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De Bie

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[54] **AUTOMATICALLY CONTROLLING THE OXYGEN CONTENT IN COPPER AND COPPER ALLOYS**

[75] Inventor: **Edouard De Bie,** Antwerpen, Belgium

[73] Assignee: **Metallurgie Hoboken-Overpelt,** Brussels, Belgium

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[58] **Field of Search** .... 75/72, 73, 74, 76, 69; 204/195 R, 195 S; 164/DIG. 7; 23/230 PC, 253 PC; 73/19; 266/13, 14

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Primary Examiner—Walter R. Satterfield
Attorney, Agent, or Firm—Fred Philpitt

[57] **ABSTRACT**

A process for maintaining a desired oxygen content in molten copper by generating an electrical signal proportioned to the oxygen content of the molten copper and using this electrical signal to control the volumes of fuel gas and oxygen containing gas that are passed through heaters prior to their being burned in the furnace that produces the molten copper.

1 Claim, 1 Drawing Figure

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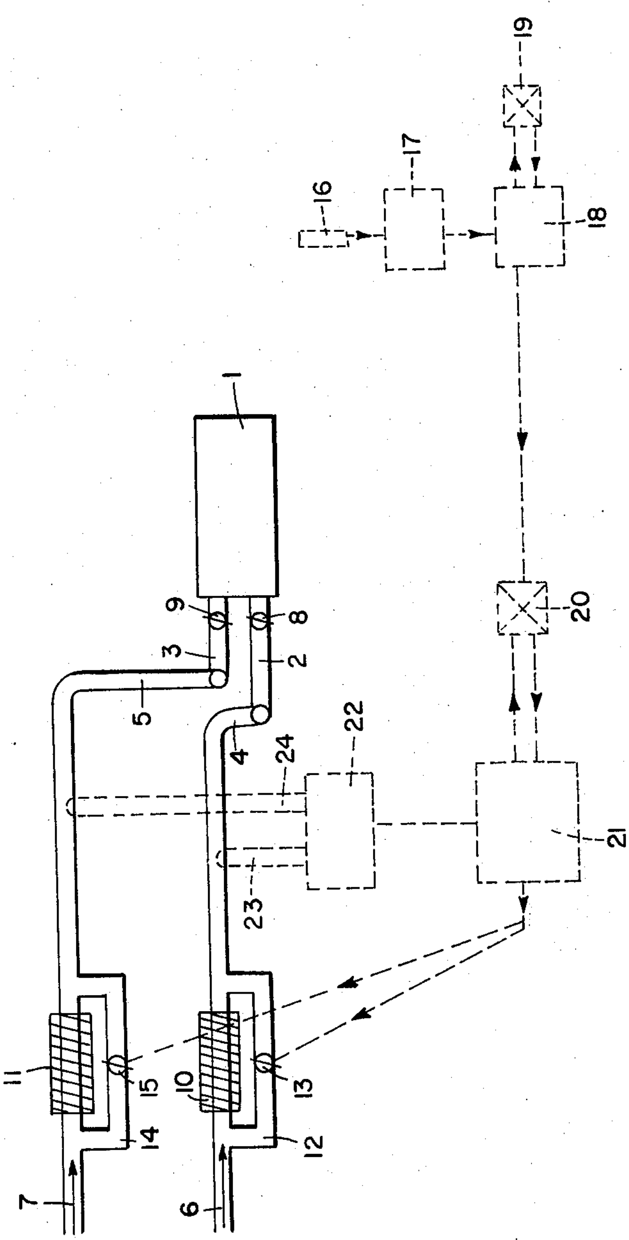

AUTOMATICALLY CONTROLLING THE OXYGEN CONTENT IN COPPER AND COPPER ALLOYS

The invention is particularly useful in copper melting.

It is known that, according to the oxygen content of the charge to be processed and to the oxygen content of the product to be obtained, certain metallurgical melting or conditioning processes require an oxidizing atmosphere, others require a reducing atmosphere and others require a neutral atmosphere. It is also known that the oxidizing-reducing character of the hot gases generated by a burner can be adjusted by regulating the ratio between the amounts of fuel and oxygen containing gas delivered to the burner.

It is known that the maintaining of a particular atmosphere throughout a metallurgical melting or conditioning process sets particularly difficult problems. Thus, for instance, in the case of a burner supplied with a gaseous fuel such a natural gas or butane and an oxygen containing gas which are pre-heated at given temperatures, a variation in the temperature of the preheated gases of some tens of degrees - which is rather usual when preheating is done in a heat recuperator - is sufficient in order that the hot gases generated by the burner shall have an appreciably different oxidizing-reducing character.

Formerly, the control of the oxidizing-reducing character of the hot gases generated by a burner was usually done discontinuously by hand. Thus, for instance, in a known copper melting process, in a gas-furnace, through direct contact of the copper with the very hot products of combustion injected into the furnace by a series of burners, the hydrogen content of the combustion gases in the burners was measured from time to time, and if the measured content deviated from the control content, that is the content which was known by experience to be suitable for the processing of a charge with a given initial oxygen content, the ratio of the quantity of fuel to the quantity of oxygen containing gas delivered to the burners was adjusted by hand so as to obtain the desired hydrogen content in the combustion gases. This way of adjusting was discontinuous and manual, and it had in addition the disadvantage of not taking into account unforeseen variations, which are always possible, in the initial oxygen content of the charge to be treated.

For the melting of copper in a gas-fired furnace it was also proposed to take samples of molten copper at the tap hole, to determine the oxygen content in these samples and, if this oxygen content deviated from the desired oxygen content, to correct the oxidizing-reducing character of the combustion gases by acting upon the supply of the burners. This way of control has also the drawback of being discontinuous and manual.

As to the actual regulation of the ratio between the amount of fuel and the amount of gas delivered to the burners in order to adjust the oxidizing-reducing character of the combustion products, this was formerly done, when a gaseous fuel was used, by acting upon the pressures of admission to the burners of the fuel and of the oxygen containing gas. This way of adjusting had the disadvantage of not taking into account unforeseen, but always possible, variations in the temperature of the gaseous fuel and/or of the oxygen containing gas which are delivered to the burner, an increase in the

temperature being attended with a loss of output (moles/time unit) for a given pressure and vice-versa.

According to the present invention the oxygen content of a molten metallurgical product, especially pure or impure copper, or copper alloys, leaving a gas furnace equipped with burners which are supplied with a gaseous fuel and an oxygen-containing combustive, is continuously measured by electrochemical means, the measured value is automatically compared with a control value, and the difference between the measured value and the control value is utilized to automatically act upon the ratio between the amount of fuel and the amount of combustive delivered to the burners, in order to obtain an oxidizing-reducing character of the combustion gases ensuring obtaining of the said molten metallurgical product with an oxygen content corresponding to the said control value.

According to another characteristic feature of the invention, the ratio between the amount of fuel and the amount of oxygen containing gas delivered to the burners in the course of a melting or conditioning process is regulated by acting upon the difference between the intake temperatures at the burners of the fuel and of the oxygen containing gas, by maintaining a fixed value for the ratio between the intake pressure of the fuel and that of the combustive. The said fixed value may preferably ensure a desired oxidizing-reducing character of the hot gases, generated by the burners, when starting up the said melting or conditioning process.

Other characteristic objects and features or the invention will appear clearly from the description given hereafter of a way of carrying out the invention, which is given as a nonrestrictive example and is illustrated in the accompanying diagrammatic drawing, in which the regulating system is shown by a dash line. This embodiment concerns the regulation of the oxidizing-reducing character of the hot gases generated by the burners used to fire any gas furnace for melting copper. In such a furnace the burners, which emerge in openings in lateral wall of the furnace, are supplied with a gaseous or liquid fuel and with an oxygen containing gas, for example air, which are pre-heated, preferably at the same temperature.

Referring to the drawing, the numeral **1** represents one of the burners of the gas furnace (not shown). This burner **1** is connected through pipes **2** and **3** with the main supplying conduits bringing the gaseous fuel **4** and the air **5** respectively. The fuel **6** and the air **7** are supplied under a predetermined positive pressure. The pressure under which the fuel **6** and the air **7** are delivered to the burner **1** can be regulated by valves **8** et **9** respectively; here independent valves are shown, but a device known per se could be used as well, by which the valve **8** gives a fuel pressure proportional to the pressure of the air delivered to the burner through valve **9** or vice-versa.

The fuel **6** and the air **7** are preheated by the devices **10** and **11** respectively; these devices may be supplied with heat in any suitable manner, for exemple electrically or by the heat of the furnace; the device **11** may also be heated by the heat of the furnace and the leaving hot air may be employed to heat the gas in the device **10** or vice-versa. The main manifold **4** supplying the fuel **6** in provided with a by-pass **12** enabling the fuel to pass round the preheating device **10,** the valve **13** permitting to regulate the turned off amount. In the same way the main manifold **5** supplying the air **7** is provided with a bypass **14** to pass round the preheating device **11** and the turned off amount can be regulated by valve **15.**

The numeral **16** represents an electrochemical cell with a solid electrolyte of a known type, for a continuous measuring of the oxygen content of molten metals, in particular copper. The cell **16** is dipped into the molten copper leaving the gas furnace (not shown) and connected with an apparatus **17** which converts the measurement effected by the cell **16** into an electrical signal proportional to the oxygen content of the molten copper leaving the gas furnace. Said electrical signal is introduced in a regulator **18** which compares it with a predetermined electrical signal emitted by the control transmitter **19**, said predetermined electrical signal being proportional to the desired oxygen content of the molten copper leaving the furnace. The regulator **18** acts upon the control transmitter **20** connected with the regulator **21** to an extent proportional to the difference between the signal imposed by the transmitter **19** and the signal from apparatus **16** and in the direction of the polarity of the said difference.

The transmitter **20** emits an electrical signal, the intensity of which is proportional to a predetermined difference between the temperatures of the fuel **6** and the air **7** delivered to the burners and the polarity of which indicates the desired direction of said predetermined difference. The regulator **21** is also connected with an apparatus known per se (**22**) for measuring the temperature of the fuel **6** and of the air **7** delivered to the burners by means of the thermocouples **23** and **24**, the junctions of which are located in the main conduits of the fuel **4** and of the air **5** respectively after the by-pass **12** and **14**, and which transform these measurements into an electrical signal the intensity of which is proportional to the difference between said temperatures and the polarity of which indicates the direction of said difference.

The regulator **21** acts upon the valves **13** and **15** of the by-passes **12** and **14** to an extent proportional to the difference between the signal sent to it by the control transmitter **20** and the signal sent to it by the apparatus **22** and in the direction of the polarity of said difference.

The above described apparatus is operated in the following way. In starting up a melting process, possibly preceded by a process of gradual preheating of the furnace, the control transmitter **20** is set for example at zero so as to induce equality of the temperatures of the fuel and of the air delivered to the burners. The regulator **21**, which is informed by the control transmitter **20** set at zero and by the apparatus **22** indicating the difference between said temperatures, ensures the equalization of said temperatures by acting upon the valves **13** and **15** of the by-passes **12** and **14.** Owing to the combined action of these controls and preheating devices **10** and **11**, the fuel **6** and the air **7** arrive at the burners, when starting a melting process, at a preheating temperature of say 200°C, which temperature can be read on the apparatus **22.**

The valves **8** and **9** are then set so as to supply the burner **1** with fuel and air a ratio ensuring, at the given preheating temperature, an oxidizing-reducing character of the combustion gases which is adapted to the kind of melting to be carried out, and in quantities ensuring a heat output of the burner adjusted to the desired melting rate. The supply of the other burners (not shown) is regulated in the same way, which enables starting up the melting process under required conditions.

Unless it is desired to alter the initially chosen melting rate, the valves **8** and **9** will, according to this invention, keep their initial setting position throughout the entire melting process, possible corrections to be made in the oxidizing-reducing character of the combustion gases during the melting procedure being carried out by the operating valves **13** and **15** of the by-passes **12** and **14** so as to alter the difference between the intake temperatures at the burners of the fuel and of the air.

Let us suppose for example that during the melting process, the products of combustion become too highly reducing; the cell **16** will then measure an oxygen content of the molten copper leaving the furnace, that the regulator **18** finds to be lower than the desired oxygen content imposed to it by the transmitter **19.** The regulator **18** will then act upon the control value of the transmitter **20** so that the latter orders an increase in the temperature of the fuel in comparison with that of the air, for example of 10°, and this will decrease the amount of fuel in comparison with that of the air delivered to the burners and hence generate combustion products which are less reducing in character. Lastly, the regulator **21** will act upon the valves **13** and **15** so as to obtain the difference in temperature which is ordered by the transmitter **20** until the apparatus **22** informs it that the operation has succeeded.

It is obvious that the above described control system can also be applied to the gas burners of a holding furnace or of a casting channel for molten metallurgical products.

It is also obvious that the above described control system, which supposes a process in which it is advantageous to operate with equal initial preheating temperatures of the fuel and the oxygen containing gas, can easily be adapted to processes in which it would be advantageous to operate with different initial preheating temperatures of the fuel and the oxygen containing gas.

It will have been noticed that the process according to the invention offers the advantage of being automatic and of taking into account unforseen changes in the oxygen content of the charge to be treated, and, if a preheated gaseous fuel and/or a preheating combustive are used, of taking into account unforeseen changes in the preheating temperature or temperatures.

What I claim is:

1. A process for maintaining the oxygen content of a molten copper or copper alloy at a desired value in a furnace heated by burners supplied with a gaseous fuel and an oxygen-containing combustive gas selected from the group consisting of air, oxygen-enriched air and oxygen which comprises:

a. maintaining the ratio between the intake pressures of the gaseous fuel and the oxygen-containing gas to each burner at a fixed value,

b. heating a portion of the gaseous fuel that is conducted to each burner and not heating another portion,

c. heating a portion of the oxygen-containing gas that is conducted to each burner and not heating another portion,

d. continuously measuring the oxygen content of the molten copper or copper alloy by electrochemical means so as to generate an electrical signal,

e. comparing the electrical signal generated by step (d) with an electrical signal which corresponds to the desired oxygen content of the molten copper or copper alloy and generating an electrical signal proportional to the difference therebetween,

f. continuously measuring the temperature of the gaseous fuel that enters each burner,

g. continuously measuring the temperature of the oxygen-containing gas that enters each burner,

h. comparing the difference in the measured temperature of the gaseous fuel and the measured temperature of the oxygen-containing gas, and converting this measured difference into an electrical signal, and

i. adjusting the volume of the unheated portion of either the gaseous fuel or the oxygen-containing gas in proportion to the difference between the magnitude and polarity of the electrical signal generated by step (e) and the electrical signal generated by step (h).

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