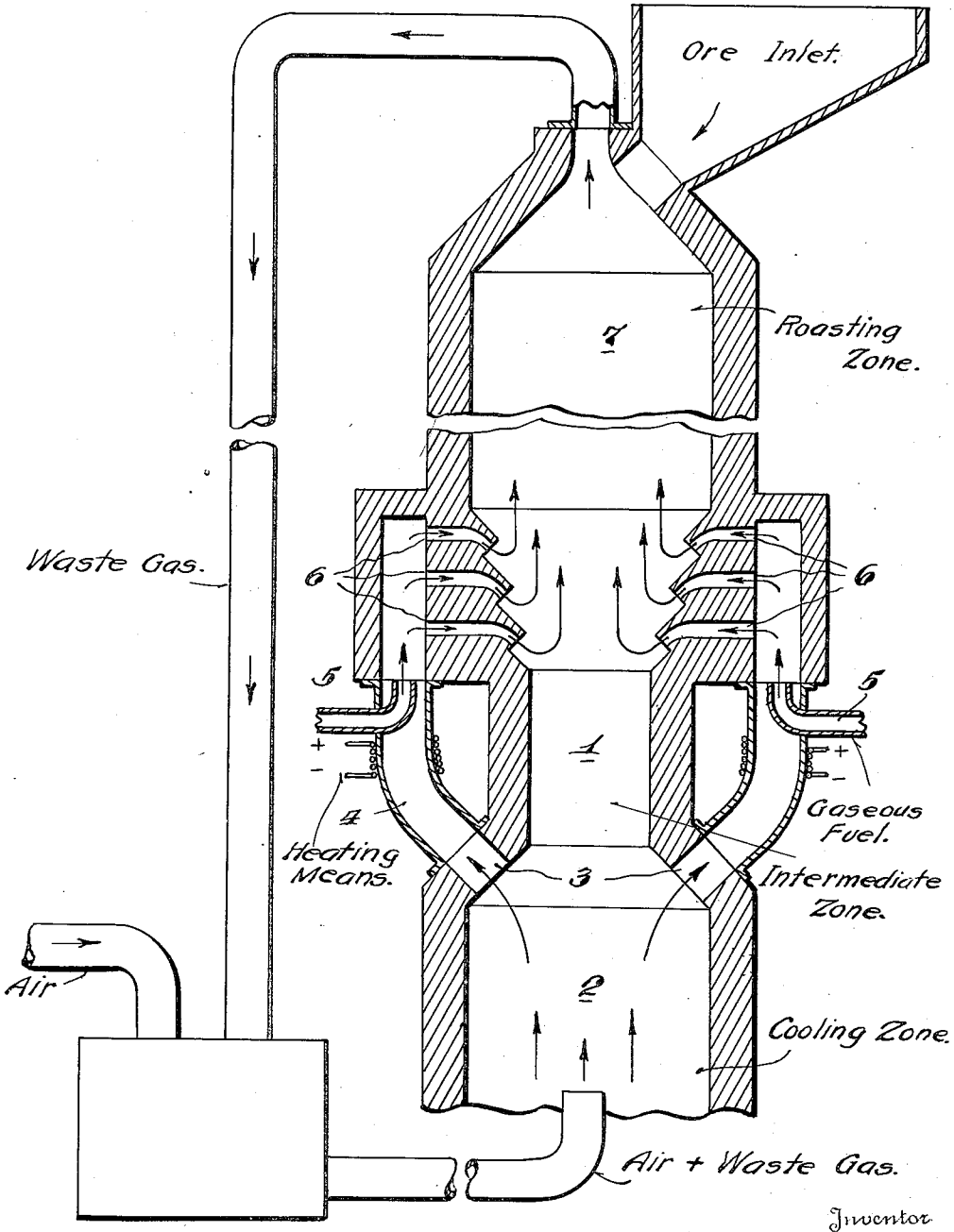
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METHOD OF AND APPARATUS FOR OPERATING SHAFT FURNACES FOR ROASTING AND THE LIKE

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METHOD OF AND APPARATUS FOR OPERATING SHAFT FURNACES FOR ROASTING AND THE LIKE

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This invention relates to a method of and apparatus for operating shaft furnaces for roasting and the like and, more particularly, to a roasting method and furnace in which a current of combustion air or gas flows in opposite direction to the passage of ore through the furnace.

The temperature necessary for carrying out the roasting process in a shaft furnace is in many cases closely below the sintering or melting temperature of the ore to be roasted. Thus, for instance, iron ores containing carbonic acid bound to lime must be heated to a temperature between 750 and 850° in order to be thoroughly roasted, while melting takes place at temperatures as low as 1000° and in some cases even at 900°.

The temperature in shaft furnaces for roasting depends upon the consumption of fuel per ton of raw material. The lower the consumption of fuel, the better the heat developed by combustion of the fuel distributed over the material to be treated, and the lower the temperature. However, the fuel consumption should not be below a certain minimum, because otherwise there will not be produced the heat necessary for the roasting process. Hence the roasting process determines a definite minimum temperature for the gas and the ore to be roasted. Furthermore, it must be considered that, in the usual shaft furnaces for roasting, the combustion air is used for cooling the ore upon thorough roasting and also for preheating the ore to a temperature not far below the working temperature of the furnace. Moreover, the ore within the combustion zone and, in the case of roasting furnaces operating with a distributed combustion, the solid fuel will assume the working temperature of the furnace. Finally, as the greatest part of the ore in the combustion zone is thoroughly roasted, a consumption of heat causing a lowering of the temperature in the roasting process will hardly be noticeable. Accordingly, almost the entire heat of combustion is used for heating the gas and the ore to higher temperatures, so that in case of a "sensitive" ore, a sintering and melting takes place resulting in an undesired partial liquefaction and a following solidification and parting of the material. The temperature in the roasting furnace may be somewhat lowered when the furnace is operated very slowly. However, the aforementioned liquefying and again solidifying of ore material due to sintering and melting cannot be prevented by operating the furnace in this way.

On the other hand, if the combustion in a roasting furnace is carried out with an excess of air, the temperature of the products of combustion and therewith the temperature to which the ore to be roasted is heated, is lower than in case of a combustion of the gases with the theoretically required amount of air. Accordingly, it would appear that the aforementioned liquefaction can be prevented by using an excess of air during the combustion. However, in roasting furnaces using a distributed combustion with an excess of air a proper combustion is not possible, because a surplus of air introduced into the furnace would cause combustion of a greater amount of fuel and, in addition, rising of the fire in the furnace or a faster operation of the furnace. Also in the case of gas-fired furnaces the danger of liquefying and parting of the material due to sintering and melting, can only be reduced to a limited extent by introducing an excess of air, because the air ascending in the furnace will gradually combine with the gaseous fuel and undergo combustion therewith. If now gaseous fuel is no longer present, the excess air will combine with the formed combustion gases until all air has been consumed and all gas constituents form a uniform mixture. Apparently this process continues as long as the gas contains just the required amount of air and undergoes combustion at a correspondingly high temperature. Excess air will be supplied to the combustion gases and cause a lowering of the temperature only during the further course of the process. Therefore, if an excess of air is used, there is still danger of partially sintering and melting the ore material.

My invention has for its object primarily to provide a method of oparating shaft furnaces for roasting in such a way as to prevent the aforementioned liquefying and again solidifying of the material due to sintering and melting. I accomplish this essentially by adding non-reacting gases to the gaseous fuel or the combustion air. This method permits, for instance, increasing the amount of the gases passing through the furnace, while the amount of heat supplied by the fuel remains unchanged. As a result, the roasting temperature may be regulated without reducing the fuel supply. On the other hand, it is also possible to regulate, as customary, the amount of fuel supplied to the furnace. The most convenient way of adding non-reactive gases to the combustion air consists in introducing waste or exhaust gases into the combustion air, for instance the exhaust gases or part of the exhaust gases of the furnace. Another way of adding gases to the combustion air consists in supplying it with

nitrogen, for instance nitrogen available from oxygen production plants for blast furnaces. In the case of shaft furnaces using a solid fuel, the addition of non-reacting gases to the combustion air is the only way of avoiding the aforementioned formation of liquefying and again solidifying the ore material due to sintering and melting.

For gas-fired roasting furnaces there are still other possibilities of carrying out the process according to my invention. Thus, for instance, the non-reacting gases may also be added directly to the gaseous fuel of the furnace, the effect being the same as when adding the non-reacting gases to the combustion air. Adding the non-reacting gases to the combustion gas may be preferable if hot waste or exhaust gases, for instance those of the roasting furnace, are available. The latter have still a temperature of at least 150° and may be introduced into the furnace without essential losses of heat.

However, adding hot waste or exhaust gases is only possible if the amount of air introduced from below into the furnace is sufficient for the cooling of the ore to be roasted. In general, the minimum amount of air required for the combustion of the gas is not sufficient for this purpose. Therefore, the admixture of hot exhaust or waste gases to the heating gas, as a rule, is only possible if, besides the hot exhaust or waste gas, an excess of air can be introduced into the furnace from below. In this case it is possible to save fuel due to the use of hot exhaust or waste gases.

In order to attain a proper saving of fuel, when using hot exhaust or waste gases, and in order to utilize, in addition, said exhaust or waste gases for the cooling of the ore to be treated without damage to the latter, it is advisable to introduce the exhaust or waste gases into a zone of the lower part of the furnace in which the temperature corresponds to the temperature of the available non-reactive gases, while the cold combustion air is introduced into the furnace quite at its undermost part. This mode of operating the furnace may be used with gas-fired furnaces as well as with furnaces heated by distributed combustion.

My new method of operating shaft furnaces for roasting may also be used in such a way that a second partial current of air or gases is admixed to the current of air or to the gases passing through the lower part of the furnace and furnishing the heat necessary for preheating the ore. In such cases, the second current of air or gases is supplied through nozzles and its heat content is such that the gas mixture formed by both currents and passing through to the roasting zone of the furnace does not assume an impermissible temperature. The heat content and the amount of the partial current of gas or air passing through the lower part of the furnace may be determined in accordance with the prevailing conditions. If, for instance, the working temperature of the furnace is supposed to be at 900° C., this partial current should have a temperature of about 750° C. If the second partial current is introduced through nozzles and both currents carry the same amounts of gas or air, a temperature of about 1000° C. of the mixture of both partial currents, in accordance with the working temperature of the furnace at 900°, is obtained by giving the partial current passing through the nozzles a temperature of 1250°. This may be accomplished by the combustion of a combustible gas, for instance, with a definite excess of air.

In some cases, especially if low temperatures are used, it may be advisable to heat air in steel recuperators or to preheat air therein and to further heat this air to the desired temperature by adding a definite amount of gaseous fuel thereto. In this manner there is attained a proper regulation of temperature as well as the possibility of reducing the carbonic acid and water-steam concentration, thereby expediting the roasting process.

The introduction of a current of gas or air at a temperature of 1250° may in many cases lead to the undesirable liquefaction of ore material, this being due to the fact that the mixing of the additive air or gas current with the ascending partial current, and therewith the lowering of the temperature to the average temperature of both partial currents, does not take place instantly.

In such cases it is advisable to take a further step which forms also part of my invention. This step, which is of especial usefulness also under other circumstances in order to attain the objects of my invention, consists in withdrawing fully or partly the gas or air current, which has passed through the lower part of the funrnace, from the shaft of the furnace, thereupon heating the withdrawn quantity outside the furnace to the required temperature, for instance 1000°, according to the above example, and again introducing the heated gas into the furnace. For this purpose, the furnace is preferably constructed in such a manner that a contraction is formed between the roasting zone and the lower part of the furnace in order to ensure that the gases actually follow the desired path and that, in addition, not too large a partial amount of gas will ascend within the furnace.

In the accompanying drawing I have shown an exemplification of a furnace construction suitable for carrying out my new process in the last mentioned modification, the illustration showing a vertical section through the essential parts of the furnace.

The furnace as shown in the drawing is formed with a contracted cross-section in its middle part as indiciated at 1 in the drawing. The upper part of the furnace, designated by 7, represents the roasting zone proper. The lower part, denoted by 2, is relatively cool when in operation. The ore to be roasted is supplied from above, passes through an uppermost preheating zone into the roasting zone 7, thence through the contracted zone 1 into the cooling zone 2 and is withdrawn at the bottom of the furnace. The cross-section of part 1 is, for instance, one fourth of the general cross-section of the furnace. The furnace is supplied with gaseous fuel through supply conduits 5. A mixture of combustion air and non-reactive gas, as described above, is supplied from below through the lower or cooling zone 2 of the furnace. This mixture is composed so as to obtain the desired combustion and temperature within the roasting zone. The arrows indicate the flow and direction of the gases within the furnace. The gases ascending within the lower part 2 of the furnace flow through connecting channels 4 after having left the lower part at 3 and, after having mixed with the fuel, again enter the furnace through channels 6 ending in downwardly directed nozzles as shown in the drawing.

I claim:

1. The method of operating a shaft furnace having an upper roasting zone and a lower cooling zone subsequently traversed by the material to be treated in counterflow to the furnace gases, which comprises supplying into the furnace near the roasting zone a current of firing gas, supplying a current of air from below the cooling zone, withdrawing gas from the furnace at a place between the cooling zone and the roasting zone, admixing the withdrawn gas to said firing gas and reintroducing it together with said firing gas into the roasting zone.

2. The method of operating a shaft furnace having an upper roasting zone and a lower cooling zone subsequently traversed by the material to be treated in counterflow to the furnace gases, which comprises introducing a mixture of air and non-reactive gas into the furnace from below the cooling zone, withdrawing part of the mixture after its passage through the cooling zone at a place between the two zones, mixing the withdrawn part of said mixture with fuel gas, and introducing the latter mixture into the furnace near the roasting zone.

3. The method of operating a shaft furnace having an upper roasting zone and a lower cooling zone subsequently traversed by the material to be treated in counterflow to the furnace gases, which comprises introducing a mixture of air and non-reactive gas into the furnace from below the cooling zone, withdrawing part of the mixture after its passage through the cooling zone at a place between the two zones, heating the withdrawn part of said mixture outside the furnace to a higher temperature, mixing said heated mixture with fuel gas, and introducing the latter mixture into furnace near the roasting zone.

4. The method of operating a shaft furnace having an upper roasting zone and a lower cooling zone subsequently traversed by the material to be treated in counterflow to the furnace gases, which comprises supplying into the furnace near the roasting zone a current of firing gas, supplying a current of air from below the cooling zone, withdrawing gas from the furnace at a place between the cooling zone and the roasting zone, passing the withdrawn gas outside the furnace and heating it to a high temperature and admixing it to fuel gas, and introducing the mixture of withdrawn gas and fuel gas into the furnace near the roasting zone.

5. The method of operating a vertical shaft furnace having an upper roasting zone and a lower cooling zone subsequently traversed by the material to be treated in counterflow to the furnace gases, which comprises introducing a mixture of air and non-reactive gas into the furnace from below the cooling zone, withdrawing part of the mixture after its passage through the cooling zone and before its passage through the roasting zone, mixing the withdrawn part of said mixture with fuel gas, and passing currents of the total mixture thus obtained into the bottom portion of the roasting zone.

6. Roasting furnace having a substantially tubular wall forming an upper roasting zone, a lower cooling zone and an intermediate zone of a smaller cross-section than said upper and lower zones, means for supplying an air current into the furnace from below said lower zone, ducts traversing said furnace wall substantially between said intermediate zone and said cooling zone for withdrawing gaseous mixture, fuel conduits opening into said furnace at points substantially above said intermediate zone and at the bottom of said roasting zone, and conduit means connecting said ducts with said fuel conduits for admixing said withdrawn mixture to the fuel gas supplied through said fuel conduits.

7. Roasting furnace having a substantially tubular wall forming an upper roasting zone, a lower cooling zone and an intermediate zone of a smaller cross-section than said upper and lower zones, means for supplying an air current into the furnace from below said lower zone, ducts traversing said furnace wall substantially between said intermediate zone and said cooling zone for withdrawing gaseous mixture, fuel conduits for supplying firing gas to said roasting zone, said fuel conduits comprising nozzle openings opening into the furnace at points above said intermediate zone and near the bottom of said roasting zone and extending in downwardly inclined directions respectively, and conduit means outside said zones connecting said ducts with said fuel conduits for admixing said withdrawn mixture to the fuel gas supplied through said nozzle openings.

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