Decarburization of High Carbon Cobalt Metal

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RECENTLY this laboratory undertook the task of preparing some low carbon metallic cobalt by the carbon reduction of precipitated cobalt oxides. The oxides came in two lots and had the compositions given in Table I. Industrially, cobalt rondels¹ are made by the carbon reduction of cobalt oxide in small reverberatory furnaces at temperatures near but not above 1050°C. This is a slow and tedious small batch process but does give cobalt metal which is low in carbon (1 pct C).

Inasmuch as these cobalt oxides were relatively low in copper and iron it was decided to reduce them with petroleum carbon in a small three-phase electric arc furnace of about 3 to 5 lb of metal capacity.² It was hoped such a procedure would save considerable time and perhaps also indicate an improved commercially feasible process.

The furnace was preheated by using small pieces of carbon electrodes to maintain the arc until a temperature of 1500°C was reached. The broken pieces of electrodes were then removed and 500 g of the cobalt oxides and 60 to 100 g of petroleum coke added. At the end of the reduction reaction, a high lime flux was added to the furnace to facilitate the removal of sulphur.

Due to the fineness of the cobalt oxide powder used and also to the presence of chlorides there was considerable dust lost in charging the furnace. This was overcome by preparing briquettes composed of the cobalt oxides, charcoal, and a little bentonite to serve as a binder. The results obtained are summarized in Table II, which shows that the cobalt metal produced in the arc furnace was high in carbon varying from 2.5 to 3.5 pct. This, of course, is much too high. For certain uses, such as in the preparation of permanent magnets, the carbon content of cobalt must be low. It was necessary therefore to find an effective method of reducing the carbon content of the cobalt that had been prepared in the arc furnace.

Van Arkel³ recommends the use of Co_2O_3 as a means of removing carbon from cobalt. Experiments by the authors indicate that carbon is removed with difficulty by this method. Other methods used, including lancing of the molten high carbon cobalt with a jet of oxygen, proved to be ineffective. The method finally used makes use of the fact that cobalt metal is decarburized by carbon dioxide at the temperature of the molten metal.

Two methods were used: 1—carbon dioxide was bubbled up through the molten cobalt, and 2—molten cobalt was maintained in a carbon dioxide atmosphere. In the first method the gas was introduced below the surface of the molten metal by means of a quartz tube. A high frequency induction furnace was used to keep the cobalt molten in both of these experiments. This kept the metal somewhat agitated and no doubt was an important factor

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Table I. Composition of Cobalt Oxides

	Co, Pct*	S, Pct	Cl, Pct	Cu, Pct	Fe, Pct
Lot 1	65.5		2.9	1.2	
Lot 2	59.5	0.17	7.9		1.4

* There was approximately 1 to 2 pct Ni present.

Table II. Carbon Reduction of Cobalt Oxides in a Three Phase Electric Arc Furnace

Exp. No.	Charge		Power Used, Kw-hr*	Reduction Time, Min	Metal Recovered, g	Recovery of Co-balt, Pct	Assay, Pct C**
	Cobalt Oxide, g	Carbon, g					
1	500	110	4	41	327	99.5	3.5
2	500	60		40	184	55.9	0.9
3	500	90	5.1	45	291.5	91.0	2.87
14	500	100	3.3	41	180	63.2†	2.5
32	483‡	96	1.1	19	251	88.0	

* Power used in a large furnace operation would be very much more favorable.

** Carbon determined on a standard combustion boat and Orsat-type carbon analyzer.

† Temperature not high enough at time of pouring resulting in viscous slag shotted with metal.

‡ Briquettes of cobalt oxide, carbon, and bentonite used.

Table III. Decarburization of Cobalt Metal with Carbon Dioxide

Exp. No.	Total Time Metal is Molten, Min	Total Time Metal is Lanced with CO_2 , Min	Type of Lancing	Analysis	
				Head Sample, Pct C	Product, Pct C
8	10	4	Submerged	2.4	1.44
9	15	6	Submerged	1.44	0.22
10	10	7	Submerged	0.50	0.012
27	61	31	Submerged	2.6±2	0.03
28	98	42	CO_2 atmosphere	2.25	0.003*

* Beyond the limits of accuracy of the carbon determination.

in hastening the decarburization process by the second method. Both methods gave satisfactory results as shown in Table III. An interesting observation in connection with this work was that a small sample of carburized cobalt metal could be decarburized by heating it with an acetylene torch adjusted to give an oxidizing flame. This may have been due to the presence of carbon dioxide in the products of combustion.

Samples of molten high carbon steel were decarburized by the same method and it is suggested that nickel and perhaps manganese can be decarburized in a similar manner. Additional work, including rate studies and other theoretical aspects of this problem, is in progress in this laboratory.

References

- ¹ Roland S. Young: *Cobalt*. A.C.S. Monograph No. 108, Reinhold Publishing Corp. New York (1948).
- ² W. Martin Fassell, James P. Blackledge, and J. Hugh Hamilton: A Three Phase Direct Arc Furnace for Laboratory Use. Utah Engineering Experiment Station Bull 49 (April 1951).
- ³ A. E. Van Arkel: *Reine Metalle*. (1939) Berlin. J. Springer.