Duplex process for production of low carbon ferrochrome

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ABSTRACT

The Duplex Process for the production of low carbon ferro chrome has been highlighted and its advantage over Perrin process has been brought out. The production of Low Carbon Ferro-chrome in Perrin process demands rigid operating conditions compared to the Duplex process. The life of the refractories in the Duplex process are also longer compared to Perrin process and the specific raw material consumption and energy are comparable. The demand for Low carbon Ferrochrome is reducing due to adoption of V. O. D. and A. O. D. process in India by the major stainless steel manufacturers. However, the importance of Low Carbon Ferrochrome will continue for a few years till the new process of stainless steel manufacture are adopted by all.

Introduction

The metallurgical use of chromium is in the form of ferrochrome for production of stainless steel and other special steels, namely, heat resisting, high speed, alloy, tool, etc. The ferochrome in the following categories are being utilised for stainless steel production and they have the following approximate composition :—

	%Cr.	%C	%Si	%S	%P.
1. Charge chrome	50-60	6-8	3·6	.05max	.05max
2. High Carbon Ferro-chrome	60-72	4-8	1.5-4	.05	.05
3. Low Carbon Ferro-chrome	65-75	.05max	1.5max	.05	.05
4. Silico-chrome	35-41	.05max	39-45 max	—	—

The Indian standard for low carbon ferrochromium for various grades specifies as follows as per I. S. –1170—1967 :

Cr. — 60-75%
C. — .025-1% max.
Si — 1.5% max.
S. — .05% max.
P. — .05% max.

There is a trend in the world to increase consumption of chargechrome and high carbon ferrochrome due to change in stainless steel technology by adoption of A. O. D. and V. O. D. processes. The consumption of low carbon ferrochrome is going down day by day as charge chrome and high carbon ferrochrome prove to be much cheaper and is successfully used in the above processes. In India the major stainless steel producers like alloy steel plant, VISL, Jindal Strips, Mukand Iron and Steel have already decided in favour of the new technology

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for stainless steel production and others may join in the near future. However, the requirement of low carbon ferrochrome will continue for some time in India as the smaller units will be slow in adoption of new process due to economic reasons. The importance of low carbon ferrochrome as such will continue to stay for few more years in our country although the total demand will be diminishing from 1983 onwards drastically.

The low carbon ferrochrome is being produced in the world by various processes, namely :—

1) Perrin Process.
2) Duplex Process.
3) Simplex Process.
4) Triplex Process.
5) Fusion Process.

In the Perrin process silicochrome is produced in one of the smelting furnaces from the raw materials directly and chrome ore and lime melt is produced in another furnace. The silico chrome produced contains about 35—43% Si, 38—40% Cr. depending on the chromium iron ratio of the ore and with .03% C to .05% C. The slag produced in the slag furnace has about 24—26% chrome oxide and 40—46% lime. The rest are SiO_2 MgO, Al_2O_3 and FeO. The slag so produced is allowed to react with silicochrome in a cyclic manner as shown in Fig. - 1. The

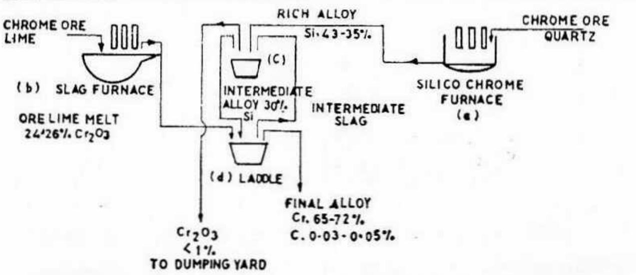

FIG. 1 — FLOW SHEET OF PERRIN PROCESS

Perrin process has been adopted in different plants with certain modifications by many producers. The molten SiCr is reacted with an intermediate slag produced from 'd' containing about 14% Cr_2O_3 which produces a final slag with 1% Cr_2O_3 and the semi-product contains about 25—30% Si. The rich slag from 'b' reacts with intermediate semi-product with 25% Si from ladle 'c' to produce the final low carbon ferrochrome alloy. The approximate power and raw material consumption for making a ton of low carbon ferrochrome by this process are as follows in some plants :—

Name of raw material	Quantity / M. T.
Limestone	2.5 — 2.6
Chrome ore (depending on the analysis of ore)	1.44 — 1.5
Silicochrome	0.66 — 0.7
Electrode paste	0.022 — 0.025
Electrical energy (excluding requirement for SiCr Prodn.)	3,200-3,500 Kwh.

The above consumption will vary depending on the analysis of the raw material and scale of operation. The overall recovery of chrome is 90—92% in this case. The finished product will have carbon less than .03% and Si - 1.5%.

The Duplex process is much simpler and uses silicochrome in the solid form. The process can be best understood from the flow-sheet in Fig. - 2. The process consists of the use of

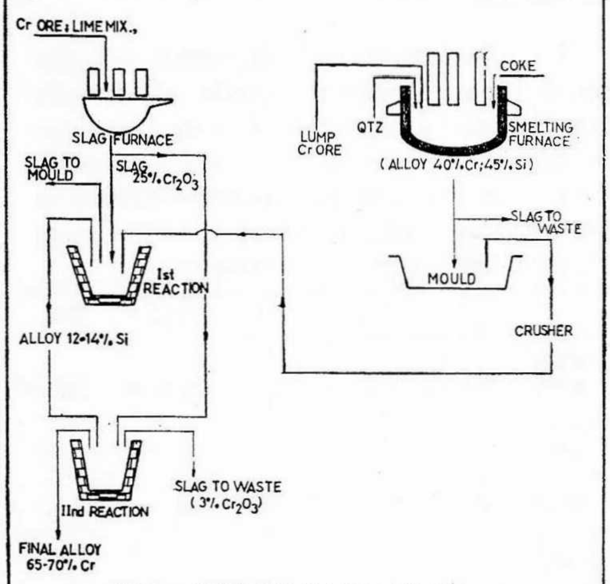

FIG. 2 — FLOWSHEET OF DUPLEX PROCESS

silicochrome of the following composition in solid form :—

Cr. — 38–40%

Si. — 43–45%

C. — 0.03–0.05%

The silicochrome produced is crushed to size 5—10 mm. The ore lime melt, i.e., the slag produced in arc furnace is tapped to a ladle outside the furnace. The slag has a composition of about 25—28% Cr_2O_3 and 40% CaO. The powdered silicochrome is vibrated into the ladle and the weight of alloy being controlled to give an alloy of 12—14% silicon. The quantity of silicochrome will depend on the :

a) analysis of the silicochrome,
b) analysis of ore lime melt,
c) the desired analysis of the final product,
d) the recovery of the material in the reaction, and
e) the thermo metallurgical condition which determine the temperature cycle of the reaction and the temperature of the final product.

The metal and slag from the reaction ladle are poured into a transfer ladle for good mixing. The purpose of this is to have the reduction of the Cr_2O_3 of the slag as complete as the metallurgical equilibrium condition permits. The slag is poured out which has a Cr_2O_3 content of about 1% After pouring out of the required quantity of slag the metal is again brought back to the furnace and a fresh batch of ore lime melt is reacted with the same to reduce the silicon content to 1% or less. A small amount of excess slag is used for desiliconisation going practically to completion and final slag contains about 3% Cr_2O_3. This is somewhat higher than that in Perrin process.

In Perrin process the reaction takes place in liquid stage and the temperature attained is much higher as the reactions are exothermic. The high temperature produced in the process forms favourable conditions for the reaction of carbon deoxidisation and high utilisation of silicon from Silicochrome. However, this process requires synchronising the operations of two or more furnaces. This may create further complications in Indian conditions where power supply is very unsteady. In contrast the Duplex process where crushed Silicochrome is used is simpler as it does not require synchronisation in tappings of two or more furnaces. In the Duplex process the final temperature of reaction is less compared to Perrin process and results in low concentration of silicon in the metal and also the loss of Cr_2O_3 in slag is comparable. Due to higher temperature in the Perrin process and higher silicon in the intermediate metal, the life of the ladle lining is comparatively less than that in the Duplex process. The raw materials and power consumption are marginally higher in the Duplex process. There is no chance of explosion in the Duplex process and the process is very safe to handle compared to the Perrin process. The process was tried at Ferro Chrome Plant and gave very encouraging results. It can be adopted by any plant for its simplicity and safety.

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