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PREPARATION OF TITANIUM BORIDE IN AN ARC FURNACE

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Titanium diboride is being evaluated as a substitute cathode material in aluminum cells for energy savings. A reduction of approximately 1 volt in the cell voltage and 20% power savings have been reported. Various methods of preparation of titanium boride include arc melting of TiO_2, B_2O_3 and carbon mixture. Conditions for the preparation of TiB_2 in a 60 KVA arc furnace have been worked out and the results presented. 95% TiB_2 was obtained.

Key words: TiB_2, arc furnace

INTRODUCTION

Titanium boride is an important refractory hard metal possessing very high melting point (2920°C) and hardness value of 9 on Mohs scales. It is practically resistant to oxidation upto 1500°C and has a high thermal conductivity. Titanium boride is an excellent electronic conductor with a conductivity of 28.4 microhm cm at 20°C and becomes superconducting at 1.26K [1].

The invention in 1952 [2] that TiB_2 is wetted by molten aluminium initiated many developmental programmes which culminated in a continuously drained cathode in the aluminium cells. The main advantage was the reduction in the anode-cathode spacing of 20 mm as compared with the usual 45 mm in aluminium cells. This eliminates the severe voltage fluctuations and loss of current efficiency produced by distortion and erratic movement of the conventional liquid cathode viz. aluminium, thereby leading to 20% energy conservation [3].

Titanium boride is applied in the Hall-Heroult aluminium cells as such or as cermets or as a thick coating over graphite [4,5]. A mushroom shaped cathode with the horizontal upper surface facing the anode was reported to cost only 30% as much as the solid cylinder [6]. Composites of TiO_2 with graphite have also been reported in the literature [7]. By the application of titanium boride, cathode drop can be considerably reduced and various types of cell structures also become feasible [2].

Titanium boride can be prepared by a number of methods [8]. High purity TiB_2 was prepared at Central Electrochemical Research Institute (CECRI) by the electrolysis of molten NaF - NaCl - B_2O_3 - TiO_2 at 800°C [9]. The conditions for the preparation of arc melted borides of high temperature metals at high pressures of Ar have been reported [10]. Ferrotitanium and ferroboron were reacted at $>$ 1700°C to give TiB_2 crystals [11]. Chemical vapour deposition of TiB_2 by the hydrogen reduction of a mixture of $TiCl_4$ and BCl_3 was studied to obtain a thick and uniform coating [12]. The preparation of pure TiB_2 powder of uniform size by heating TiH_2 at 900°C in a stream of H_2 and BCl_3 has also been reported by a Japanese firm[13]. Results of the preliminary studies for the preparation of TiB_2 employing a 60 KVA arc furnace at CECRI have already been reported [14] in which the boron contents of the TiB_2 did not exceed 21%. Hence studies were continued to standardise the conditions for producing this material of better quality in the arc furnace.

EXPERIMENTAL

A 60 KVA arc furnace was employed in all the experiments in which varying compositions of TiO_2, B_2O_3 and C were employed and molasses was used as binder to make briquettes for preventing loss of charge during experiment. Currents of 600-1000 amperes were fed at 25-30 volts and the durations of the experiments were 45-60 minutes. The weight of the charges varied between 6 and 10 kg of the raw materials and 300 to 500 g of the product was obtained which was analysed according to the standard procedure reported [15].

Typical results of the experiments conducted in the arc furnace are presented in the following Table.

Table I: Data collected for the preparation of TiB_2 in a 60KVA arc furnace

Sl. No.	Composition of charge (in proportion by weight)			Chemical analysis (%)		
	TiO_2	B_2O_3	C	Ti	B	Rest
1	1	1	1	56.2	22.8	Others
2	1	1	2	51.5	22.46	”
3	1	1	3	43.9	23.50	”
4	1	2	1	62.3	32.05	”
5	1	2	0.75	64.75	30.5	”
6	1	2	0.9	62.8	32.8	”

RESULTS AND DISCUSSION

From the Table it is observed that increasing the composition of carbon in the charge in experiments 1 to 3 results in decrease of both the percentages of Ti and total TiB_2. Presumably the product is contaminated with carbon. In the experiment No.4, the B_2O_3 alone in the charge was doubled and as expected, this resulted in substantial improvement in the quality of the product. In the next two experiments, keeping the TiO_2 and B_2O_3 the same, the carbon contents were slightly varied and this has altered the percentage of

Ti and B only very slightly. It is also clear from experiments 4 to 6 that charge compositions of 1:2:0.75 to 1 of TiO_2, B_2O_3 and carbon yield TiB_2 of around 95%, the rest being mostly carbon in the free and combined state. Molten metal borides usually contain 3% carbon and boron carbide [16]. However these impurities can be removed by reheating the boride samples with additional TiO_2 or B_2O_3 at temperatures ranging from 1300-1900°C.

CONCLUSION

Titanium boride of around 95% purity has been produced in the experimental arc furnace. Further studies are in progress to eliminate the impurities.

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