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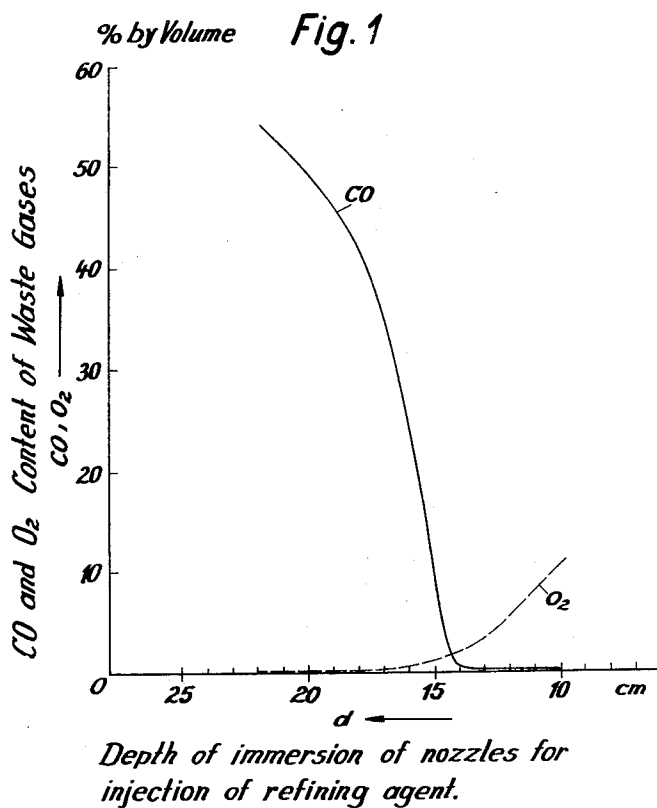
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METHOD FOR REFINING METAL BATHS IN ROTARY DRUM FURNACES

Filed May 16, 1958

2 Sheets-Sheet 1



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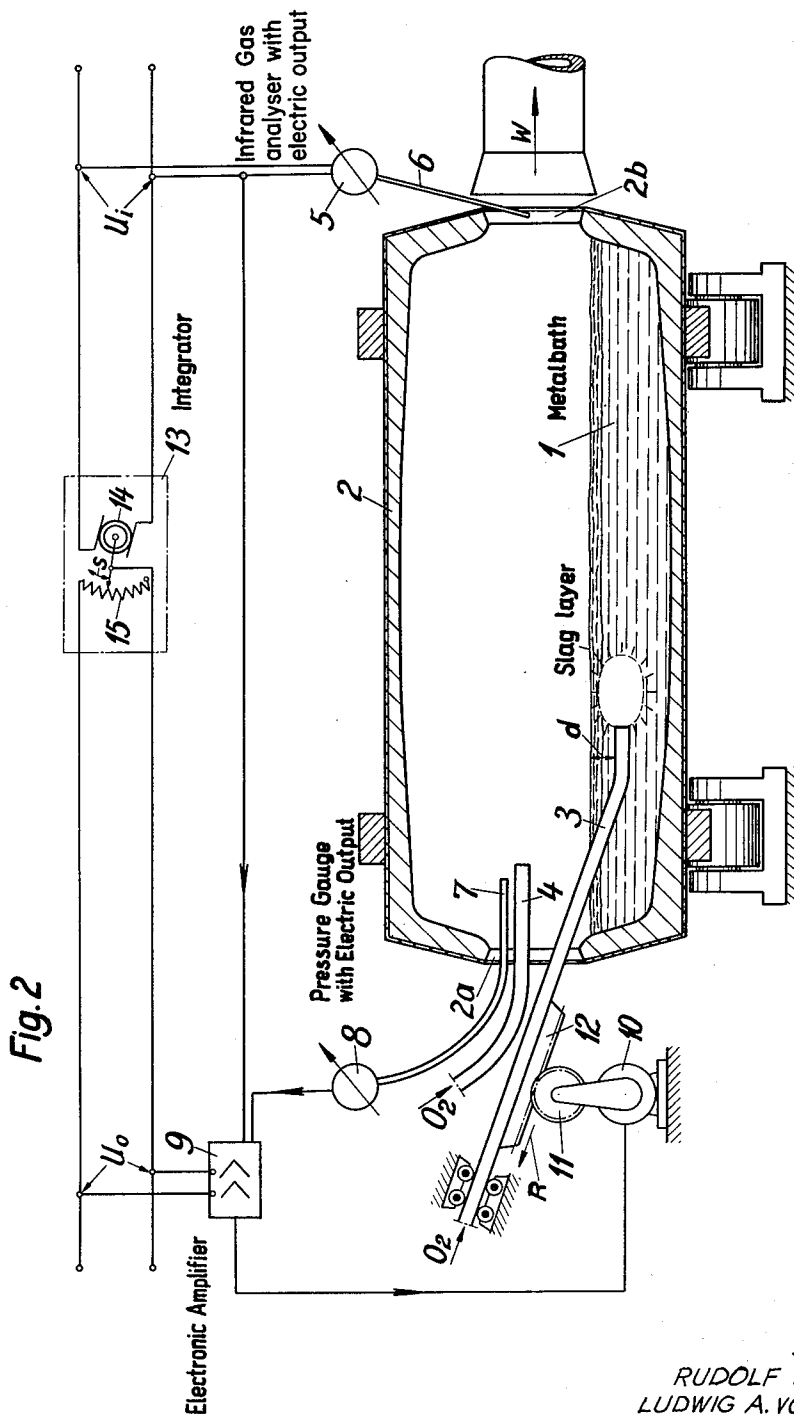
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METHOD FOR REFINING METAL BATHS IN ROTARY DRUM FURNACES

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This invention relates to a method for refining metal baths in rotary drum furnaces, and more particularly in drum furnaces adapted for rotation about a substantially horizontal axis.

Processes for refining metal baths are known in which a drum furnace containing the metal bath, rotates about a substantially horizontal axis and has in its end walls openings through which there are introduced injection means that end in nozzles dipping below the surface of the metal bath, and through which a refining agent, for instance oxygen or air, is injected into the metal bath. Furthermore, the combustion waste gases formed in the drum furnace during the refining process, are removed from the interior of the furnace through the aforesaid openings. Such processes are described, for instance, in Patents 2,806,687 and 2,839,382.

In this process, the products of the combustion of the carbon contained in the metal bath rise from the bath in the form of gaseous carbon monoxide. It is indeed an important advantage of the rotating drum furnace that it permits burning of the carbon monoxide and thereby increasing the thermal efficiency of the process. The carbon monoxide containing gases are burnt by oxygen which is introduced through auxiliary nozzles protruding through the above mentioned openings in the end walls of the furnace, and ending in the free space above the metal bath. The amount of oxygen introduced through these auxiliary nozzles should exceed the theoretically required stoichiometrical amount of oxygen for burning the carbon monoxide released from the metal bath, to carbon dioxide, because the oxygen is always partly consumed by the bath.

It has been found that that ratio of the supplementary blast of refining agent to the main blast introduced beneath the surface of the bath, which corresponds to a complete combustion of the carbon monoxide in the furnace to carbon dioxide without leaving any unused oxygen in the waste gases, is very strongly influenced by the depth of immersion of the main blast nozzles in the metal bath. If the above-mentioned ratio is maintained constant, small variations in depth of immersion of the blast nozzles result in substantial variations in the content of carbon monoxide in the waste gases. If the depth of immersion of the main nozzles below the metal bath surfaces increases, the rate of carbon monoxide development from the bath will also increase, and an insufficient amount of CO will be burnt unless the rate of refining agent introduced through the auxiliary nozzles above the bath surface is also increased. If that amount of auxiliary refining agent remains unchanged, and the depth of immersion of the main nozzles decreases, less CO will be developed from the bath, and the waste gases leaving the furnace will contain unburnt carbon monoxide, the potential thermic energy of which will thus be lost.

If the level of the blast nozzles remains stationary relative to the horizontal axis of the furnace, variations in depth of immersion of the nozzles are unavoidable, because the interior wall of the furnace is practically never

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a surface derived from revolution coaxial with the axis of the furnace. Consequently, the level of the surface of the metal bath rises and falls during rotation of the furnace relative to the stationary axis of rotation of the latter.

These changes in level increase with the increasing and irregular wear of the lining of the furnace the longer the latter has been in use.

If, in order to achieve maximum thermal efficiency without loss of oxygen, combustion of the gases rising from the metal bath is carried out as completely as possible, it is necessary for the immersed nozzles to follow every variation in the surface of the bath so that the depth of immersion is at all times that which leads to the minimum possible content of CO in the waste gases.

It is possible to measure continuously the CO content of the waste gases with the aid of well known analyzers, described, for instance, by Winterling in "Gaswärme" (1954), pages 138-140, and in the literature cited therein, and to increase or decrease the depth of immersion of the main blast nozzles in accordance with the indications of the analyzer so as to maintain the desired CO content in the space above the gas and in the waste gases leaving the furnace opening. This method, however, is only feasible when the variations in level of the surface of the bath do not occur too quickly. There is a certain time lag between the change in composition of the waste gases at the place of immersion, which change arises from variation in the depth of immersion of the blast nozzles and the arrival of these waste gases at the analyzer where the change in composition is recorded.

It is, therefore, an object of our invention to provide for a method whereby changes in the depth of immersion of the blast nozzles for injecting refining agent below the metal bath surface in a rotary drum can be detected immediately and can be made to serve for an immediate correction of the depth of immersion of the aforesaid nozzles, independent of the above-stated time lag between the occurrence of changes in the depth of immersion, and recordal of the resultant changes in the waste gases from the furnace by an analyzer.

This object is attained by the method according to our invention which is based on our discovery that changes in the depth of immersion of the blast nozzles result in practically instantaneously detectable and measurable changes in the pressure prevailing in the space above the metal bath in the drum furnace. This is due to the fact that an increase in depth of immersion results immediately in the formation of more CO, while a decrease in depth of immersion results immediately in the formation of more CO₂, and consequently, if the rate of supply of oxygen is maintained constant, more gas is produced when the depth of immersion increases and less, when the depth of immersion decreases. For 1 liter of oxygen produces either 1 liter of CO₂ or 2 liters of CO. Since the cross sectional area of the exit opening of the drum furnace from which the waste gases escape remains constant, the pressure in the furnace increases instantaneously, when the amount of CO rises and decreases as quickly when the amount of CO falls.

The invention accordingly provides for a method for refining metals in a drum furnace rotating about a substantially horizontal axis and provided in its end walls with openings through which pipe means for the injection of refining agent extend with their blast nozzles (primary nozzles) immersed beneath the surface of the metal bath, while auxiliary injection means end with supplementary blast nozzles (secondary nozzles) in the space above the surface of the metal bath, which method comprises providing for the combustion of the carbon monoxide rising from the metal bath and for the combustion gases to leave the furnace through the aforesaid openings, while simultaneously (a) maintaining the rate of supply of oxygen

to the furnace constant, and (b) maintaining the gas pressure in the interior of the furnace above the metal bath at a substantially constant value, which corresponds to a desired, predetermined CO content of the waste gases, by either increasing the depth of immersion of the blast nozzles, when the gas pressure falls below said value, or decreasing the depth of immersion of the blast nozzles when the gas pressure rises above said value, thereby restoring the gas pressure to the value corresponding to the desired CO content of the waste gases.

Electrical instruments are known which are operable by low gas pressures to transform pressure variations of the magnitude here in question instantaneously into an electrical impulse. Such an instrument is, for example, described in the periodical "Elektronik," 1956, published by Franzis Verlag, Munich, Germany, pages 47-49. According to the method of our invention, upward or downward deviations in gas pressure in the drum furnace from the value corresponding to the desired CO content of the waste gases are transformed by an electrical instrument of this type into electrical impulses which, after amplification in an amplifier of known type, provide control current for a motor controlling the depth of immersion of the nozzles, the motor increasing the depth of immersion of the blast nozzles when the CO content of the waste gases falls, and decreasing the depth of immersion of the blast nozzles when the CO content of the waste gases rises, until the gas pressure in the furnace corresponds again to the desired CO content of the waste gases.

If the gas pressure in the drum furnace is maintained constant in this way, there is also maintained a constant CO content in the waste gases leaving the furnace, and it is immaterial that the analyzer measures this CO content with a time lag. If it is desired to maintain a higher CO content of the waste gases, the electrical pressure-measuring and impulse-generating instrument is set to a higher datum pressure, and this datum pressure is then automatically maintained in the drum furnace as already described. Adjustment of the datum pressure of the electrical instrument thus makes it possible to vary the CO content of the waste gases as desired.

Even though the gas pressure in the refining drum is maintained constant, certain changes in the CO content of the waste gases may occur, for instance, when the rate of oxygen supply changes as the result of variations in pressure or temperature of the blast. A compensating adjustment of the datum pressure of the electrical instrument may thus be needed to maintain a constant CO content of the waste gases. To effect this compensating adjustment automatically in accordance with the invention, an analyzer, which measures the CO content of the waste gases and is set to the desired CO content, supplies, in the event of deviation of the CO content of the waste gases from the desired value, electrical impulses to the amplifier through an integrator of known type, described, for instance, by W.C. Elmore and M. Sands in "Electronics Experimental Technique," published by McGraw-Hill Book Company (1949), pages 405-410, said analyzer impulses being superposed on the impulses from the electrical pressure control instrument. Consequently, the gas pressure maintained by the electrical instrument no longer oscillates about the datum pressure but about a value greater or smaller than this datum pressure in proportion to the degree by which the CO content of the waste gases corresponding to the set datum pressure as detected by the analyzer exceeds or is less than the desired CO content.

The invention will be still better understood from the further description thereof in connection with the accompanying drawings, in which

Figure 1 is a graph illustrating the functional relationship between the CO- and the O₂-content, respectively, of the waste gases leaving the drum furnace, on the one hand, and the depth of immersion of the main blast nozzles below the surface of the metal bath in the furnace, and

Figure 2 illustrates schematically the arrangement of the main and auxiliary injection means for the refining agent in a rotary drum furnace, and the control means and circuit diagram associated therewith for carrying out the process according to the invention.

Referring to the drawings more in detail, Figure 1 shows a graph as described above, by way of example, in a specific case of a given constant ratio of 2:3 of a first portion of the refining agent injected below the bath surface to a second portion of refining agent injected into the furnace space above the metal bath. For this example, the curves in Figure 1 indicate the changes in percentage content of CO and O₂ in the waste gases in relation to the depth *d* (in centimeters) of immersion of the blast nozzles. This shows that, in this particular case, a change in depth of immersion of from about 14.5 cm. to about 18 cm. increases the content of CO in the waste gases from 2% to 40%. Fig. 1 also shows that, in this particular example, a reduction of the depth of immersion of the blast nozzles to less than 14.5 cm. resulted in a rapid increase in oxygen content of the waste gases. The optimum depth of immersion for securing the desired result of a minimum possible content of CO in the waste gases is, in the example illustrated in Fig. 1, that depth which corresponds to the point of intersection of the CO curve with the O₂ curve.

One embodiment of carrying out the process according to the invention will now be described with reference to Fig. 2 of the accompanying drawing.

The metal bath 1 is contained in a drum 2 lined with ceramic material and is refined by a blast of oxygen. The oxygen is supplied beneath the surface of the bath by a water-cooled primary nozzle 3 and above the surface of the bath by a water-cooled secondary nozzle 4, both nozzles extending through the same opening 2a in the end wall of the drum.

An analyzer 5 continually determines by means of a probe tube 6 the composition of the waste gases leaving through opening 2b in the opposite end wall of the drum as indicated by arrow W.

Above the secondary nozzle 4, a water-cooled tube 7 which acts as a pressure probe, passes through opening 2a into the interior of drum 2 above the metal bath. To this tube is connected a pressure meter 8 which measures the pressure in the drum practically instantaneously and continuously and which is described in "Elektronik" supra. In this instrument, deviation of the pressure from a set datum value is converted into a weak electrical impulse which is amplified in an amplifier 9. The amplifier 9 actuates an electrical motor 10 in its output circuit controlling by means of a gearing 11 and a rack 12 the depth of immersion *d* of the primary nozzle 3. Whenever the pressure read by the instrument 8 exceeds the set datum value, a positive difference voltage of a magnitude proportional to the pressure deviation is fed to the amplifier 9, amplified by the latter and passed on to the motor 10 which then withdraws the nozzle in the direction of arrow R, thereby decreasing immersion depth *d*. When the aforesaid pressure is too low, the reverse takes place. If the nozzle is controlled in accordance with any pre-set datum pressure, a constant CO content is obtained in the waste gases but that CO content is not necessarily the desired content. To ensure that the desired CO content in the waste gases is the one maintained by the above arrangement, the difference between the desired and the actual CO content measured by the analyzer 5 is also applied as a difference voltage to the amplifier 9. Thus, if, for example, the CO content of the waste gases is constant but too high, the amplifier 9 receives from the analyzer 5 an additional voltage of a sign opposite to that of the voltage from the pressure measuring instrument 8. This additional correcting voltage produces the same effect as would a correction of the datum pressure in the sense necessary to make it correspond to the desired

CO content. The pressure no longer oscillates about

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the datum pressure to which pressure meter 8 is set, but about a pressure which lies above or below the datum pressure depending on whether the CO content of the waste gases is above or below the desired value. The CO content thus adjusts itself gradually to the desired value and as soon as the latter is reached, the correcting impulse from the analyzer 5 will disappear. However, disappearance of the corrective impulse renders operative the original datum pressure which, as previously mentioned, does no longer correspond to the correct, desired CO content. To prevent this, there is provided between the analyzer 5 and the amplifier 9 an integrating device 13 of well known type, which stores and supplies to the amplifier the deviation in CO content from the desired value. This storage can readily be effected by causing the impulse to control the speed of rotation of a Ferraris motor 14 which adjusts a voltage selector 15 in the sense required to make the output (secondary) voltage U_o proportional to the primary voltage U_i multiplied by the time for which this primary voltage has prevailed, indicated by the deviation s .

The method according to the invention will be further illustrated by an example of carrying the same out in practice. It will be understood that this example is not intended to be limitative of the invention in any way or form.

Example

During a refining treatment in which the pressure fluctuates between +10 millimeter water column and -5 millimeter water column above and below atmospheric pressure, the datum pressure of the instrument 8 is set, for example, to a +5 mm. (water). The instrument 8 controls the depth of immersion of the nozzle 3 so that the set datum pressure is obtained in the drum 2. The CO content of the waste gas is, therefore, maintained constant, at a value, for example, of 20% by volume, of the waste gases. The desired value is, for instance, 5%. The analyzer 5 accordingly provides a difference voltage, corresponding to the difference of (20-5)% CO, which difference voltage is fed as an electrical impulse to the amplifier 9 and so reduces the datum pressure to the lower value corresponding to 5% CO in the waste gases. At the same time the integrator 13 comes into operation and provides an output voltage which increases progressively with the time during which the erroneous CO content prevails. Its voltage signal also operates to reduce the datum pressure. The inertia-free pressure regulator 8 then raises the nozzle 3 somewhat so that the pressure corresponds to the new lower datum value. The CO content of the waste gas is now smaller and the difference voltage between the desired and actual CO contents gradually disappears. The pressure would then return to the originally set datum value but for the fact that the integrator 13 has operated in the desired sense to produce a permanent change in the datum pressure.

It will be understood that while there has been given herein a certain specific example of the practice of this invention, it is not intended thereby to have this invention limited to or circumscribed by the specific details of materials, proportions or conditions herein specified, in view of the fact that this invention may be modified according to individual preference or conditions without necessarily departing from the spirit of this disclosure and the scope of the appended claims.

What we claim is:

1. In a process of refining a carbon-containing metal bath covered with slag, in a rotary furnace during the rotation of the latter about a substantially horizontal axis, by injecting gaseous oxygen-containing refining agent, on the one hand, into the metal bath at a level below the surface of the latter, and, on the other hand, into the space above the bath surface in order to burn at least partially the carbon monoxide developed from the bath, and by selecting a desired carbon monoxide

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content which is to be maintained during at least part of the refining process in the waste gases leaving the furnace by adjusting said level of injection of refining agent below the bath surface, and maintaining said content of carbon monoxide in the waste gases by continuously controlling and adjusting said level of injection, the improvement which comprises maintaining a constant rate of supply of said gaseous oxygen-containing refining agent to the furnace and simultaneously continuously adjusting said level of injection in immediate response to any deviation in total gas pressure from a desired total gas pressure corresponding to the desired carbon monoxide content in the waste gases leaving the furnace, by lowering the level of injection when the total gas pressure falls below said desired total pressure and raising the level of injection when the total pressure rises above said desired total pressure, thereby restoring the gas pressure with substantially no time lag, to the value corresponding to the desired carbon monoxide content of the waste gases.

2. In a process of refining a carbon-containing metal bath covered with slag, in a rotary furnace during the rotation of the latter about a substantially horizontal axis, by injecting gaseous oxygen-containing refining agent, on the one hand, into the metal bath at a level below the surface of the latter, and, on the other hand, into the space above the bath surface in order to burn at least partially the carbon monoxide developed from the bath, and by selecting a desired carbon monoxide content which is to be maintained during at least part of the refining process in the waste gases leaving the furnace by adjusting said level of injection of refining agent below the bath surface, and maintaining said content of carbon monoxide in the waste gases by continuously controlling and adjusting said level of injection, the improvement which comprises the steps of (1) controlling the total gas pressure in the said space above the bath surface which corresponds to the CO content of the waste gases leaving the furnace with a view to maintain a determined value of said CO content, (2) transforming deviations in total gas pressure occurring from the pressure corresponding to said determined CO content value immediately into electrical impulses, (3) transforming the latter immediately into mechanically effected changes of the depth of immersion of said blast level below the bath surface so that when the total gas pressure falls, the level of injection is lowered and when the total gas pressure rises, the level of injection is raised, and (4) simultaneously maintaining a constant rate of supply of gaseous oxygen-containing refining agent to the furnace.

3. In a process of refining a carbon-containing metal bath covered with slag, in a rotary furnace during the rotation of the latter about a substantially horizontal axis, by injecting gaseous oxygen-containing refining agent, on the one hand, into the metal bath at a level below the surface of the latter, and, on the other hand, into the space above the bath surface in order to burn at least partially the carbon monoxide developed from the bath, and by selecting a desired carbon monoxide content which is to be maintained during at least part of the refining process in the waste gases leaving the furnace by adjusting said level of injection of refining agent below the bath surface, and maintaining said content of carbon monoxide in the waste gases by continuously controlling and adjusting said level of injection so that when there is a CO content in the waste gases which is above the desired CO content the level of injection is raised, and where there is a CO content less than the desired CO content, the level of injection is lowered, the improvement which comprises the steps of (1) controlling the gas pressure in the said space above the bath surface which corresponds to the CO content of the waste gases leaving the furnace with a view to maintain a deter-

mined value of said CO content, (2) transforming deviations in gas pressure occurring from the pressure corresponding to said determined CO content value immediately into first electrical impulses, (3) analysing currently the CO content of the waste gases leaving the furnace and detecting deviations thereof from said determined value, transforming occurring detected CO content deviations into second electrical impulses, (4) integrating by said first and second electrical impulses, and (5) transforming the integrated impulses into mechani-

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cally effected changes of the depth of immersion of said blast level below the bath surface.

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