Melting of crude antimony in the low-tonnage production

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Melting of crude antimony in the low-tonnage production

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Abstract. The project of low-tonnage production of crude antimony is proposed. The process scheme is based on the process of precipitation smelting. The possibility of combining the process of crude antimony smelting and its electrothermal refining from impurities in one melting unit is considered, the main technical and economic indicators are determined.

1. Introduction

Antimony, due to its fragility, is hardly used in industry in its pure form, but it is widely used in the form of alloys with lead, tin and copper. From 50 to 70% of all consumed antimony is in the form of metal for the alloys production, the rest amount of antimony is used in the form of various compounds. Antimony alloys with metals have an increased hardness, resistance to corrosion and wear resistance. The most known alloys of antimony are hard lead or antimony lead, printing metal, bearing metal. Hard lead containing from 5 to 15% of Sb is used for the manufacture of battery plates, sheets and pipes for the chemical industry, cable telegraph, telephone, electrical cable-sheaths, electrodes for certain types of electrolysis with insoluble anodes. Bearing metals or babbits are used in the manufacture of bearing liners for rail and motor transport and for other machines. Tin-based bearing metals contain 4-15% Sb, 60-80% Sn, 2-8% Cu, up to 25% Pb, have the required hardness, high abrasion resistance. Lead-based bearing metals containing 60-90% Pb serve as cheap substitutes for tin-based alloys. Metal antimony is also used for military purposes: it is added to lead, which is used to make shrapnel and bullets [1].

For a long time, the main supplier of antimony and its compounds to the regions of the former USSR remained the Kadamjay Antimony Plant (now the Kyrgyz Republic). But the current economic situation made production at this plant unprofitable. The Sakha-Ural Antimony Plant put into operation in 1996 is not able to fully meet the growing year by year demand for antimony and its compounds both in Russia and abroad. Thus, one of the ways out of the current situation is the development and implementation of a technology for a low-tonnage antimony production in the regions where heavy industry enterprises are concentrated. To date, the Sentachanskoye gold-antimony deposit in the Sakha Republic (Yakutia) is the most promising for the resource base of antimony production in Russia.

2. Smelting of crude antimony in the low-tonnage production

For the conditions of low-tonnage production the pyrometallurgical scheme for the antimony raw materials processing is most preferable. The technological scheme of antimony raw materials processing using the precipitation smelting process is shown in figure 1. The scheme includes precipitation melting, the products of which are matte, slag, gas phase and crude antimony. The latter, in its turn, is subjected to fire refining. The content of antimony in the feedstock is ~40%. The precipitation smelting of antimony ore is based on the great affinity of sulfur and oxygen to iron, rather than to antimony.

The main purpose of smelting the antimony raw materials is the transfer of the main substance of ore – antimony in a less contaminated by iron crude metal. During melting, sulfides react with iron, forming sulphurous iron and metallic antimony, droplets of which collect on the bottom of the furnace, and the empty rock is slagged. The addition of soda as a flux for antimony-sodium matte formation binds the iron sulphides of antimony to stable thiosalts, increasing the yield of matte and providing its good separation from the metallic and slag phases [2]. Iron turnings (steel or cast iron) are used in melting as a precipitator. During the precipitation smelting coal or coke are used as reducing agents, which prevent the oxidation of antimony and sulphide sulfur by the air oxygen. The coal consumption is 2-4% of the mass of ore raw materials. The raw materials and fluxing materials supplied to the electric smelter must be stored in the enclosed spaces. The moisture content of the charge components should not exceed 4-5%. To ensure better dosage and averaging of the composition before melting lump ore, coal, limestone are crushed to size of 20-30 mm, and the iron turnings are rattled to remove swarf strand from turnings. Melting of the concentrate is carried out at a temperature of 1250 ÷ 1400 ^{0}C. The resulting crude metal contains, wt%: 85 – Sb, 10 – Fe, 3.25 – S, 0.06 – As, 1.68 – others.

It is proposed to use an ore-thermal furnace with a capacity of 0.35 MW as the main unit for the antimony production. The electric furnace is devoid of a number of drawbacks inherent in reflective furnaces. Thus, the absence of a gas flare contributes to the release of less gases, which reduces the possibility of entrainment of antimony with them. During electric smelting the operate at a higher temperature without increasing the loss of antimony is possible. The use of more refractory slags can reduce the consumption of alkaline fluxes by replacing them in part with cheaper calciferous ones [3].

Slag and matte are transported to the dump because their processing is economically inexpedient in view of the small volume of production.

The furnace has the following parameters: casing diameter – 3400 mm; height of the furnace – 2600 mm; diameter of the bath – 1880 mm; height of the bathtub - 1800 mm; the area of the furnace bottom – 2.8 m^2; number of electrodes – 3; the diameter of the electrodes – 200 mm. Furnace round in section, three-phase. The bath of the furnace is lined with periclase-spinel refractory. The bottom of the furnace is laid out in the reverse arch; the vault is metal, water-cooled, lined with heat-resistant refractory concrete. Evacuation of gases is carried out through the opening in the roof of the furnace. Slag belt of the furnace is cooled by the applied caissons. Over the caissons are cast-iron plates, which carry the upper part of the lining. The current to the melt is fed by graphitized electrodes fixed in the electric holders and entering the arch of the furnace through the sealing rings [4, 5, 6]. Electromelting of antimony concentrate in the ore-thermal furnace is carried out in the regime of periodic charging of batch and periodic production of melting products. The technological cycle includes operations for preparation of melting, heating the melt, charging the batch, melting the charge, discharging the slag, releasing the crude metal or matte. The nominal load on the electrodes is maintained automatically by means of a power regulator.

The main materials used in the production and fire refining of antimony are: antimony concentrate KSUF – 4 (GOST 48 – 101 – 76); soda ash of grade B (GOST 11078 – 78); limestone flux grade 1 (TU 48-7-2-77); coke; iron turnings; sulfate of sodium technical grade 2 (GOST 6318-77); graphite electrodes with a diameter of 200 mm (GOST 4426-71). When preparing the charge, the fluxes are dosed according to the calculation of slag production of 60% SiO_2, 15% Na_2O, 15% CaO and 10% of others. The practical consumption of fluxes and reagents during the smelting of different types of concentrates is: soda ash 20 – 25%, limestone 15 – 20%, iron turnings 12 – 20%, coal 2 – 4% of the mass of the concentrate. The charge is loaded into the furnace by feeders through the arch. With this loading and nominal power selection the batch that enters the furnace melts without the formation of slopes, and the temperature under the roof is stably maintained at 600 – 700 ^{0}C. The rarefaction under the furnace roof is regulated remotely and does not exceed 2 mm of water in order to avoid a large suction of air into the furnace and the burnout of the electrodes.

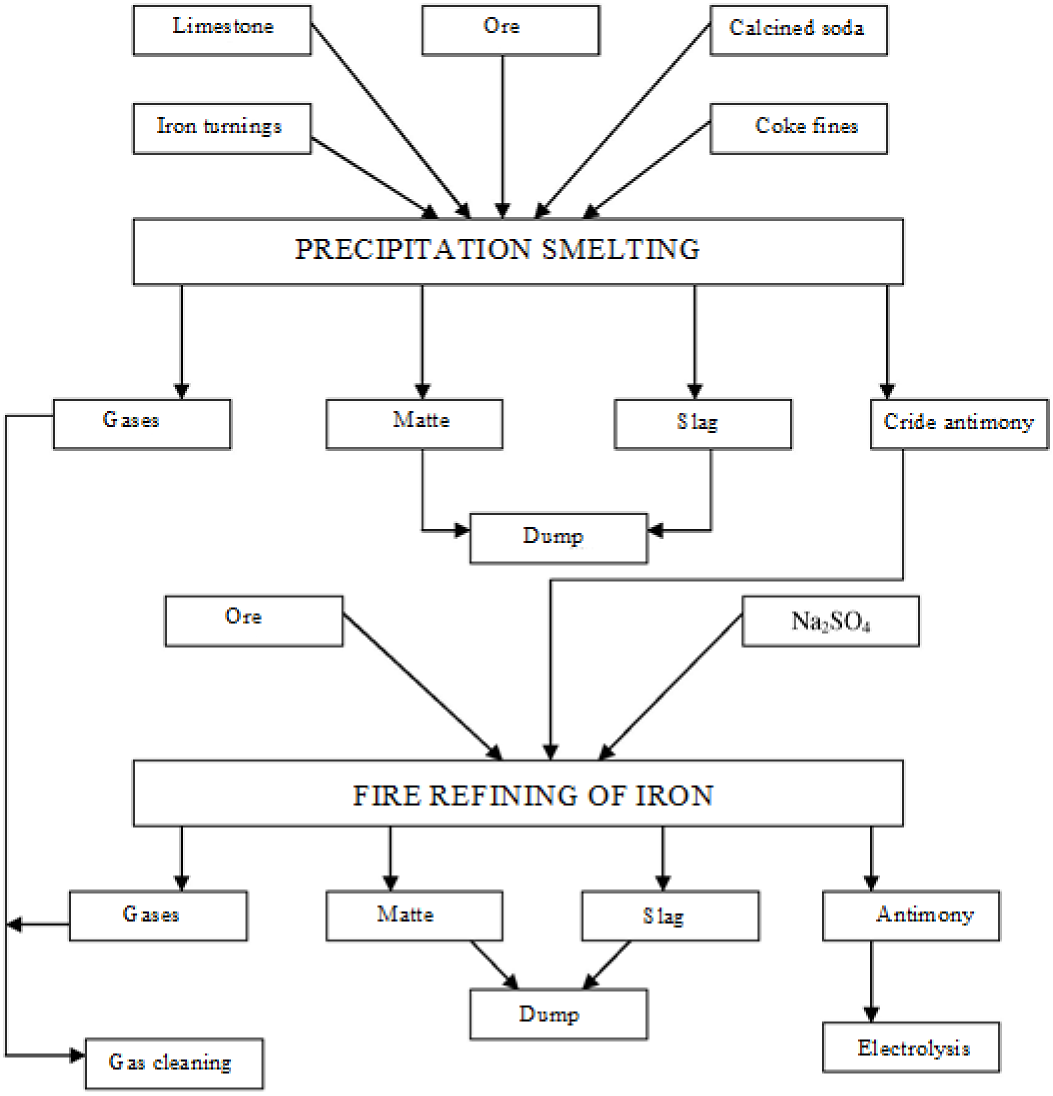

Figure 1. Technological scheme of antimony raw materials processing using the process of precipitation smelting.

The slag is discharged once every 8 hours through the slag tap into the cinder pot. Density of slag is 3.3 – 2.5 g/cm^3. At a time about 1.8 tonne is poured out. Before the release, the floating layer of the batch is melted, and the melt is heated to reduce the viscosity of the slag and improve the sludge. The slag has a temperature of 1250 – 1400 ^{0}C at discharge. The crude metal and matte are poured twice a day, i.e. in each shift either crude metal or matte is tapped. Matte is poured out through the matte tap-hole before the slag goes. Matte is poured into a special container (lined), made by the type of a cinder pot. At a time 2.2 tonnes is produced. When tapped, the matte has a temperature of the order of 1000 – 1250 ^{0}C. The crude metal is poured out through the tap-hole for the antimony tapping. At one time about 1800 kg of metal is discharged. The metal during discharging has a temperature of 900 – 1100 ^{0}C. From the tap-hole the metal enters the intermediate trough, from which it pours out onto the roll crystallizer. The melt, falling into the wedge-shaped space formed by the rolls, spreads along their entire length, simultaneously forming "crusts" that easily break down and slopes down into the box for crude antimony. Then this box is transported to the section for batch preparation, where the charge is prepared for refining. In the refining cycle, the metal is mainly discharged, and the matte and slag are discharged as they accumulate. The number of furnace gases varies from 600 to 1300 m^3/h; gases contain, % (volume): up to 20 - 24 – CO_2, 2 - 6 – CO and 1% – O_2. Melting of the concentrate in the electric furnace is 2.4 – 2.7 t/(m^2·day); electricity consumption 1050 – 1250 kW·h per 1 tonne of concentrate or 3700 - 4400 kW·h per 1 tonne of crude metal; the consumption of graphitized electrodes is 4-6 kg/t and 15-20 kg/t, respectively. The direct yield of antimony into the crude metal is 83 – 87 %, into dust 8 – 12%, into matte 2 – 3%, and into slag 1 – 1.5%. The annual capacity of the department is 625 tonnes of metal.

In order to save capital investments, the technology involves combining in one melting unit the processes of smelting of crude antimony and its refining from iron. This is achieved by successively carrying out the melting and refining operations in the same electric furnace.

The refining of antimony is based on the oxidation or sulphidation of impurities contained in it. The regime for performing the operation of antimony firing is determined by the processes of removal of iron and arsenic. Smelting of black antimony is conducted in succession for 20 days. Then for 8 days the fire refining is conducted. Single loading of crude metal into the electric furnace is 1.75 tonnes.

The number of refining cycles is 4 per day. The daily capacity of the furnace in the refining mode is 1.75·4 = 7 tonnes. The composition of the refined metal, %: 96 – Sb, 0.08 – Fe, 0.067 – As, 3.5 – S, 0.11 – Pb, 0.243 – others.

Purification of technological gases of ore-thermal furnaces is carried out in three stages: capture of coarse dust is carried out in the cyclone, dust of medium size is caught in the coolers, and for fine cleaning bag filters are used [7]. In connection with the small scale of production and low concentration of SO_2 in the gases, the organization of sulfuric acid production in this case is economically and technologically inexpedient. Therefore, the calciferous method is chosen for purification from small contents of sulfur dioxide. This method is distinguished by its simplicity and is carried out with the help of cheap reagents (limestone, calcite, chalk, dolomite, lime), and therefore requires a small initial capital investment, which predetermines the low operating costs at a sufficiently high degree of gas purification (85 – 98%).

3. Conclusion

The proposed technological scheme is based on modern efficient and environmentally safe processes that provide high technical and economic indicators of ore and industrial products processing, such as precipitation electric smelting, refining in the electric furnaces, chemical cleaning of waste gases. The technology of antimony production is practically non-waste. The refined slags, captured dust, partially matte are returned to the processes for the antimony extraction. The dump slags, calcareous (gypsum) sediments from wet cleaning are used in the construction industry as raw materials for the production of building materials.

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