volumes over 5,000m^3 and produce many millions of tonnes of iron each year. These are very large facilities and one consequence is that the coke used has to be very strong to hold the enormous weight of the material in the top of the furnace. This has generated a specialised market for some coals (coking coal) and this sells at a significant premium to thermal (power station) coal (Table 1).

Table 1: Pertinent prices for steel making in March 2016

		$/t
Coking coal	FOB Australia	79.10
Thermal coal	FOB Newcastle	55.86
Iron Ore	China (CFR)	55.5

Because not all coal can produce high strength coke, this can limit the scale of blast furnace operations which are dependent on a local coal resource. This was the case at Newcastle where local coals could only support relatively small blast furnaces. Coking coal in Australia is produced from selected mines in the Bowen Basin in Queensland and exported to the large integrated steel operations in China, Taiwan, Japan and South Korea. These operations now dominate world production of low cost export steel marginalising many operations in US, Europe and Australia.

The reduction of iron ore using coal is innately a large emitter of carbon dioxide. Approximately two tonnes of CO_2 are emitted per tonne of iron produced. Clearly introduction of carbon emission charges would exacerbate the current economics of steel production in Australia. Furthermore, since the major facilities (blast furnaces, coke ovens) are long life items, poor economics makes major investment in more efficient plant unlikely.

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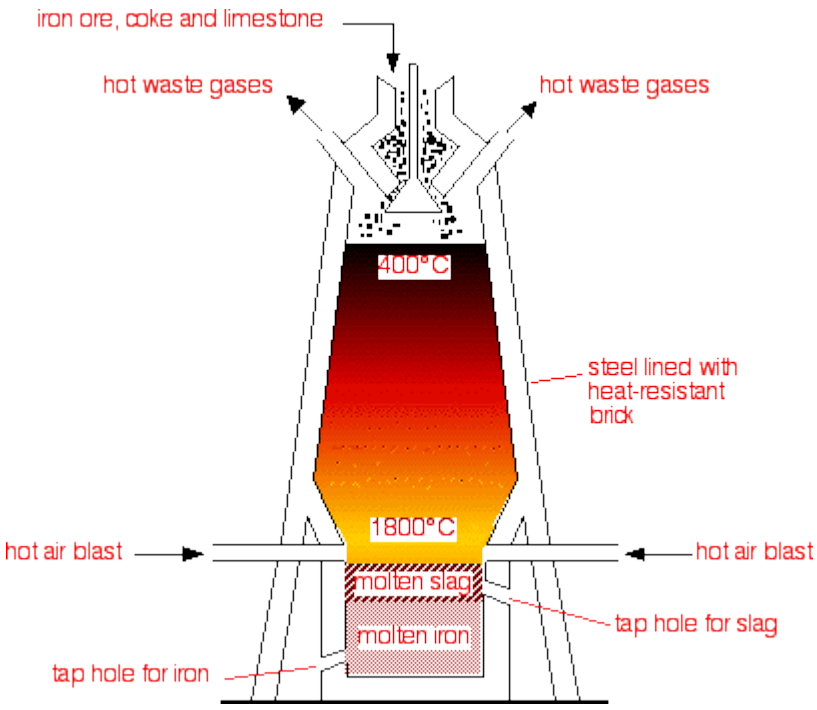


Figure 1: Blast furnace

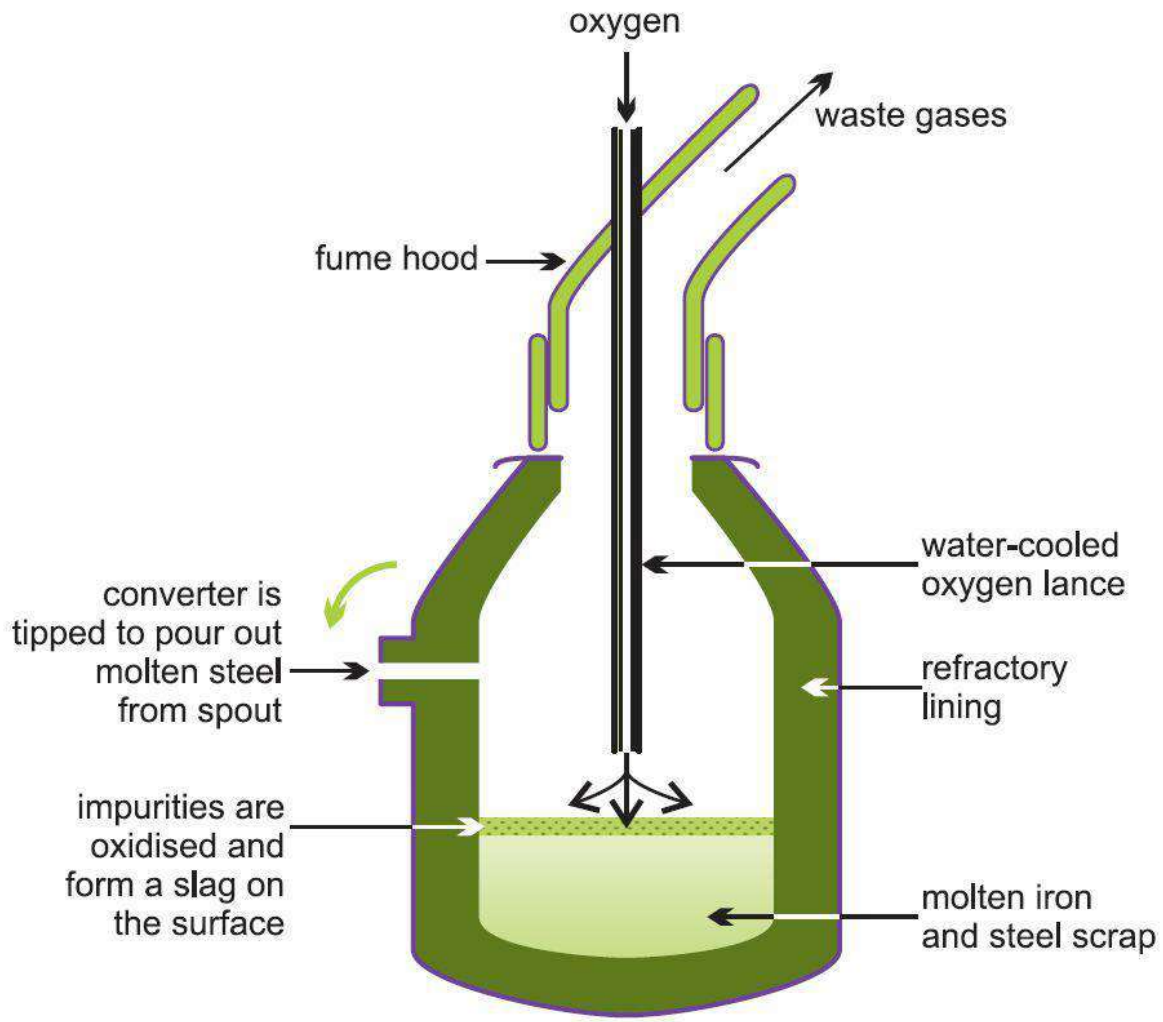
This is from http://www.chemguide.co.uk/inorganic/extraction/blastfurnace.gif

SOME OTHER PICS WHICH MAY BE OF INTEREST

Port Kembla Blast Furnace

Port Kembla: Source Illawarra Mercury

Coke Oven : https://upload.wikimedia.org/wikipedia/commons/b/bd/Coke_Ovens_Abercwmboi.jpg



Basic Oxygen Steelmaking: http://www.essentialchemicalindustry.org/images/stories/740_Steel/Steel_06.JPG

http://www.rsc.org/learn-chemistry/content/filerepository/RES/00/000/023/RES00000023-L.JPG