Industrial Application of Dense Media Separation for Recovering FeCr Entrained in Slag and Discarding Slag Admixed with FeCr Fines

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ABSTRACT

In smelting of FeCr the losses that occur are usually of the order of 6 - 8% Cr that report in the slag. Most of this is in the form of oxides that cannot be recovered, but a small percentage, usually 15 - 20%, is in the form of FeCr alloy that can be recovered by gravity methods.

Also in casting the FeCr melt some slag is admixed with the alloy which on crushing reports on the fine size fraction thus reducing their market potencial. The recovery of the FeCr entrained in the slag and the removal of the admixed slag in the fine sizes of crushed FeCr, can be easily and succesfully attained by Dense Media separation. In the present paper details of industrial practice of DMS in the Hellenic Ferroalloys smelter are given and the economics of the process discussed.

The FeCr smelter of the Hellenic Ferroalloys S.A. situated by the Gulf of Volos in Almyros, Greece, started operating in May 1983 by smelting high grade chromite concentrates from its own mines in Kozani Northen Greece.

The smelter is now operating at full capacity producing annually 36,000 t FeCr with 60-64% Cr and 40,000 t slag with 6% Cr.

Of this slag, half is granulated slag containing 4% Cr and other half coarse containing 8% Cr.

Right from the beginning it was established that some FeCr was carried away with the slag and some slag reported with the FeCr. The reason for this can be explained by examining the tapping and casting procedure.

On tapping, the FeCr settles in the bottom whilst half the slag floats on top, with the remaining other half overflowing and directed to water pool where it is granulated.

This granulated slag contains about 4% Cr mostly in the form of oxides and is not recoverable.

The laddle with the molten FeCr/slag melt is removed from the furnace and tilted in order to discard the floating slag. In this procedure it is not possible to get an absolute clear split and some FeCr is carried away forming thin sheets on cooling. Tests have shown that on crushing this slag to (-60)mm the FeCr is easily liberated, contains about 60% Cr and represents about 40% of 8% elemental Cr, contained with the slag according to following distribution:

-60+30	37%	with	1%	FeCr	or	0.22%	Cr
-30+10	31%	with	6%	FeCr	or	1.12%	Cr
-10+ 3	17%	with	10%	FeCr	or	1.02%	Cr
- 3	15%	with	11%	FeCr	or	0,99%	Cr
Total	100%					3.35%	Cr

It will be shown that of the 20,000 t annual production of coarse slag about 95% of this FeCr can be recovered increasing the contained Cr metal production by:

212	tons	Cr	from the	-30+10	fraction
194	tons	Cr	from the	-10+ 3	fraction
188	tons	Cr	from the	- 3	fraction

After tilting, a small amount of slag remains in the laddle which on casting rest on top of the FeCr as a thin film. On crushing the cast FeCr (-80)mm all of this slag reports in the (-30)mm fraction which renders it inferior in quality and difficult to market. If this small amount of slag could be removed the quality would be improved at the expense of quantity and if the expense of removal is included the net economic result would be negative. However the policy of the company is to market as clean as possible FeCr and it is of primary importance that this small amount of admixed slag must be removed even if a relatively small economic loss is entailed.

Accordingly research was initiated to find the best method for removing the slag from the FeCr and recovering the FeCr entrained in the coarse slag. From the initial tests that were carried out it was found that mangnetic methods were ineffective.

Jigging was effective for the (-10+3) fraction and tabling gave excellent results for the (-3) fraction. However for the (-30+10) fraction, which was the most important commercially, jigging proved ineffective and with a poor recovery. Dense media separation was also considered but there are some doubts as to its applicability since although the FeCr has a density of 7.0 gms/cm^3, that of the slag varied from 3.3 to 3.6 gms/cm^3 and hence a medium density of at least 3.6 gms/cm^3 would have to be used. It was decided however to carry out batch tests in a small 60 litre capacity cone pilot unit using special coarse atomised FeSi and operating with density of 3.6 gms/cm^3.

The batch test proved very succesfull for both the (-30+10) and (-10 + 3)mm size fraction with a recovery about 95% but it was not possible to answer two vital questions in order to justify the capital investment for an industrial Dense Media unit. Could a medium density of 3.6 gms/cm^3 be substained in practice and what would be the operational costs?

Fortunately the company had in its mine an old dismantled DMS drum unit 1.8 m in diameter and with a rated capacity of 15 t/h when treating (-25+5)mm chromite ore with a medium density of 2.65 gms/cm^3 (preconcentration). It was estimated that this unit could be placed in operation at a fraction of cost for a similar new one. And it was therefore decided to go ahead with the project.

The unit was finally set-up, and is now in operation since October 1985 with results that conclusively prove that DMS is applicable in removing admixed slag in the FeCr and recovering FeCr from slag, both from the (-30+10) and (-10+ 3)mm size fraction respectively.

From the results of six months operation the following facts were established.

a.- It is not necessary to operate at a density of 3.6 gms/cm^3 and with a density of 3.3 gms/cm^3 separation a recovery of 95% is attained. This is due to the viscosity effect which has no influence on the heavy FeCr but hinders the settling velocity of the slag.

b.- The capacity of the unit is 10 t/h and 5 t/h feed for the (-30+10) and (-10+3)mm size fraction respectively.

c.- The total power draft including conveyor belts and water reclamation circuit is 70 kW.

d.- The FeSi consumption is 1.5 kg/t feed which is considered somewhat excessive. This is mostly due to the old equipment used and in a modern unit it should be considerably reduced.

e.- Two operators are required per eight hour shift. These were originally unskilled labourers, but quickly picked up the relatively simple functions of the unit.

Although technically DMS has proved succesfull in our company's FeCr smelter, the question remains as to whether in an another FeCr smelter with the same conditions, its applications is an economic proposition. The answer to this can be given by considering the following operating cost analysis.

Annual feed for the treatment:

7200 t	(-30+10)	FeCr at	10 t/h	= 720 h
4300 t	(-10+ 3)	FeCr at	5 t/h	= 864 h
6200 t	(-30+10)	slag at	10 t/h	= 620 h
3400 t	(-10+ 3)	slag at	5 t/h	= 680 h
21120 t feed				=2884 h

That is about 360 eight hour shifts of operation with an annual operating cost of:

Personnel	360 x 2 x $30	$ 21600
Power	360 x 8 x 70 x ¢ / kWh	12096
FeSi	21120 x 1.5 x 55 ¢ / kg	17424
Spares and maintenance		10608
Total		$ 60000

Now, without taking into account the improved marketing conditions of the cleaned FeCr, although the expense of removal of the admixed slag has been included, the annual recovered FeCr from the coarse slag contains

212 t Cr in the (-30+10) fraction and
194 t Cr in the (-10+ 3) fraction

Even with the lowest market prices for contained Cr metal in FeCr, the annual revenue is of the order of $290.000 or a net profit of $230.000 if the operational costs are subtracted. As to the capital investment for a new modern DMS unit of the same capacity (1.8 m diameter drum) this is of the order of $ 300.000 installed.

This means that practically the capital investment can be paid off in less than two years.

In conclusion it can be stated that Dense Media separation is an efficent and economic method for recovering FeCr from slag and removing slag admixed in the FeCr.