The COREX®-Process with Brasilian Coals

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INTRODUCTION

As for the past 200 years the coke or char coal fueled blast furnace has been the major economical basis for steelmaking we can now introduce a new technological route beginning with the COREX®-Process, which is a coal smelting reduction process.

The COREX®-Process is based on the use of a wide range of raw coals, including noncoking coal which are directly fed into the process. The product from the COREX®-Process is a hot metal of high purity. A by product is a medium BTU gas for export use.

The COREX®-process development started in the late 1970's and after successful small scaled tests in 1978 KORF ENGINEERING and VOEST ALPINE AG, the owners of the COREX®-process, decided to build a semi-commercial demonstration plant. This COREX®-plant at Kehl (Southern Germany) started the first test campaign in June 1981 with immediate success. The plant has now operated more than 6000 h with raw coal and iron ore from a great number of sources from all over the world.

DESCRIPTION OF THE COREX®-Process

The COREX®-Process produces hot metal from a wide variety of feed materials:

- iron ore in the form of pellets, lump ore and sinter;
- raw coals with a particle size range from 0 to 50 mm, containing volatile matters up to 40 %.

The basic idea of the COREX®-process is the separation of the blast furnace process into two major steps:

- The production of reducing gas as well as the melting of the sponge iron to produce the hot metal occurs in a melter gasifier vessel.
- The reduction of the iron ore occurs in a separate shaft furnace.

In the upper part of the melter gasifier, the coal is dried and degassed prior to be gasified under partial oxidation in a fluidized bed in the lower part of the melter gasifier.

The reducing gas generated in the melter gasifier after having passed a coarse dust separation is transferred into the reduction shaft arranged above the melter gasifier.

The reduction shaft operates according to the counterflow principle, the reduction temperature being approx. 850 °C. The hot sponge iron resulting from this process step is directly conveyed into the melter gasifier, where it is melted down by the energy generated by the partial oxidation of the coal. Hot metal and slag are tapped periodically from the hearth of the furnace.

In case the exportgas cannot economically utilized the top gas will be recycled via a CO_2-removal to the melter gasifier. The advantage of this operation is the fact that the coal and oxygen consumption will be reduced considerably.

CHARACTERISTICS OF COALS FOR THE COREX®-PROCESS

Raw coals of a wide variety can be used, although certain limits have to be considered, as there is of course an influence to the process from the coal. The content of volatile matters, sulfur, ash, the particle size and the water content of the coal fed to the process determines temperatures, export gas volume, hot metal quality and therefore operation parameters.

The most important property of the coal is its volatile content. It determines the coal consumption. The ash content is less critical, also its alkaline amount is less critical than in a blast furnace.

MELTING METALLURGY

A distinguishing feature of the COREX®-Process is that the energy released during coal gasification is used for melting of the sponge iron. The limiting value for the quantity of sponge iron throughput is the melting capacity available in the fluidized bed. The liquid hot metal and the slag are collected at the furnace hearth. The separation is effected by the different densities.

The sulfur distribution between slag and hot metal is controlled by the basicity of the slag. The target value for basicity ($B_2 = CaO/SiO_2$) is approximately 1.2 - 1.3. Basicity is adjusted by the addition of limestone and uncalcined dolomite or the use of a self-fluxing ore material.

Limestone and/or dolomite are charged with the ore via the shaft. A dolomite charge leads to higher MgO content in the slag, which decreases slag viscosity and improves sulfur distribution. Also, the Al_2O_3 percentage is reduced. The sulfur content in the hot metal is also influenced by the sulfur content in the coal and specific coal consumption.

The metallization degree and the C-content of the sponge iron have an influence on the metallurgy in the melter gasifier. The sponge iron analysis, however, depends on the specific reducing gas volume (M^3/t sponge iron),and the reduction potential of the gas ($CO + H_2/CO_2 + H_2O$).

For good desulfurization, the hot metal should have a high temperature and high carbon. Also a low FeO content in the slag is necessary.

The liquid hot metal tapped at the bottom of the melter gasifier has the following typical analysis:

- Carbon:	approx.	4.0	%
- Sulfur:	0.02 -	0.1	%
- Silicon:	0.6 -	2.5	%
- Tapping temperature:		1.400	°C.

EMISSIONS AND EFFLUENTS

In comparison to the conventional iron making route of coke oven and blast furnace operation the COREX®-plant has no significant air emissions and only a small amount of water effluents. Whether a chemical or biological water treatment is necessary depends on the coal composition and the local environmental laws.

TEST WITH BRAZILIAN RAW MATERIALS

1986 high ash and high volatiles coals from Santa Catarina (CMSC) and Rio Grande do Sul wer tested together with CVRD ores in the pilot plant. Hot metal produced was similar to that of the blast furnace and the plant availibility was very high. A transformation of the test result to a commercial plant shows that a coal consumption of about 1 t Santa Catarina coal per ton of hot metal and a gas caloric credit of 12 GJ/t HM can be assumed. With char coal, medium volatile coal, anthracite or petrol coke a gas recycling via a CO_2-Pemoval is possible and therefore a coal consumption below 500 kg and a oxygen consumption below 300 m^3/t HM are possible.

MARKETING

There are a number of obvious reasons for building a COPEX®-plant. Countries having little or no coking coal at their disposal but have other coal deposits can be in steelmaking very economically now. COREX®-plants with a capacity from 100.000 tons to 300.000 tons of hot metal per year can be installed presently.

The first production unit with a capacity of 300.000 tons per year is in the final stage of construction in South Africa and will start operation at the end of this year.