Iron and Steel

HIGHLIGHTS

■ **PROCESSES AND TECHNOLOGY STATUS –** The basic materials for iron production are iron ore, coal and coke (also used as energy input to the process) or alternative reducing agents, limestone and dolomite. Steel production requires iron, steel scrap and lime (burnt limestone). The iron ore is smelted to produce an impure metal called "hot metal" when in liquid phase or "pig iron" when in solid phase. In smelting, a reducing agent - usually coke - and heat are used to remove oxygen from the metal ore. Carbon dioxide (CO_2) and carbon monoxide (CO) are produced during the reduction process. Limestone is used to remove impurities such as slag. Blast Furnace, Midrex Direct Reduction Iron (DRI), Corex Smelting Reduction Iron (SRI) and Hylsa are currently commercial processes. Hismelt Smelting Reduction Iron and Hi-Oxy coal plants (with a high rate of coal powder injection) are new processes currently available at the pilot plant level. Iron and steel production processes with CO_2 emissions capture and storage (CCS) are still under development and testing.

■ **COST –** The main components of the iron and steel production cost are capital investment and raw materials. Investment costs for the traditional production processes are approximately $211 for Blast Furnaces (BF) with a capacity of one ton of pig iron per year (US $/(t/a)) and $100 for a Basic Oxygen Furnace (BOF) with a unit capacity (US $/(t/a). Investment costs for the alternative production technologies range from $220/t-yr for Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) combinations to $320/t-yr for the Smelting Reduction (SRI) technology. Other main cost drivers are scrap and electricity. Total costs amount to $92/t for BF and BOF combinations (including energy inputs), $214/t for DRI and EAF combinations and $198/t for SRI.

■ **POTENTIAL & BARRIERS –** The iron and steel production sector is the second-largest industrial consumer of energy - after the chemical sector. It accounts for about 20% of industrial energy consumption and is the largest industrial emitter of CO_2, including all the process emissions from coke ovens, blast furnaces, etc.

PROCESS OVERVIEW

Pure iron is not readily available since it easily oxidises in the presence of air and moisture. The iron industry reduces iron oxides to obtain pure iron, i.e. *metallic iron*. Steel is an alloy based on iron and carbon, with carbon concentration ranging from 0.2% to 2.14% in weight. High carbon content results in higher hardness, tensile strength, and lower ductility. The resulting steel is also more brittle. Steel alloys can be enriched with other materials to tune the final material properties that also depend on production techniques and on the quality of the basic materials. ■ **Iron Ore classification** – The basic material for iron and steel production is iron ore or ferrous scrap. Iron ores are classified based on shape and volume. *Iron fines* have a majority of particles with a diameter of < 4.75 mm; *iron lump* ore has a majority of particles with a diameter of > 4.75 mm; *iron pellets* are a fine-grained concentrate rolled into balls (with a binder) and *indurated* in a furnace. Their diameter ranges from 9.5 to 16.0 mm. ■ **Iron and Steel production** – The iron and steel production process can be subdivided into 3 sub-processes: iron-making, steel-making and steel manufacturing. All processes can be summarized as in Figure 1 [2]. A more detailed scheme and material flow can be found in Figure 9. Conventional steel production takes place in integrated steel mills that often include facilities for coking and sintering. In the basic process, the input materials - a combination of sinter, iron pellets, limestone and cokes - enter a *blast furnace* (BF) to be converted into molten *pig iron*. The pig iron is then loaded into an oxygen furnace to produce steel slabs. Alternative processes are *direct reduction iron* (DRI) and smelting *reduction iron* (SRI). Ferrous scrap can also be processed in an electric arc furnace (EAF) to obtain steel. Today most used steel-making processes consist of a combination of a blast furnace and basic oxygen furnace. Some SRI processes can produce steel directly.

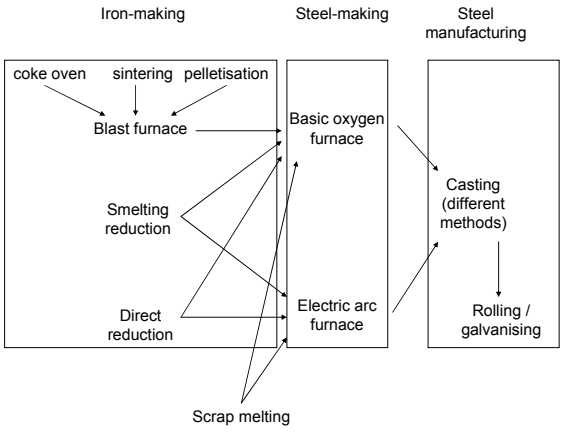

Fig. 1 - Iron and steel production technologies [2]

IRON PRODUCTION

■ **Blast Furnace (pig iron) –** Blast furnace (Figure 2) is a process for producing liquid raw iron by smelting pellets or sinter in a reducing environment. The end products are usually molten metal, slag and blast furnace gas. In the reduction process, oxygen (O_2) is taken out of the pellets or sinter. Coke is often used as a reducing agent, as well as fuel. Fuel (coke) and pellets or sinter are supplied continuously through the top of the furnace and O_2-enriched air is blown out the bottom by electrical air ventilators. The chemical reactions take place while the materials move downward. Coke also serves as a carrier to move the bulk material column downward in the blast furnace [5]. Various alternative reducing agents are available, such as hydrocarbons, coke, coal, oil, natural gas (nowadays in some cases, also plastics). In the past, a widely used reducing agent was charcoal, in particular charcoal from eucalyptus trees. Whatever the fuel and

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