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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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STRATEGIC-UDY IRON SMELTING PROGRESS REPORT:

by

E. K. Sandbach, Koppers International, Ca.
United States of America

SUMMARY

The Corporacion Venezolana de Guayana (CVG) has converted its number nine electric smelting furnace to a new iron-making process - Strategic-Udy. Koppers Company, Inc. has made the conversion which is expected to double the rated capacity of the furnace by the addition of a rotary kiln and by modifications to the furnace roof and feeding mechanism.

The rotary kiln, 107 meters long, supplies hot, partially reduced material to an electric furnace where smelting is completed in an open bath heated by slag resistance between self-baking electrodes.

The Strategic-Udy smelter, which was started up in March, 1963, uses El Pao and Cerro Bolivar ore fines. These fines are screened out during sizing of these ores for the eight conventional electric furnace smelters at the plant. The Strategic-Udy operation employs, as a reductant, non-coking Naricual coal from Northern Venezuela. Fluxes are of domestic origin.

Problems associated with the material handling systems have prevented the operation of the unit at its rated capacity (400 tons per day). Modifications are being made to the material handling system, and, when these changes are satisfactorily completed, there is every expectation that the plant will operate at its designed capacity.

INTRODUCTION

The world's first commercial application of a unique iron-making process — Strategic-Udy — became a reality in mid-March, 1963, at Matanzas in Venezuela.

The Orinoco Steel Plant of Corporacion Venezolana de Guayane (CVG) was designed to smelt iron ores in nine 33,000 KVA submerged-arc electric furnaces. Early in 1960, Strategic Materials Corporation proposed the conversion of one of the nine electric furnaces to a new process for making iron — The Strategic-Udy Process.

Modification of the furnace and installation of the kiln started in June of 1962, and first power was applied to the electric furnace in March, 1963.

While normal electrical and mechanical start-up difficulties were encountered during initial operation, these problems were aggravated by difficulties in getting the raw material to the kiln; and heated, reduced sinter from the kiln to the furnace using the existing telpher system.

In the normal course of events, operations would have been suspended in May or June and necessary plant modifications made. However, the Latin American Iron and Steel Institute was having its fourth meeting in Venezuela in early July, and arrangements had been made for a visit to the Orinoco Steel Plant. It was, therefore, decided to continue operation of the Strategic-Udy smelter, and because of this, only temporary repairs were made.

Operations were suspended in mid-July and the necessary modifications are being made to the plant and equipment to insure optimum operating conditions.

All of the repairs and changes to existing facilities should be completed early in the new year, and full information on the technical and economic operation of the Strategic-Udy Process will be then available.

THE STRATEGIC-UDY IRON MAKING PROCESS

The Strategic-Udy Process does not involve new chemistry. (1 & 2). On the contrary, it gives better control over the old chemistry and increases efficiency by combining standard equipment with improved operating techniques. This new combination has the advantage of much wider latitudes in the size and quality of raw materials than is possible with conventional processes.

A specially adapted rotary kiln is combined with a specially designed electric furnace. With this combination of equipment, the functions ordinarily performed in the stack of the conventional blast furnace are now done in the rotary kiln.

These functions include drying and heating of the ore, reduction of the iron ore to a mixture of metallic iron and lower oxides of iron, and the calcining of limestone. By the substitution of coal for coke the use of a less expensive form of carbon is possible. Furthermore, the volatile matter of the coal supplies a substantial portion of the heat requirements of the kiln. The kiln also provides a mixing action which is not obtained in the conventional processes, thereby creating an opportunity for intimate contact of the raw materials. When coals of high volatile content are used, it is necessary to design the kiln to effect and control the gradual release of the heat of the volatile matter along the length of the kiln. (3)

In the Strategic-Udy Process, the electrodes of the smelting furnace are slightly immersed in the slag, thereby generating a major part of the heat by slag resistance. The functions which take place in the hearth of the blast furnace in conventional operation; namely, the final reduction of iron oxides to iron, the melting and separation of metal and slag, and the removal of impurities from the metal, are all done in the electric furnace.

It will be recalled that submerged-arc electric furnace operation requires the electrodes to be deeply submerged in carefully-sized charge materials — Strategic-Udy, by contrast, operates with an "open bath", which permits the free escape of gases formed during the final reduction to iron. As a result, the Strategic-Udy Process possesses two major advantages: first, it permits the use of fine-sized raw materials; second, it permits the continual charging into the furnace of material with a relatively high percentage of metallization. The latter advantage results in greater production of iron with much lower expenditure of power and corresponding cost reductions. Further, electric power consumption follows a smooth, efficient pattern.

The open bath technique used in the Strategic-Udy Process also permits operation with closely controlled amounts of carbon reductant, thus increasing the precision with which the carbon and silicon content of the pig iron is maintained. This will insure quality control of the iron produced by this method and is another advantage of Strategic-Udy over conventional processes.

The separation of iron-making into two steps — kiln and furnace — provides an additional opportunity to reduce the amount of phosphorous or sulfur in the metal. The sulfur is partially oxidized and removed from the kiln as a gas and a portion of the phosphorous is also removed.

From 1955 to date, more than 50 different types of iron ore have been smelted in the Strategic-Udy pilot plant at Niagara Falls, Canada. While many of these have been low- or off-grade ores, far inferior to the Venezuelan ores, the versatility of the process makes possible the economic recovery of their metal values. This feature is vital to those countries which are not as fortunate as Venezuela in having an abundance of high-grade iron ores.

In 1961, a major step forward was made when the semi-commercial smelting plant was brought into operation at Niagara Falls, Ontario. During a preliminary iron smelting campaign a 1 to 2% silicon foundry iron was produced for 1227 KWH per ton. (4). This plant later switched to the production of charge grade ferro chromium from chemical grade chrome ore. (5).

The operation in Venezuela is the final step in the translation of Dr. Marvin Udy's original ideas to full scale commercial practice.

STRATEGIC-UDY IRON MAKING PROCESS AT MATANZAS

The Strategic-Udy Installation at the Orinoco Steel Plant consists of a rotary kiln and a modified electric furnace. The number nine furnace was selected as the unit to be converted because of its location at the end of the smelter building.

The Kiln and the Transfer System

The rotary kiln has a length of 107 meters and an inside diameter of 3.35 meters, reduced to a working diameter of 3.05 meters by the thickness of the brick lining. This kiln is capable of processing sufficient raw materials to produce 400 tons per day of hot metal from the furnace.

Ore, coal, and fluxes are transported by conveyor belts to five feed bins in four head houses located along and above the kiln. Precisely controlled quantities of material are metered by weigh belts into troughs and introduced into the kiln by means of scoops. The mixture of ore and flux is fed into the upper section of the kiln. Coal is introduced at four locations downstream of the ore feed.

Eleven forced-air fans, spaced along the kiln, govern the quantity of air introduced and thus control the rate and location of combustion. Kiln temperature is critical to successful operation.

The major portion of the heat requirement for the kiln comes from two sources: the combustion of volatile matter from the coal, and carbon monoxide from the reduction of the iron oxide. Supplementary heat at the present time comes from combustion of #6 fuel oil at the discharge end of the kiln. When furnace gas, now being flared, is recovered, it will be used instead of oil.

At the upper end of the kiln, directly after the dust chamber, is a fan capable of exhausting 125,000 cubic feet of gases per minute at 260 degrees Centigrade. This fan provides draft control for the kiln and removes the products of combustion.

Raw material flow, air pressures, temperatures, fuel feed, and speed of rotation of the kiln are automatically controlled from a centrally located panel at the discharge end of the kiln.

The hot, partially metallized, material from the kiln is transferred to the smelting furnace by a high speed telpher system using brick-insulated buckets with a capacity of three tons per trip. The weight and chemical analysis of material charged to the furnace is vital to quality control. Therefore, a scale car weighs the material at the discharge end of the kiln and samples are taken before transfer to the telpher system. The telpher car delivers the hot sinter to surge hoppers above the smelting furnace. The pneumatically operated outlet gates of these hoppers open automatically — delivering the charge material into the furnace in a uniform pattern. Throughout this operation, thermal losses are kept to a minimum.

The Furnace

Physical changes to the original furnace are few but of major significance. The most noticeable modification has been in the roof structure. It is now a flat, suspended roof made of basic brick rather than arched alumina brick. This permits operation at higher roof temperatures.

The inside diameter of the furnace is 11.38 meters, and the inside height from hearth to the underside of the roof is 4.93 meters. The standard furnace was modified by the installation of a cinder notch which is essential to the operation. The iron notch and the cinder notch are 0.61 and 1.22 meters respectively above the hearth bottom. Electrodes are the self-baking type, 1.5 meters in diameter, and spaced two meters apart, face-to-face. They are identical in size and composition with those used in the other eight furnaces. It is anticipated that the maximum electrical load for this furnace will be 22,000 KW.

The charge material falls onto the bank of fused ore and slag which has built up into a protective crucible around the furnace walls. It slides down into the high temperature smelting zone surrounding the electrodes where very rapid reduction to molten iron and slag ensues.

The absence of side-thrust on the self-baking electrodes, a feature of the Strategic-Udy technique, is a major advantage. It minimizes electrode breakage which would interrupt operation and incur additional expense.

The furnace operates normally on a six hour tap-to-tap cycle providing 100 tons of hot metal for the open hearth or pig casting machine. Feed is continuous during tapping. Slag is tapped as necessary to maintain the optimum resistance layer above the metal. Furnace off-gas is presently flared through an auxiliary stack. It will eventually be cooled and cleaned for use as supplementary fuel in the general plant system.

Preliminary Operations

All of the ore used to date has been fine material, screened out during the sizing of the feed for the other eight furnaces. These fines were used without agglomeration or other preparation.

In this initial phase of operation, both El Pao and Cerro Bolivar fines have been used. (See Table I).

There is little difference in chemical composition of the Cerro Bolivar fines and lump ore. The El Pao fines, however, contain substantially more gangue material (and hence less iron) than lump ore. In addition, the El Pao fines have been more variable in analysis.

Imported coal was used for initial start-up operations, pending the availability of Venezuelan coal from the Naricual mine. Naricual coal, when received, was introduced into the operation. A major objective of the Matanzas installation is the use of 100% domestic coal.

TABLE I

ANALYSES OF IRON ORE

A - CHEMICAL

	El Pao		Cerro Bolivar	
	Lump	Fines*	Lump	Fines*
Fe	61.55-65.00	46.74-52.42	58.00-61.50	59.08
SiO_2	1.00- 1.43	4.19- 8.06	0.45- 1.43	1.31
$Al_2O_3+TiO_2$	2.00- 4.68	3.32- 5.94	0.74- 1.92	2.54
Moisture	1.00- 5.98	3.20- 6.00	5.08- 9.33	8.10

* Used by Strategic-Udy

B - SCREEN

	El Pao Fines*	Cerro Bolivar Fines*
+3/4	0.0	0.00
-3/4 + 3/8	0.0	0.00
-3/8 + 4	9.0	0.00
-4 + 8	16.0	0.0
-8 + 16	17.0	0.40
-16 + 30	18.0	3.40
-30 + 50	17.0	2.64
-50 + 100	10.0	27.20
-100 + 200	7.5	- 100 66.34
-200	5.5	

* Used by Strategic-Udy

Table II shows typical analyses of the imported and the Naricual coal, and also shows the difference between the selected seam coal from the Naricual mine, and the run-of-the-mine — coal actually being employed in the process.

The flux materials used in the process— limestone, dolomite, and silica pebbles — are all available in eastern Venezuela.

TABLE II

TYPICAL ANALYSES OF COAL USED IN STRATEGIC-UDY

A - PROXIMATE ANALYSIS

	Naricual Coal		Imported Coal
	Selected Seam	Run of Mine	
Fixed Carbon	49.87	42.50-38.99	62.64-64.07
Volatile Matter	46.05	43.32-44.40	26.61-27.82
Ash	4.08	14.18-16.61	8.11-10.75
Sulfur	2.00	2.00- 3.00	0.70
Moisture		10-12	9

B - ASH ANALYSIS (Major Constituents Only)

	Selected Seam	Run of Mine	Imported Coal
Fe_2O_3	25.71	21.00	15.64
SiO_2	18.3	42.11	48.19
CaO	8.22	3.76	1.24
Al_2O_3	22.47	22.32	32.67
MgO	3.66	4.66	0.00
Fusion Point °C	1120	1100	1450

Operations to Date

Any discussion of the operations to date must of necessity concern itself with the problems which have prevented the unit from operating at its rated capacity and the manner in which these problems will be overcome.

The problems encountered in the operation of the Strategic-Udy plant at Matanzas have had nothing to do with the metallurgy of the process itself — only with the functioning of the mechanical and electrical equipment. Some were experienced in the existing smelter plant, and others in the raw material handling system.

Table II which illustrates the typical analysis of the Naricual coals shows that there is a marked difference between the run-of-the-mine and the selected seam coal. The major problem encountered in handling this coal resulted from the moisture content combined with the clay content of the ash which caused it to compact readily. The selected seam coal on the other hand, has a much lower ash content and is less susceptible to compacting when wet. When the coal reached the storage bins it compacted and bridged across, consequently, feeding became difficult and at times impossible.

There are various possible solutions to the problem: Washing at the mine, heating and drying at the smelter, or redesigning the bins and material handling system so as to make the material flow. This is a highly volatile coal, which tends to spontaneously ignite if heated and dried — therefore the necessary mechanical changes are being made to permit the material to flow easily from the bins. This entails relining the bins to give a steeper slope and providing a new type of feeder at the outlet which will handle this wet and sticky material.

Similar problems were encountered with the iron ore fines. During the rainy season, the stockpile becomes very wet and because the ore is not treated in either the sinter plant or the drier it is hard to feed from the bins.

The iron ore bins are being modified in a manner similar to the coal bins although at present it is felt that no changes will be required in the feeders.

The intermittent operation of the kiln and furnace due to feeding problems has resulted in excessive wear on the refractory. The furnace roof is constructed from suspended basic refractories and the resistance of these refractories to variations in temperature is slight. Normally, once the furnace is operating at its designed power loading, there is very little change in the temperature within the furnace and a reasonable roof life can be expected. At Niagara Falls in smelting chrome ores to produce charge grade ferrochrome, the roof was found to be in excellent condition when the furnace was shut down after almost one year of continuous operation. This condition prevails despite the fact that the furnace operates at a temperature about 200°C higher when smelting chrome ores than it does when smelting iron ores. However, at Matanzas wide variations in temperature within the furnace were experienced for the reasons outlined above and as a result severe spalling occurred in the delta zone of the roof, and this section had to be replaced.

The design of the kiln nose brick was based upon that used in other commercial kiln operations and proved unsatisfactory in practice, resulting in a loss of brick. The nose ring brick design has been altered to obviate this problem and a new nose ring installed.

The scale car and telpher system used to supply the furnace is the same in design and construction as that used on the other furnaces and while it appears adequate at this time, it is being modified to assure continuity of operation at the increased tonnages to be handled when the plant is operating at its design capacity. This is important since the balancing of power input against material feed is one of the key controls in the process.

In conclusion the initial operations of the Strategic-Udy plant at Matanzas showed that because of the moisture content of both the coal and the ore and also the high clay content of the coal difficulties arose in the materials handling system, and as a result insufficient material was charged to the system to permit operation at the rated capacity.

Modifications to plant and equipment are now being made to permit these materials to be handled readily irrespective of the physical condition, and within a few months the plant should be operating at or above its designed capacity.

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