

Low carbon high chromium alloy without low carbon ferro-chrome

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AS AN alloying element, chromium is a component of numerous grades of steels and special alloys. It is well known that steel alloyed with chromium acquires valuable physical properties.

Due to the beneficial effects on mechanical and chemical properties of steel, chromium is widely used in the manufacture of structural, tool and special steel.

Because of the useful properties of chromium steel it plays an important part in the construction of many machine parts and equipment for handling and production in a modern steel plant.

For smooth running of the plant it is essential that the supply of the spare parts for the equipment should be uninterrupted. But due to very limited reserve of our foreign exchange it is neither possible nor advisable to import all spares and equipment needed to run the existing industries. Quite a few of these can be manufactured from indigenous resources.

An attempt has been made in the present paper with regard to the development of a low-carbon-high-chromium alloy (without the low-carbon-ferro-chrome, which is an imported product). With the use of this alloy different types of chrome steel necessary for various spare parts of the steel plant could be made either in the plant or in the country. The low-carbon-high-chromium alloy will certainly be also of great use to our Alloy Steels Plants and other manufacturing units in this country.

Experimental procedure

With this in view, in the laboratory, a few heats have been worked out to find the best procedure to produce a chromium bearing alloy so as to utilise the same for making any desired alloy required in the plant.

The experimental procedure consists of the following steps :

- (i) Chromium ore crushed to 3 mm size and Fe-Si to about 10 mm size and burnt powdered lime were taken for the experiments.

- (ii) The experiments were undertaken in a gas fired crucible furnace in which the temperature could be raised up to 1700°C.

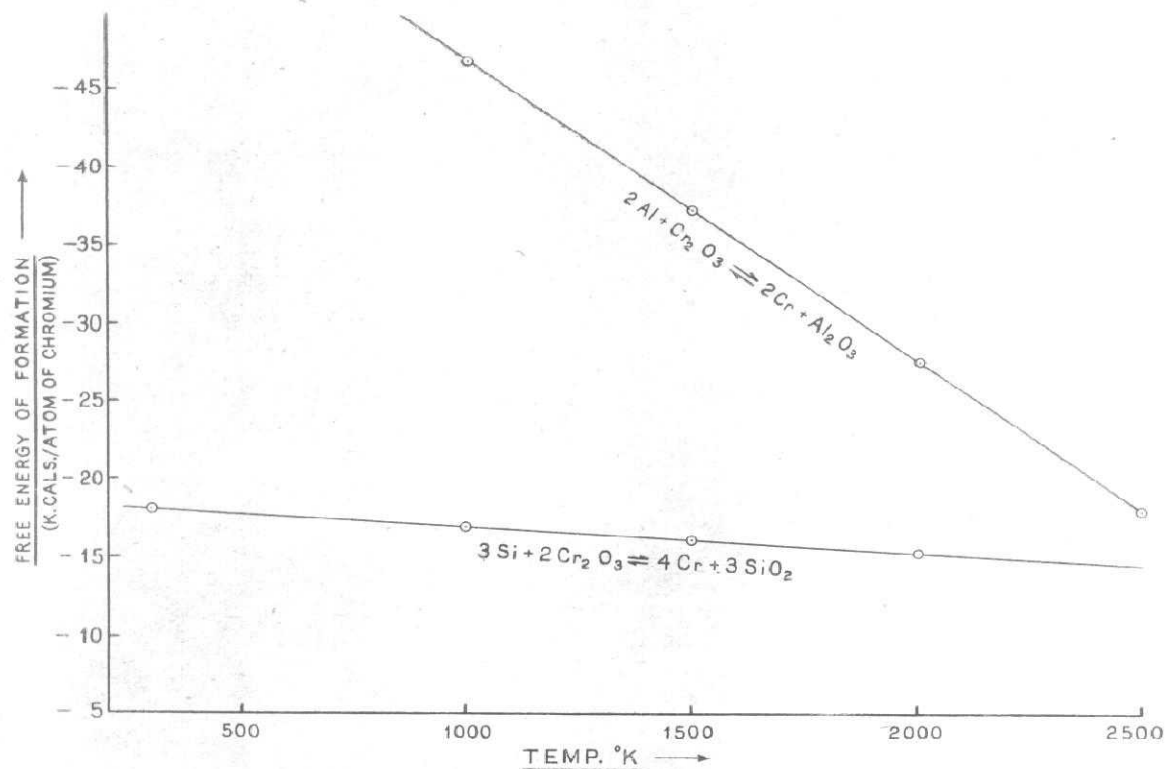
- (iii) For want of any ready made crucible about 3 kg. capacity crucibles were made in the laboratory from magnesite powder after ramming it into a suitable container as a mold.

A. For experiment No. 1 and 2.

- (a) Weighed quantities of scrap were first melted and then chromium ore (powdered) and lime were added.
- (b) At about 1650°C calculated quantity of ferro-silicon was gradually added.
- (c) The process of additions of chrome ores, lime and ferro-silicon were repeated at intervals until all the pre-determined quantities of charge were added up.
- (d) Samples of metal and slag were collected at intervals before each addition.
- (e) The charge was then tapped and final samples were collected for analysis.

B. With the object of getting better results the above procedure was modified as below for experiment Nos. 3 and 4.

- (f) A mixture of chrome ore and burnt lime was first charged into the crucible and was heated up to the fusion temperature (around 1700°C), and then gradually calculated amount of ferro-silicon was added.
- (g) When the charge had melted down completely a weighed quantity of scrap was added to facilitate the separation of metal and slag, as well as to bring down the chrome content of the alloy to the steel composition range.



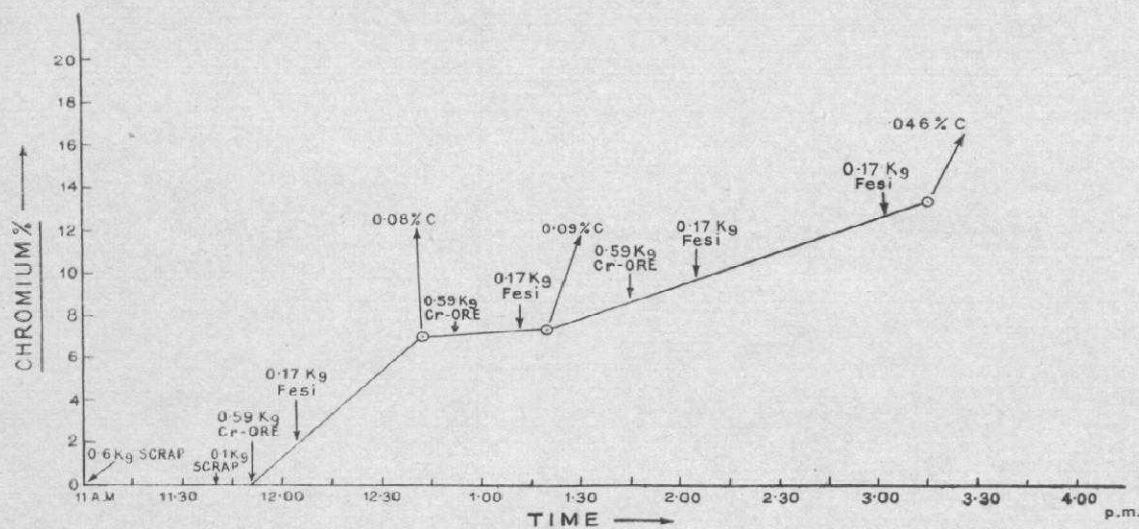
1 Change of the free energy curve with temperature

TABLE I Analysis of raw materials

Raw materials	Cr ₂ O ₃	FeO	Fe ₂ O ₃	Si	SiO ₂	Al ₂ O ₃	CaO	MgO	C	L.O.I
Chromium ore	50.0	16.0	—	—	4.0	9.0	2.7	17.6	—	—
Burnt lime	—	—	1.80	—	4.9	1.04	75.35	—	—	12.68
Ferro silicon	—	—	—	77.0	—	—	—	—	0.14	—

TABLE II Experimental results

Sr. No.	Analysis of alloy			Wt. of Alloy	% Reco- very of Chromium	Charge			
	Cr%	C%	Si%			Scrap	Cr-Ore	Fe-Si	Lime
Experiment No. 1	13.2	0.046	10.83	1.42 kg	32.8%	0.7 kg	1.77 kg	0.68 kg	—
Experiment No. 2	22.9	0.06	29.2	2.47 kg	64.5%	0.6 kg	2.36 kg	0.68 kg	1.5 kg
Experiment No. 3	60.5	0.07	1.39	0.80 kg	76.9%	ml	1.85 kg	0.36 kg	1.48 kg
Experiment No. 4	46.7	0.08	0.98	0.665 kg	80.0%	0.16 kg	1.14 kg	0.21 kg	0.91 kg

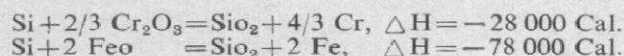


2 Experiment No. 1

Experimental results and discussion

The analyses of the raw material and the experimental results are given in Tables I and II.

Reduction of the chrome ore by silicon from ferro-silicon takes place according to the reactions.



The exothermic nature of the reaction indicates that at high temperature the reactions are less complete than at lower temperatures. This is indicated by the change of free-energy curve with temperature shown in Fig. 1. The figure shows that the over-all free energy change for the reaction per mole of chromium decreases with the size of temperature. But at lower temperature owing to the viscosity of the high chromium slags, the diffusion processes are greatly retarded and the rates of reaction fall considerably. Reduction of iron from ore oxides however helps the reaction from left to right, at the same time it lowers the melting point of the melts. From thermo-dynamical data it can be seen that a low silicon content, ferro-chromium may be obtained with a high chrome oxide concentration in the slag.

The equilibrium value for the reduction of chromium and iron is favoured by the addition of lime (decreasing the activity of silica). The higher the basicity of the slag the less free silica will be there in the slag and hence less silicon will remain in the metal and the less chromic oxide in the slag.

This can be easily seen from the results of the heats in experiments No. 1 and No. 2, shown graphically in

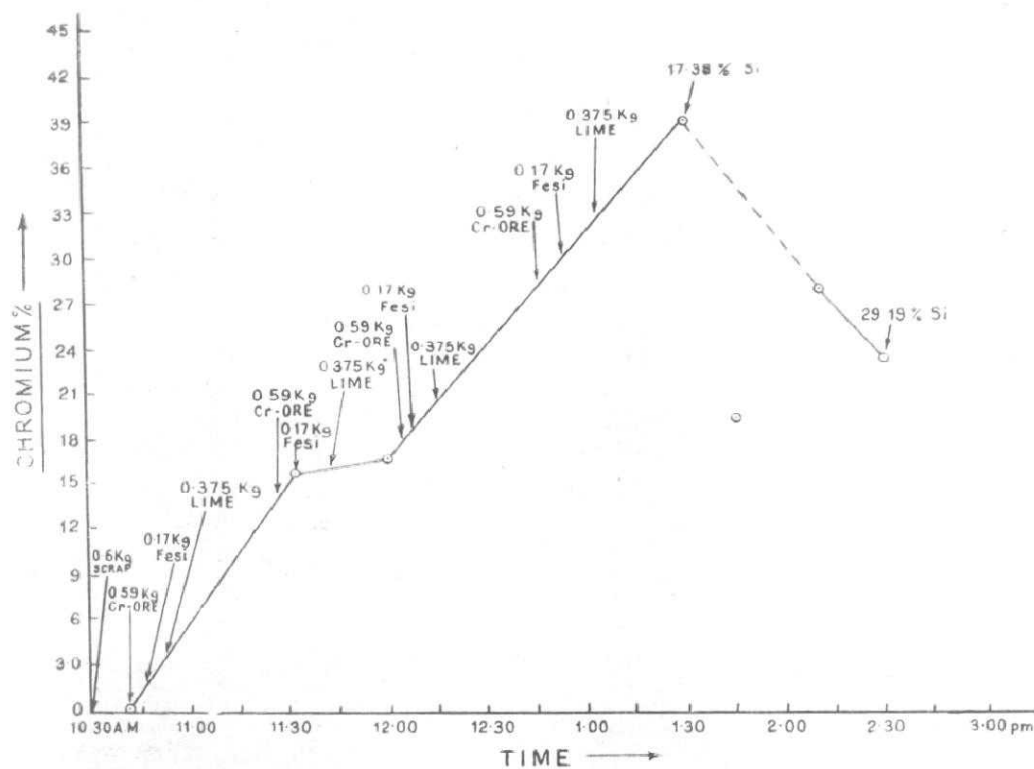
Figs. 2 and 3. In the experiment No. 1 no lime was added and hence the recovery of chromium in the melt was poor as can be judged for the chromium analysis of the final melt. In the experiment No. 2 sufficient lime was added in stages to have an overall slag basicity of 2.2 leading to a better recovery of the chromium. The results are shown in Table II.

But from the results of experiment No. 2, it was felt that for a still higher recovery of chromium from the ore, the temperature of the bath should be raised and at the same time, the reduced chromium and the silica released should not be kept in contact for a long time at that temperature as is evident from the fall of percentage of chromium in the melt on continued exposure to higher temperature.

The recovery of chromium in the experiment No. 3 was high and was of the order of 77% chromium of the ore. But without any addition of scrap, the ratio of the alloy to slag was 1 is to 3.53 and this is too low for any effective separation of alloy and slag. Because of high volume and viscosity of the slag some entrapped alloy was found in the slag. In order to avoid this, in the experiment No. 4, after the addition of ferro-silicon a little quantity (weighed) of low carbon scrap was added on the top of the slag before tapping the alloy. This however decreases the percentage of chromium in the final melt, but it facilitates the separation of alloy and slag as it helps to wash out the entrapped alloy from the slag.

Conclusion

So far no low carbon ferro-chrome is manufactured in



3 Experiment No. 2

India. But due to urgency of spare parts and non-availability of low-carbon ferro-chrome, the above method of production of a master alloy containing different percentages of chromium has been developed in the laboratory utilising indigenous raw materials. By certain effective modification as indicated in the discussion the recovery of chromium from chrome ore may be made high.

Acknowledgement

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