TESTING OF SOME REFRACTORY AND ELECTRODE MATERIALS FOR LIQUID ACTIVE WASTE VITRIFICATION FURNACES

G. B. Borisov, A. S. Polyakov, and Z. S. Khasanov
Academician A. A. Bochvar's All Union Scientific
Research Institute of Inorganic Materials

ABSTRACT

In connection with the development of a pilot-commercial furnace for liquid active waste (LAW) vitrification, this paper presents some results of corrosion resting a tin dioxide electrode with an uncooled metallic current lead and a furnace brickwork made of zirconium oxide and chromium oxide base bricks. The tests were conducted in a furnace for model LAW vitrification to produce borosilicate glass of high iron and sulphur contents. This paper describes some features of the electrode operation and the corrosion of the furnace refractory brickwork.

INTRODUCTION

The following materials well-known for their high glass-resistance are being tested as possible materials for the bath of the pilot-commercial vitrification furnace:

- Zirconium and aluminum oxides based on fused refractories (bakor 33, 41);
- Chromium and aluminum oxides (XAU-30), which in Europe are called ER-1681, 1711, ER-2161, respectively.

Molybdenum is accepted as an electrode material for a vitrification furnace. The availability of ferrum (III) and sulphur (sulphate-ion) aggressive to molybdenum required more corrosion resistant materials to be used as electrodes. In the tests of pilot vitrification, furnaces having tin dioxide rod electrodes and a chromiumalumozirconium refractory (XAU-30) brickwork, some disadvantages were revealed;

- Thermal cracking of long tin dioxide rods due to current load variations;
- Unreliable operation of a water-cooled current lead;
- Strong corrosion of refractory (XAU-0) bricks joined by molten glass.

It was suggested that the cause of the interjoint corrosion of the refractory brickwork was insufficient grinding of the bricks and the absence of a mechanical brace usually used to compress the bricks at their outlet from the furnace. As for as the general corrosion of the electrodes and the bricks is concerned, the high glass resistance was confirmed for a tin dioxide and chromium oxide base refractory.

The electrode was designed consisting of tin dioxide bricks with an uncooled current lead. The work continued along these lines:

- Testing a new design of a tin dioxide electrode;
- Comparative testing chamotte, bakor-33 XAU-30 refractories the assemblage of which was accomplished by the pre-grinding and mechanical bracing of the bricks.

The furnace where the comparative testing of refractories was conducted is comprised of (Fig. 1):

- A bath with the working volume of 14.5 1 (7.3x1.85x1.00 dm) assembled from the indicated refractory bricks;
- A unit of a continuous discharge of molten glass;
- A tin dioxide base electrode with a metallic current leading rod grind to the former from the outside

Fig. 1

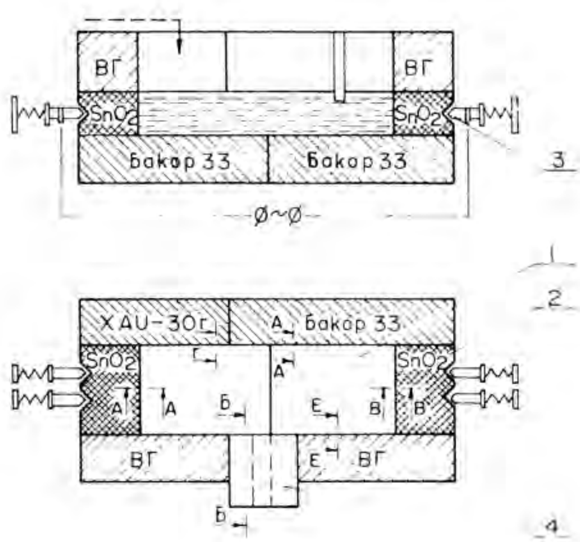

Fig. 1. Schematics of LAW Vitrification Furnace for Testing Refractory and Electrode Materials.1-Brickwork Bath 2- Electrode 3-Current Leads 4- Discharge Unit

(see Fig. 1). The tin dioxide electrode has one or two current leading rods.

The development of the electrode unit was preceded by the choice of a current lead material. The major requirements placed on the current lead material were:

- Minimum possible contact interaction between a current lead material and tin dioxide under conditions of the electrical current of the density 1.0 A/cm^2, heating to 1,000°C and the pressure by the metal on tin dioxide of 6.5 MPa;
- Heat resistance up to 1,100°C.

The investigations into the contact interaction resulted in the choice of a nickel base alloy as a current lead material. Table 1 presents the data on the contact interaction between tin dioxide and some nickel alloys.

The tests were conducted by feeding a suspension of a model solution and a borosilicate flux; the suspension containing up to 10% iron oxide and 1.0% sulphate-ion. The molten borosilicate glass was continuously discharged.

TABLE I
Contact Interaction Between Tin Dioxide and Nickel Alloys

Type of contact pair	Testing time, h	Current density of contact pair, A/cm^2	Tempera-ture, °C contact-electrode	Mode of interaction in contact zone
Tin dioxide Monel-metal (70% - Ni, 30% - Cu)	50	0.9	980-840	Monel - metal oxidizes to form a scale
Tin dioxide-Ni base alloy (70% - Ni 15 - 17% - Cr the balance-Ti	50	0.9	980-840	Alloy does not oxidize but sinters with tin dioxide, retains its initial appearance

Table II tabulates the electrical parameters of the electrodes and the temperature of the corrosion tests.

The furnace was periodically disconnected, emptied from molten glass and then the corrosion of the electrodes and the bricks was determined from the corrosion extent at the level of the glass and below it.

The nickel-base alloy rod electrodes operated for 2,500 h without a failure. The specific feature of the operation of a brick electrode with two rod current leads is the fact that more than 94% of the total current goes through one of the rods. The cause of the current's non-uniformity is likely to be because of a difference in the electrical resistance of the contacts. In this instance, the other rod would be a stand-by.

The mode of the corrosion of the electrodes and the bricks is shown in Fig. 2.

The values of the brick corrosion are given in Table III.

After testing for 2,500 h, the electrode corrosion near the feed of the suspension to the furnace was 4-9 mm; the corrosion of the opposite one was 1-5 mm. The high corrosion of tin dioxide in the feeding is due to the reactive components of waste not incorporated into the glass. It can be seen from Table III and Fig. 2 that in the series of the tested refractories, chamotte, bakor 33, and XAU-30, the latter is the most resistant to the molten borosilicate glass with high contents of iron and sulphur.

The following features of the brick behavior were revealed:

As compared to Bakor and chamotte, XAU-30 has a low thermal stability which was indirectly found from the number of cracks at the working surface of the bricks. The chamotte bricks had practically no cracks;

Despite the grinding and mechanical bracing of the bricks, corrosion took place along the brick joints and resulted in the molten glass penetration deep into the interjoint space.

The highest interjoint corrosion was observed at the tin dioxide electrode XAU-30 brick joint. The least corrosion is observed in the case of the chamotte bricks, which is likely

Fig. 2

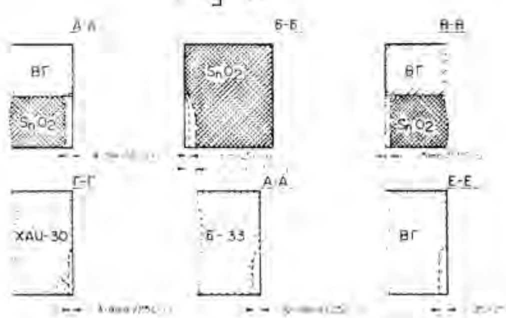

Fig. 2. Mode of Electrode and Brick Corrosion.

to be *explained* by the leakage of electric currents going through more electric conductive XAU-30 (see Table IV).

Thus, the tests of the LAW vitrification furnace to produce borosilicate glass showed:

The general serviceability of uncooled metallic current leads to tin dioxide showed:

The high glass resistance of bricks from Bakor and XAU-30 under significant interjoint corrosion between XAU-30 and tin dioxide electrodes.

In this connection, further investigations and tests are required to make an ultimate choice of a refractory and electrode for a bath of a LAW vitrification furnace.

TABLE II
Electrical Parameters and Testing Temperature

Electrical current distribution over electrode current leads, A: Electrode I near charge		Electrode 2		Current density of electrodes, A/Cm^2	Voltage of electrodes, V	Temperature of melt, °C	Electric power in glass, kW
left current lead	right current lead	left current lead	right current lead				
97.0	3.0	98.0	2.0	0.55	135.0	1,150	13.5
171.0	9.0	172.0	8.0	1.0	105.0	1,150	19.0

TABLE III
Comparative Corrosion of Bricks in Molten Borosilicate Glass

Brick	Corrosion, mm/2,500 h
High alumina chamotte	20 - 25
Bakor-33	10 - 14
XAU-30	3 - 4
SnO_2 (discharge unit)	1 - 2

TABLE IV
Specific Electrical Resistance of Bricks

Specific electrical resistance, ohm.cm at temperature, °C	Bricks XAU-30	Bricks B-33	Bricks Chamotte
1,100	80.0	100.0	747.0
1,450	47.0	205.0	721.0