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THE CURRENT STATE OF ELECTROMETALLURGY IN UZBEKISTAN

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The monograph provides the results of theoretical and experimental research conducted in primary metals establishment in the framework od A-3-82 project "Methods of increasing efficiency of application of energy sources at electrosteel-smelting ovens of ferrous metallurgy establishments".

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INTRODUCTION

Progress in electric steel production equipment and technology, reducing specific energy consumption per unit of production, as close as possible to the electric performance level converters, as well as environmentally friendly electric steel production make it more attractive to the industry.

Priority development of secondary metallurgy processes using modern electric smelting and rolling should be one of the areas of restructuring in the steel industry. The use of powerful electric furnaces will provide savings of up to half of the energy costs compared to integrated steel-making enterprises.

Given the global trend of faster growth of electric smelting steel production that by improving the process has reached 34% of world production and its cost has become competitive with the converter mode of production, it is proposed to install 80 tons of AC electric arc furnace (EAF) with scrap drying capable of production volume of 700,000 tonnes per year.

Currently, the share of steel produced in electric arc furnaces around the world is more than 30% (33% in 2010). Steel output in 2020 is forecast at 830 million tonnes/year, with the share of 40% of electric. Electric steel smelting with oxygen converter steel production continues to increase to 14–16% surpassing the open-hearth production, which was a major in steel production in the early 20th century. Capacity furnaces increased from 3 tons in 1900 to 150–200 tonnes in 2000. Experience has shown that the use of 1 ton of metal saves 4–5 tons of crude ore, 1.2 tons of coking coal, reduces emissions of pollutants into the atmosphere in 6.5 times, reduces the consumption of energy throughout the metallurgical cycle in 3 times. Electric smelting plays leading role in the production of high-quality and high-alloy steel. Due to a number of fundamental features this method is adapted to produce a diverse in composition superior metal with a low content of sulfur, oxygen and other harmful and undesirable impurities and a high content of alloying elements imparting steel special properties — chromium, nickel, manganese, silicon, molybdenum, tungsten, vanadium, titanium, zirconium, and other elements.

Arc furnace compared with other melting units have advantages as in electric furnaces metals can be quickly heated, melted with fine-tuned temperature, creating an oxidizing, reducing and neutral atmosphere or vacuum. These furnaces can produce steel and alloys of any composition, more fully deoxidize the metal to form a minimum number of nonmetallic inclusions — deoxidation products.

Minimizing the raw material and energy costs, the share of which in the production of electric is more than 70%, it is the main focus of the art and technology of melting in an arc furnace.

On the results of the technical and economic indicators of a modern AEF equipped with gas-oxygen burners, devices for injecting carbonaceous powder materials has virtually no effect except for smelted assortment of stainless and high-speed steels. Thus, the small metal losses make it less expensive than open-hearth, or BOF produced steels.

At the present stage of development of electrometallurgy, based on the price of materials constituting the metal part of the charge, it may be noted that the scrap metal is the most affordable feedstock material. Thus, according to the forecast of world demand for steel scrap of the International Iron and Steel Institute in 2020 should increase to 435–440 against 379 million tons per year in 2010.

The share of steel scrap, which is formed in the steel industry, is about 40% of its total consumption for today. It is important that this is the most high-quality scrap, as a rule, does not require significant preparations to use.

At present, the steel scrap price increases, at the same time because of the need to transport scrap metal becomes expensive and lightweight metal without processing in gathering places — unprofitable.

Large specialized companies for processing scrap invest in equipment that allows processing both mixed and lightweight scrap. Therefore, while maintaining the volume of high-quality large-sized scrap, proportion of recycled scrap increases. Mostly, packaged scrap prepared by pressing and cutting, and also shredded.

CHAPTER I. DEVELOPMENT OF STEEL ELECTROMETALLURGY IN UZBEKISTAN

JSC "Uzmetkombinat" is one among electro metal manufacturers. In 1994, Uzbek Metallurgical Plant, as a result of its merger with Shirin engineering plant and cost accounting control of "Vtorchermet" enterprises, was transformed into an open joint stock company "Uzbek Metallurgical Plant" in accordance with the decree № 159 (March 24, 1994) of the Cabinet of Ministers of the Republic of Uzbekistan "On establishment of the joint-stock production association" Uzbek Metallurgical Plant"

All the past years, the factory, and then the plant, marked by a strong belief in the course of technical progress, the construction of new production lines, modernization of equipment, introduction of innovations, reconstruction. Commissioning (in 1962) of continuous steel casting machine, an increase in capacity ladle, reconstruction of "300" mill helped to improve operational efficiency and product quality.

In the 70's an arc-furnace plant were built and put into operation, in the early 80's the new rolling mill № 2 began production of long products and billets, in the 90's there entered into operation pipe welding shop and the site for the production of grinding balls with diameter of 67 mm and 100 mm.

In accordance with the concept of the development of the steel industry in the Republic, at the plant:

- Finished works on the reconstruction of oxygen-compressor plant with the installation of block AKAr-6–2 which allows to produce high quality argon in volume providing technological process, as well as the needs of other enterprises in the country;
- For the introduction of a new steelmaking technology there were built a new "furnace — ladle" installation in the electric shop, old furnaces were replaced by the new generation furnaces with capacity of 500 thousand tons of steel per year, which enabled reduction of the duration of smelting and energy savings.;
- In August 2001 a ball-rolling mill were put into operation, capable of production of grinding balls of 120 mm diameter, which allowed excluding imports of those in Uzbekistan;
- In 2006, workshop for the production of non-ferrous metals was commissioned, which mastered the technology of rolling copper and its alloys;

- In 2007, the steel wire sector was organized, with designed capacity of 6000 tonnes per year and welding electrodes production sector;
- In 2008, a workshop for processing steelmaking slag dumps was commissioned, which makes the extraction of additional scrap in the amount of 8 000 tonnes per year and improve the ecological situation in the region as well as the selling the slag to cement industry;
- In 2008, the works on modernization of electric arc furnace DSP-100UMK № 4 were finished. Replacement of the furnace transformer gave an increase in furnace capacity by 100 000 tonnes with a target capacity of 650 000 tons per year.
- In 2008 the works on the reconstruction of gas-cleaning plant on electric steel furnace DSP-100UMK, which gave an increase in cleaning efficiency in steel production and the reduction of solid emissions into the atmosphere;
- In 2008 the works on the reconstruction of ball-rolling mill with an increase in the production of grinding balls up to 160 000 tons per year, which makes provision for increasing demand in the grinding balls for gold mining and cement industry, as well as an increase in productivity of ball-rolling mill by 40 000 tonnes per year and a reduction specific consumption of natural gas and electricity.

JSC "Uzmetkombinat" is the only enterprise of ferrous metallurgy in Central Asia. The plant is a basic industry, and it is closely related to all other industries, so development of ferrous metallurgy in the Republic is a priority state task of the present stage of economic development.

1.1. Metal melting technology in arc furnaces

Arc-furnace has advantages over other melting units. In these furnaces an electric arc is used as a source of heat generated between the electrodes and the metal charge. Electric arc furnace (Figure 1.1.1) is powered by three-phase alternating current and has 3 cylindrical electrode made of graphite mass. Electric current is supplied from the transformer via flexible cables and copper bars to the electrode-holders, and through them to the electrodes. Between the electrodes and the metal charge there appears an electric arc, the electric power is converted into heat, which is transferred to the metal and slag by radiation. Operating voltage is 180–600 V, amperage 1–10 kA. During operation of the furnace arc length is automatically adjusted by the vertical movement of the electrodes. The furnace has a welded steel housing. Cover from the inside of the furnace is lined with insulation and refractory bricks, which can be basic (magnesite, magnesite-chromium) or acidic (silica). Hearth of furnace is stuffed with refractory body. The melting space is limited to the walls, hearths and roof which is also made of refractory bricks and have a hole for the electrodes to move. The walls of the furnace have a working window for controlling the progress of melting and tap-hole for the release of finished steel into the ladle. The furnace is charged with the roof removed. The furnace can be tilted towards loading gate and taphole. Capacity of electric arc furnaces is 0.5–400 tons. In this case, the furnace capacity is 100 tons. Arc furnaces can have a basic or acidic lining. The metallurgical workshops commonly use electric arc furnaces with basic lining, and foundries — with acid.

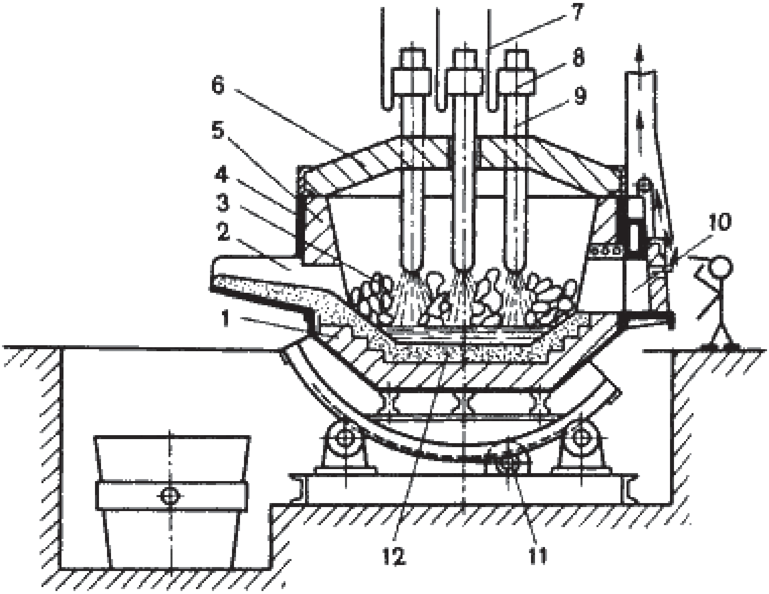

Figure 1.1 Diagram of electric arc smelting furnace

1 – heat-insulating firebrick; 2 – trough; 3 – metal charge; 4 – welded steel casing; 5 – wall; 6 – roof; 7 – flexible cables; 8 – Electrode-holder; 9 – Cylindrical electrodes; 10 – working window; 11 – tilt mechanism; 12 – hearth.

The furnace examined is the basic arc furnace. Melting it is carried out on the carbon charge (with oxidation of impurities). This technology is most often used in the production of structural carbon steels. Structural steel — steel, designed for the manufacture of machine parts and tools. The melting was carried out in 2 periods: the oxidation and reduction. This technology is also known as smelting on a fresh charge with oxidation and is used in the furnaces of small and medium capacity (less than 40 tonnes) in the smelting of high-quality alloy steels. Smelting consists of the following periods (stages): furnace filling; furnace loading; melting; Oxidative period; the recovery period; Steel release.

Filling– fixing of worn and damaged parts of the lining of the hearth.

After filling the furnace, removal of the metal residue and slag from the previous heat, fixing the damaged places of the lining, the furnace is charged with the charge: steel scrap (90%), pig iron (10%), the electrode scrap or coke for carburizing metal and 2–3% of lime. After filling the charge, electrodes are lowered down and switched on. The charge under the electrode melts and the metal accumulates in the hearth of the furnace. During the melting of charge begins oxidation: due to oxygen in air, oxide in the charge and slag, carbon, iron, silicon and manganese oxidize. Together with calcium oxide contained in the exhaust, the oxides of these elements form a basic ferrous slag that promotes the removal of phosphorous from the metal. After heating the metal and slag to 1500–1540^{o}C, the furnace is charged with ore and lime. Oxygen contained in the ore rapidly oxidizes the carbon and causing boiling of the liquid metal due to the evolved carbon monoxide bubbles. Slag foams (slag of metallurgical melts — after setting is lithoid or vitreous substance that covers the surface during the melting of the molten metal), its level rises. For the releasing of slag furnace is tilted towards the working window, and it flows into the slag cup. Boiling metal accelerates heating, removal of gases, non-metallic inclusions, and phosphorus from the metal. Slag is removed, ore and lime is added 2–3 times, resulting in phosphorus reduced to 0.01%, and at the same time due to the formation of carbon monoxide during boiling the carbon content is also reduced. When the carbon content becomes less than the specified 0.1% boiling is stopped and slag is completely removed from the furnace. This completes the oxidation during melting.

The reduction period involves melting metal deoxidation, sulfur removal and bringing the chemical composition to the specified parameters. After removal of the oxidizing slag, ferromanganese fed in the furnace in an amount providing a predetermined content of manganese in the steel, and also carburize the metal, if the high-carbon (up to 1.5%) steel is smelted. Then, the furnace is charged with a flux consisting of lime, fluorite and chamotte scrap. Flux — the material added into the melting furnaces or ladles for forming liquid slag, cleaning the metal of undesirable impurities. After melting the flux and slag formation the furnace is charged with a reducing mixture of lime, fluorspar, coke and ground ferrosilicon. Ground coke and ferrosilicon is added in powder form. They are very slow to penetrate through the slag layer. Iron oxide is reduced in the slag.

$$\begin{cases}(FeO)+(C)=[Fe]+\{CO\}\\ 2(FeO)+(Si)=[Fe]+(SiO_2)\end{cases}$$

The content of iron oxide in the slag is reduced, and according to the distribution law it moves into the slag. This process is called diffusive reduction of steel. Reductiong mixture is added into the furnace several times. As reducing goes on and FeO content decreases, color of slag changes, and it becomes almost white. Deoxidation under the white slag lasts 30–60 minutes. During the reduction period, the sulfur is removed from the metal, due to the high (up to 55–60%) content of CaO in the metal and low (less than 0.5%) content of FeO. This promotes intensive removal of sulfur from a metal.

During the reduction process samples are taken to determine the chemical composition of the metal. If necessary, ferroalloys may be added to the furnace to achieve a given chemical composition of the steel. When the set temperature and the composition of the metal, there begins the final deoxidation with ferroaluminum and silicocalcium. This is followed by release of the metal from the furnace into the ladle. When smelting alloy steel in electric arc furnaces, alloying elements are added in steel in the form of ferro-alloys. Alloying elements are added according to their affinity for oxygen. Nickel and molybdenum have lower affinity for oxygen than iron, so they are added into the metal during the melting or the oxidation period. Chromium is easily oxidized, and it is added during the reduction period; silicon, vanadium, titanium — before the release of metal from the furnace to the ladle, because they are easily oxidized.

1.2. Electrical equipment of metallurgical production

Electrical energy is supplied to the plant from the TPP by four overhead power lines. Two lines P.M.L–M-1,3 23.4 km long, each connected to "Metallurgiya" substation and the line L–M-2.4 each 22.6 km long, 220 kV and are connected to the "Pechnaya" substation. Substations of OJSC "Uzmetkombinat" are also electrically connected by overhead lines of