NEW TYPES OF PLASMA FURNACE

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The Electric arc furnaces take up dominant position in the Metallurgy. Getting high temperatures in electric arc furnaces is a big problem. When the temperature rises, the recovery process (desilication, dephosphorization and others) is accelerated, which means that decreases the time of these processes and energy consumption, also, the quality of smelted metal is improved and increases the affinity of coal with oxygen and it becomes possible to recover any metal from their oxides. Until now, the high temperatures were obtained only in the plasma furnaces. Modern plasma furnaces, despite of their technological capabilities, includes a many technical difficulties and requires huge economic costs. Therefore, plasma-furnaces are used only for making such materials, which can not be produced by other known methods or for treatment of the harmful materials when the environmental consequences are more valuable than economic costs. We have developed, manufactured and tested a laboratory model of the plasma furnace, which is simpler and cheaper than the electric-arc furnace, and is more effective than other plasma-furnace.

Key words: ***plasma furrnace, Arc-heated furnaces, high temperatures, desilication, oxides.***

Introduction. **The coal waste is a big environmental threat because of their large size. For example, the coal wastes of Tkibuli are more than 10 million tons and the processing of them will give the great ecological and economic effects. As is well known, the deoxidation is last stage of reception of the high standard ordinary steels. For this purpose, the active deoxidizer, 99% purity-aluminum, is used. But, because of the small weight of an aluminum (three times less than steel) it's floating on the steel surface and is oxidized from an air and slag and the 70-90% of an aluminum is uselessly lost, which negatively impact on the cost price of steel. For this reason the aluminum-alloys are used with various weighing elements (complex deoxidizers). One such widely used deoxidizer is a ferrosilikoalyuminy. Except steel deoxidation, the ferrosilikoalyuminy is used for receiving of ferroalloys - ferromolybdenum, ferrovanadium and others.**

Georgian Technical University has experience on using coal and coal-wastes in metallurgy. The Experiments for smelting of the ferrosilicoalluminy from coal-wastes and coal of Tkibuli are carried out.

With standpoint of ecology and economy the using of coal-wastes in industry is particularly important. This is one of the rare cases when processing of hazardous wastes of the production gives a great environmental effect with big economic profit. The processing of Millions tons of coal-wastes significantly will improve the ecological environment of Tkibuli and will considerably reduce the toxic effects on the overground and underground environment. As for the economic effects, demand on ferrosilicoalluminy on the international market is big and its selling will give huge profits. But, smelting of an acceptable quality ferrosilikoalyuminy from the coal and coal-wastes in the well-known arc-furnaces is practically impossible due to low temperatures.

The receiving of high-quality ferrosilikoalyuminy from the coal and coal-wastes of Tkibuli is economically profitable only in such type of the plasma furnace that is developed (at the level of invention [1]) in Georgian Technical University. This arc furnace simplifies and cheapens a smelting process of ferrosilicoalluminy

Development of the plasma furnace. The modern plasma - furnaces, despite of their technological capabilities, includes a many technical difficulties and requires huge economic costs. Therefore, the plasma-furnaces are used only for making such materials,

which can not be produced by other known methods or for destruction of the harmful materials, when the environmental consequences more valuable than economic costs.

The main limitation of arc furnace is its low temperature that is not enough to receive the high-quality ferrosilikoalyuminy; impossibility to increase power in furnace.

We have developed, manufactured and tested a laboratory model of the plasma furnace, which is simpler and cheaper than the electric-arc furnace, and a more effective than other plasma furnaces. This is achieved by increase of temperature in the furnace by voltage (not by current). This process is provided by power-source with a rectangular characteristic. The power source which has the "natural" rectangular characteristics does not exist in the World and its creation is a great innovation [2, 3].

The using of such plasma furnace becomes profitable in a most cases of metallurgical process, and for processing or to destroy the harmful wastes. Profit only from the processing of coal-wastes of Tkibuli to receive the ferrosilikoalyuminy reach at least $ 15,000,000 $ per year.

The essence of process is the following:

When an ordinary electric-arc furnace is fed from voltage source, the furnace configuration is done thereby to reach the maximum permissible temperature, and the admissible current of electrodes corresponds to this temperature. By the further increase of the voltage it is not possible to increase the furnace temperature, because the voltage increase leads to a fast increase of current, the current exceeds the maximum allowable size for electrodes and the furnace will be destroyed. Also, in this case, it is impossible to increase the length of the arc because increasing the length of the arc causes the rapid reduction of current and the arc disappears. But, when the arc is fed from current source, the arc length can be increased to any size, as in this case the arc current remains constant, while the arc-power and the furnace-temperature can be increased only by automatical increasing of arc voltage. Thus, the feeding of furnace-arc from current-source provides the opportunity to increase the furnace temperature without increasing current and it's possible to increase the temperature up to size of low temperature plasma. Thus, an ordinary electric furnace can be remade into plasma furnace, the maximum temperature of which will be determined by the heat endurance of brickwork of the furnace instead of the admissible current-size of electrodes.

For this purpose, we have created power sources with rectangular characteristics. Which have properties of current-supply when it is working in the short-circuited or operating conditions and has a characteristic of a voltage source in no-load operation. This power source is simpler than power source of the conventional electric-arc furnace.

This plasma furnace has many other positive features: auto-maintenance of size of the arc-current; a simple regulation of temperature in furnace; the process stability; the steady current in the feed network and other.

Here we obtain a plasma furnace in the complex, which is technically simpler and economically cheaper than the electric-arc furnace, but has technological opportunities of a plasma furnace.

The new type plasma-furnace will increase intensity and quality of production of conventional materials. Also, the processes of making the valuable materials and wastes-processing will be simplified and will become cheaper, therefore the using of such plasma furnace becomes profitable in a most cases of metallurgical process.

On a figure 1 the principle of work of the developed plasma furnace is explained. The plasma furnace consists of: a framework-1, between the electrode -2 and anode - 3 an arc - 4 is generated from the power source-5 having the rectangular characteristics (Figure 2). The power source consist of the power system (6), the transformer with steeply-falling characteristic (7), the transformer with rigid characteristic (8) and the rectifier (9). The arc melts the material (the working mixture) -10, which after smelting is divided into two parts as useful material -11 and slag -12. Oxygen is supplied in the furnace from hole 13, the evaporating materials go out from the hole – 14, the useful material and slag flow out from hole -15. In proposed furnaces, the formation method of arc is the following: the plasma furnace works on vertical part of the rectangular characteristic in the short circuit and operating regimes. Therefore, the arc-current is permanent and does not depend on the length of the arc or on the specific conductivity and its size is such which provides the enough temperature in the arc furnace. In case the arc is stretched, the regime moves to the horizontal part so that not happens the emergency increase of voltage and current. So easily accepted (in the furnace) the stable, high temperatures.

The process of the smelting ferrosilikoalyuminy is such (Fig. 1): At the influence of plasma arc, the wastes of the coal are melting and dividing into two parts: the melted ferrosilikoalyuminy (11) and slag (12) containing a large amount of carbon. Part of the high-temperature slag containing the large amount of carbon is burning in oxygen delivered from hole-13. Combustion products go out of the plasma furnace from hole-14. The Combustion heat is added to the heat of plasma-arc and participates in smelting of the whole coal-wastes. The received melted mass of ferrosilikoalyuminy flows from hole-15. Consumed heat of the furnace is sum of heat of plasma-arc and combustion. The average temperature (result of the relatively low and high temperature of the plasma-arc) which is established in the furnace is enough to smelt the high-quality ferrosilikoalyuminy from coal-wastes. Thus, the supplied electric energy and power of source will decrease. But, by Increasing the length of the arc is always possible receive temperature that will enough to melt the coal wastes. In addition, the power source design is simplified. (which is the most expensive component of the furnace) therefore the cost price and the maintenance costs are reduced and the production capacity increased, as a result price of the such received ferrosilikoalyuminy is twice less than received by other methods.

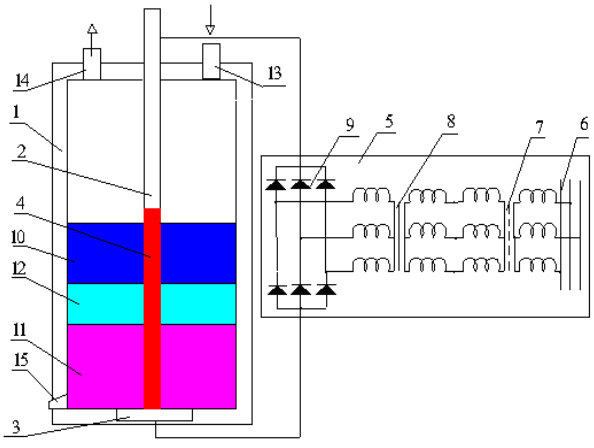

Fig. 1

Applied Potential of the Developed Plasma Furnase. **Until now arc furnaces are fed from the "voltage" sources. This creates many problems:**

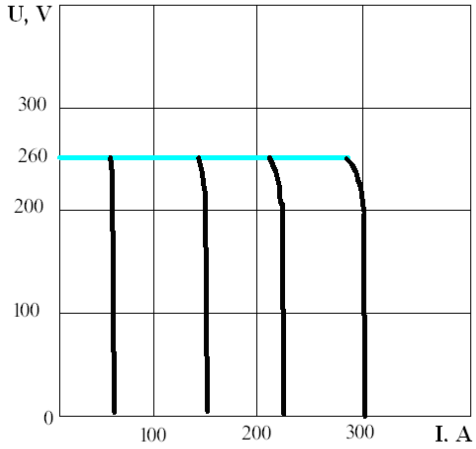

Fig. 2

The electric-arc (due to its electro-physical properties) is a non-stationary consumer of the current and during process of working in normal regime, the current is varies at about 1 kh frequency in within 60%, and in the short-circuit regime, the current increases up to 10-20 times. This leads to reduction of durability of electrodes and other current-carrying parts and quality. In case if the power source will the current source the current size is permanent and all problems is removed;

Due to the electro-physical properties of the arc the electric and respectively thermal power are entered in furnace mostly by the current, But as is known, electrical power can be entered two ways; small cuurent and big voltage or small voltage and big current (Q => W=> IU). But increase the arc voltage in the arc furnace after certain size is impossible because of the almost horizontal characteristics of the arc. In case when arc is fed from Current source this problem is removed and the share of voltage in the furnace power consumption can be increased up to 3-5 times. This basic truth have not been used so far only because there was no powerful current source. This became possible only after we have created such powerful source of current.

The area of the using of the presented high-temperature arc-furnace is very wide. (They are: melting of ferroalloys, black and nonferrous metals; receiving of the new materials; industrial and municipal waste recycling). Here are specific examples of its using:

1. During the Soviet period, the Rustavi metallurgical factory worked irrationally, so million tons of the metallurgy wastes were accumulated on the plant's territory. Many millions of tons of such waste are located in the former Soviet Union territory. They are contains of an average of 70% iron. Currently, the several small plants are melting the metals from the metallurgy wastes. The cost price of the smelted steels (from that waste) in ordinary arc furnaces is about the same that is smelted from iron ores by traditional methods. We offer the new technology of the steel smelting from these wastes, which will reduce the cost price of the steels which will be smelted from these metallurgy wastes;

2. It is especially important to use the coal-wastes for ecological as well as economic results. This is one of the rare cases when the processing of hazardous-wastes gives a great environmental effect with big economic gain, profit.

The processing of million ton of the coal-wastes significantly will improve the ecological environment of Tkibuli region and what is important that the received products will be successfully used in world Industry: the ferrosilikoalyuminy in Metallurgy, the slag in road

and building industry. Only from coal wastes of Tkibuli, it is possible to receive 35% ferrosilocoalluminy. The coal-wastes of Tkibuli are about 10,000,000 tons. From there is possible to receive 3,500,000 (three million five hundred thousand - 35%) ton of ferrosilikoalyuminy and the many ton of slag which is used in the road and building Industry. Only in the CIS countries, demand of ferrosilikoalyuminy is 200,000 (two hundred thousand) ton per year. If the 50,000 (fifty thousand) tons of ferrosilikoalyuminy will be produced in the year the coal-wastes of Tkibuli will be enough for 56 years and the new number of waste each year will be added. If we consider the international market, perspectives of commercialization of the received product are unlimited.

The using of coal-wastes is particularly important to industry as with ecological standpoint as well as economic. This is one of the rare cases when the processing of hazardous wastes of the production gives a great environmental effect with big economic profit. The processing of Millions tons of coal-wastes significantly will improve the ecological environment of Tkibuli and poisonous influence on the overground and underground environment will negligible (insignificant). As for the economic effects, need on ferrosilicoalluminy on the international market is big and its selling gives huge profits to company.

It should be mentioned, that the issue refer to processing of the hazardous wastes, in which the international community is spending a lot of money. Here we are dealing with a unique case - the processing of the harmful wastes is the great profitable business.

R E F E R E N C E S

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