

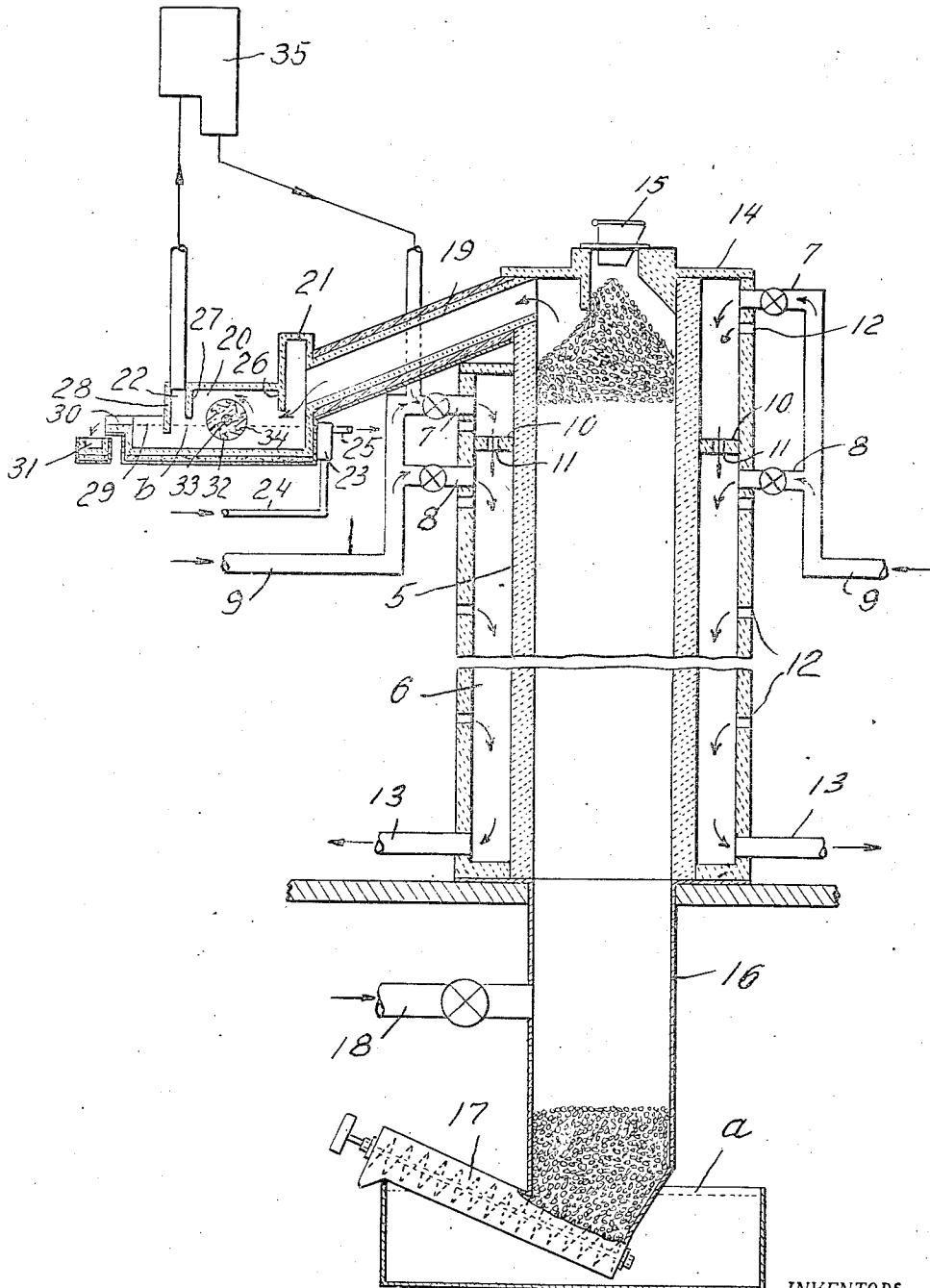
Dec. 28, 1948.

E. C. HANDWERK ET AL

2,457,552

VERTICAL RETORT PROCESS FOR ZINC SMELTING

Filed Jan. 17, 1946



INVENTORS

Erwin C. Handwerker
George T. Mahler
BY

BY

Pennie, Edmonds, Morton and Barrows

ATTORNEYS.

UNITED STATES PATENT OFFICE

2,457,552

VERTICAL RETORT PROCESS FOR ZINC
SMELTING

Erwin C. Handwerk and George T. Mahler, Palmerton, Pa., assignors to The New Jersey Zinc Company, New York, N. Y., a corporation of New Jersey

Application January 17, 1946, Serial No. 641,711

1 Claim. (Cl. 75—88)

1

This invention relates to zinc smelting, and has for its object the provision of certain improvements in the smelting of zinc ores and the like in externally heated vertical or upright retorts.

In the smelting of zinc ores in modern externally-heated vertical retorts, it is the customary practice to pass the zinc vapor through a body or column of coke or charge briquettes held in an unheated upper extension of the retort in order to obviate the formation of excessive blue powder. In this unheated extension, the ascending zinc vapor bearing gases are cleaned by a certain amount of zinc vapor that condenses with refluxing of the resulting molten zinc. The refluxing molten zinc constitutes a circulating load in the retort and diminishes its capacity for new ore burden. Even under the most favorable operating conditions, from 7 to 9% of blue powder (on the basis of the molten zinc produced) is formed in modern vertical zinc retort smelting, and in some plants the blue powder formation amounts to as much as 15%. This blue powder is customarily returned to the retorts for resmelting, and this further diminishes the capacity of the retort for new ore burden.

The aforementioned restrictions of the capacity of vertical zinc smelting retorts are imposed by the necessity of operating the retorts so as to avoid the formation of excessive amounts of blue powder in the condenser. The heretofore known types of condensers have been unable to transform to molten zinc any appreciable amount of blue powder accompanying the smelting gases or formed in the condenser. Moreover, with these known condensers it is essential to avoid dilution of the zinc vapor as much as possible, since dilution increases the formation of blue powder. We have discovered that certain improvements and economies in the operation of vertical zinc smelting retorts are possible when the zinc vapor is condensed in a splash type condenser capable of transforming substantial amounts of blue powder to molten zinc. The splash type condenser liquifies blue powder or zinc dust by stirring it vigorously into a bath of molten zinc. In consequence, it is able to deal with more dilute than heretofore normal zinc vapor bearing gases (provided, of course, that carbon dioxide is not present in large amounts), and other operating factors leading to the formation of blue powder in the condenser can be ignored since whatever blue powder forms is promptly transformed to molten zinc.

The present invention thus involves operating

2

the vertical zinc smelting retorts at their full capacity for new ore burden and without special precautions for avoiding the formation of blue powder, and passing the zinc bearing smelting gases through a splash type condenser in which the zinc vapor intimately contacts a shower of molten zinc particles thrown into the condensing chamber from a bath of molten zinc maintained in the bottom thereof. More particularly, the invention contemplates heating the column of agglomerated charge in the vertical retort above the temperature at which any substantial amount of zinc vapor is condensed with refluxing of the resulting molten zinc at any point in the charge column, and particularly approximate the top of the column. Additionally, the invention contemplates the introduction of an increased amount of displacement air at the bottom of the retort with attendant increase in internal heating of the charge and dilution of the zinc vapor bearing smelting gases. The resulting zinc vapor bearing gases are then introduced into a splash-type condenser wherein a substantially continuous shower of molten zinc is hurled upwardly by centrifugal action with such violence as to provide by itself and by its splashing against the confining upper portion of the condensing chamber turbulent sheet-like showers of molten zinc through which the gaseous stream is passed. These and other features of the invention will be best understood from the following description taken in conjunction with the single figure of the accompanying drawing which is a sectional elevation of a vertical zinc smelting retort and associated splash zinc condenser particularly adapted for practicing the invention.

The vertical zinc smelting retort 5, built up of suitable heat refractory material, is surrounded by a heating or combustion chamber 6. The combustion chamber extends over the entire length or height of the vertical retort, and is supplied with suitable firing gas through valved ports 7 and 8 connected to the firing gas supply pipes 9. The gas ports 7 are positioned near the top of the combustion chamber, and the firing gas delivered thereby combusts in an upper chamber formed by a transverse partition 10 having appropriate exit openings 11 into the lower chamber. The gas ports 8 are positioned just below the partition 10. The outer wall of the combustion chamber is provided with vertically spaced air ports 12 for supplying air for combustion of the firing gas. The products of combustion of the firing gas are withdrawn at the bottom of the combustion chamber through gas outlets 13.

3

The top of the retort is close by a cap or cover 14 and a gas-tight charging device 15 mounted thereon. The flow of the firing gas and its products of combustion is indicated by the arrows on the drawing.

The retort is charged, through the charging device, with an agglomerated charge of zinciferous material and appropriate reducing agent, e. g. carbonaceous material. The agglomerated charge passes progressively through the retort and is heated to a sufficiently high temperature to reduce compounds of zinc, e. g. zinc oxide, and volatilize the resulting reduced or molten zinc metal. The worked-off or spent charge passes from the bottom of the retort through a depending extension 16, which may be made of metal. The discharge end of the extension 16 is beneath the water level *a* in a suitable basin which provides an effective seal inhibiting the admission of uncontrolled amounts of atmospheric air into the bottom of the retort. The spent charge is removed from the bottom of the extension 16, beneath the water level *a*, by a screw conveyor discharge chute 17. Air or other appropriate combustion supporting gas, such for example as oxygen enriched air, is introduced into the extension 16 through the valved pipe 18 in controlled amount, as hereinafter more particularly explained. In operation, the retort is filled with the agglomerated charge. Worked-off charge is withdrawn from the bottom of the retort in a substantially continuous manner, and fresh charge is similarly introduced in equivalent amount at the top of the retort. The charge column thus passes downwardly through the retort and becomes progressively depleted in zinc content as the smelting or reducing action proceeds.

The top of the vertical retort 5 is connected through a downwardly inclined conduit 19 to a splash type condenser. The condenser comprises a generally rectangular condensing chamber 20 having a zinc vapor inlet 21 approximate one end and communicating with the conduit 19, and having an exhaust gas (mainly carbon monoxide) outlet 22 approximate its other end. The condensing chamber is lined with suitable refractory material and is exteriorly equipped with air or water-cooling jackets 23 having an appropriate inlet 24 and outlet 25 for the cooling medium as conventionally indicated by the arrows on the drawing. The zinc vapor inlet 21 and the exhaust gas outlet 22 are shielded by depending refractory baffles 26 and 27, respectively, to prevent splashing or spraying of molten zinc into the inlet and outlet.

The condensing chamber communicates, beneath the lower edge of its end wall 28, with a discharge well 29 having an overflow spout 30 determining the level *b* of the bath or body of molten zinc in the condensing chamber. A collecting trough 31 receives the molten metal overflowing the spout 30 and conveys it to casting equipment or the like. The lower portion of the end wall 28 dips into the molten metal between the condensing chamber and the discharge well and seals the condensing chamber from the atmosphere at this point. The volume of molten zinc in the condensing chamber is thus maintained substantially constant by continuously withdrawing molten zinc as it is condensed from the chamber.

A generally cylindrical rotor 32 is mounted within the condensing chamber 20. The rotor is carried by a water-cooled shaft 33 mounted in

4

bearings outside the condenser. The shaft 33 is horizontally disposed and extends through the side walls of the condensing chamber between the zinc inlet and the gas outlet in a direction generally transverse to the direction of gas flow through the chamber. The rotor may be constructed of graphite, silicon carbide or other suitable refractory. The peripheral surface of the rotor has a plurality of circumferentially spaced pockets or cups 34. The shaft 33 is positioned at a level substantially above that of the molten zinc adapted to be held in the chamber 20, and the rotor 32 is of such outside diameter that its lowermost pocket is beneath the molten zinc level *b*. Detailed features of the condenser's construction are described in the copending U. S. patent application of Handwerk, Mahler & Haupt, Serial No. 626,508, filed November 3, 1945. If desired, the condenser may be internally cooled as described in the copending U. S. patent application of Handwerk, Mahler and Haupt Serial No. 633,004, filed December 5, 1945.

In practicing the invention in the apparatus illustrated in the drawing, worked-off or spent agglomerates are withdrawn from the bottom of the retort and preheated agglomerates of mixed zinciferous material and carbonaceous material are introduced through the charging device 15 into the top of the retort in such manner that the smelting operation in the retort is conducted as a substantially continuous process. The upper part of the retort, surrounded by the upper part of the combustion chamber 6, is externally heated so that the charge within this portion of the retort is heated to a sufficiently high temperature to prevent any substantial condensation of zinc vapor and refluxing of molten zinc approximate the top of the charge in the retort. This temperature will generally be from about 850 to about 900° C., which is above the temperature at which any substantial amount of zinc vapor condenses with refluxing of the resulting molten metal. At this temperature the charge in the upper part of the retort forms an adequate filter for the upwardly passing stream of smelting gases without resulting in any appreciable condensation of zinc vapor. Heat is thus applied to the entire column of charge in the retort so that condensation of zinc vapor in the upper part of the charge column is substantially inhibited.

The agglomerates charged into the top of the retort are customarily coked to produce structures possessing adequate strength to withstand without substantial disintegration the subsequent smelting operation, and in the practice of the invention are preheated to a temperature of at least 500° C. and preferably higher, and to this end may advantageously be transferred directly from the coking furnace to the retort with a minimum loss of heat. When prepared in the manner described in our United States Patent No. 1,875,249 and directly transferred to the retort, the coked agglomerates will enter the retort at a temperature approximating 850° C. The heating of the charge in the upper part of the retort (i. e. above the partition 10) may be just sufficient to inhibit condensation of zinc vapor with refluxing of molten zinc in that part of the retort, or may be sufficiently intense to initiate the reduction of zinc compounds in that part of the retort. Usually, some reduction is initiated before the charge progresses below the level of the partition 10, but the heating is insufficient to initiate reduction throughout the entire upper part of the retort. The heating of the upper part of

5

the charge column in the retort, as contrasted with the heretofore customary practice of maintaining an unheated upper extension of the retort, substantially increases the capacity of the retort for new ore burden. Thus, the capacity is increased due to the absence of any circulating load such as refluxing molten zinc constitutes. Also, to the extent that reduction takes place in the upper part of the retort, the effective smelting length of the retort is correspondingly increased without increasing its actual length.

A continuous stream of zinc vapor bearing smelting gases flows through the conduit 19 and enters the condensing chamber 20 beneath the baffle 26 of the inlet 21. The gases will enter the condenser at a temperature around 850-900° C., and will generally contain around 25 to 50% zinc vapor diluted for the most part with carbon monoxide gas. The exhaust gases from the condenser (consisting mainly of carbon monoxide) may advantageously be passed through a scrubber 35 and mixed with the firing gas as diagrammatically indicated in the drawing. Dissipation of heat from the condenser is controlled by regulating the cooling medium flowing through the jackets 23 to maintain within the condenser an operating temperature of from 490 to 550° C. or may be controlled, as hereinbefore mentioned, by internal cooling of the condenser. The condenser temperature is the temperature of the molten metal near the outlet of the condenser.

The rotor 32 is rotated at a relatively high speed, say around 100-150 R. P. M., counter-clockwise as indicated by the arrow, so that the pockets 34 in rapid succession pick up and throw sheets or showers of molten zinc into the entering gas stream. A small amount of molten zinc is picked up by each pocket in passing through the body of molten zinc in the condensing chamber, and as the pocket emerges from the body of molten zinc the picked-up molten zinc is thrown by centrifugal action from the pocket upwardly into the gaseous stream passing through the condenser. The pockets pass in rapid succession through the body of molten zinc with the result that a substantially continuous upwardly-directed shower of molten metal is thrown into the gaseous stream. The pockets 34 have a generally scoop-like section with a relatively long advancing flat surface and a shallow semi-circular depression at the inner end or bottom of the pocket. The pockets terminate short of the circumferential peripheral ends of the rotor so that little or no molten metal is thrown laterally against the side walls of the condensing chamber. The upwardly-directed and rapidly succeeding sheets or showers of molten metal splash into the shower or rain of molten zinc particles falling through the chamber, and also splash against the baffle 26 and the roof of the condensing chamber, with the result that this area of the condensing chamber is substantially filled with sheet-like showers and moving particles of molten zinc which form ideal nuclei for the condensation and subsequent coalescence of the zinc vapor. Formation of blue powder or zinc dust within the condensing chamber is practically negligible, and whatever particles are formed are dissolved in the splashing and showering molten zinc or carried thereby into the bath of molten zinc and there melted. Similarly, any particles of blue powder or zinc dust included in the gaseous stream entering the condenser are effectively transformed into molten zinc by the splashing and showering molten zinc

6

particles and by the stirring action of the rotor itself.

In accordance with the invention, a further increase in the capacity of the retort is effected by increasing the volume of displacement air or other combustion supporting gas introduced into the depending extension 16 through the pipe 18. Air or the like thus introduced generates heat at the discharge end of the retort by combustion of unconsumed carbonaceous material remaining in the worked-off residual charge. The ability of the splash type condenser to handle blue powder permits dilution of the zinc vapor in the smelting gases, and hence permits the introduction of increased amounts of combustion air or the like through the pipe 18. More heat is thus internally generated in the retort so that the zinc is eliminated from the charge more rapidly. Furthermore, the resulting increased gas currents within the agglomerated charge transfer more heat from the retort walls to the interior of the retort by convection currents so that the external heating of the retort is facilitated. Moreover, the increased dilution of the zinc vapor bearing gases decreases the tendency to refluxing in the charge column by lowering the zinc dew point, so that the more intensive the introduction of combustion air, the less it is necessary to heat the upper portion of the retort to eliminate refluxing. The amount of combustion air that can be introduced is limited by the fact that too much combustion of carbon in the base of the retort is likely to produce slagging and to injure the refractory walls of the retort. Ordinarily there is no difficulty with this if the amount of combustion air is increased to two or three times the amount that can be used in the heretofore customary vertical retort smelting practice wherein the air is introduced only in amount sufficient to insure an upward draft in the retort.

In an actual practice of the invention, 3500 pounds of zinc was condensed each day over a continuous period of 9 days. The amount of scum, blue powder, coal and ore dust collected in the condenser was about 25 pounds for the 9 day period, or less than 0.1% of the weight of zinc metal condensed. The scrubber blue powder collected from the tail or exhaust gas was about 2% when operating at a metal bath temperature in the condensing chamber of about 550° C. When operating at a condenser temperature of 490-500° C., possible in the practice of the invention, the exhaust gas contains about 1% of the condensed zinc which is collected as scrubber blue powder. This represents an over-all formation of blue powder etc. of 2.1% or less, as contrasted with from 7 to 15% under heretofore customary commercial operating practices.

The advantages of the invention may be briefly summarized as follows:

1. A reduction in the amount of blue powder formed from 7 to 15% in the heretofore customary practices to 1½ to 2½% in the practice of the invention. A reduction of the amount of blue powder recirculated to the smelting retorts from about 8% and higher to about 2%, which permits from 3 to 6% increase in new ore burden and results in a 300-600 pound increase in zinc metal output per retort per day.

2. A reduction in the amount of wet and cold blue powder recirculated tends to reduce the rock oxide formation and improves the retort life.

3. Since the splash type condenser efficiently converts blue powder to liquid metal, it is possible

to reduce refluxing in the charge column by heating it to 850-900° C. This cannot be done in the heretofore customary vertical retort zinc smelting practices because of increasing the condenser and scrubber blue powder. Because of the elimination of refluxing molten zinc, a 500-1000 pound increase in zinc metal output per retort per day is possible. In addition, there is some decrease in rock oxide formation.

4. Since the splash type condenser can efficiently condense a diluted zinc vapor of low carbon dioxide content, it is possible to increase the amount of displacement air introduced at the bottom of the retort. This results in the generation of heat within the charge. An increase in displacement air from the present customary 8 to 12 C. F. M. to 20 to 30 C. F. M. (which is possible in the practice of the invention) increases the retort output from 5 to 10% or 600-1200 pounds per retort per day, the retort being about 30 feet in height and of rectangular cross section, 6 feet long and 12 inches wide. In addition, the increased dilution reduces refluxing in the charge column.

5. Externally-heated vertical zinc smelting retorts as heretofore customarily operated must be relatively narrow, usually around 12 inches internal width, on account of the difficulty of driving heat into the interior of the charge. In accordance with the practice of the present invention, sufficient internal heating can be produced by the introduction of displacement air into the base of the retort to increase the retort width by 25%, with resultant increase in retort capacity.

6. A reduction in the operating labor required in addition to an improvement in the working conditions.

7. Molten zinc is continuously withdrawn from the condenser as it is condensed therein, thus eliminating the periodic tapping of the condenser heretofore customary in vertical retort smelting practice.

8. Substantial elimination of zinc vapor condensation with refluxing of molten zinc in the upper part of the retort eliminates contact of molten zinc with the retort walls and the deleterious effect thereof upon the walls.

We claim:

The improvement in the continuous smelting of an agglomerated charge of mixed zinciferous material and carbonaceous reducing agent in

an externally-heated vertical retort, which comprises heating the top of the column of agglomerated charge in the retort to a sufficiently high temperature to inhibit any substantial condensation of zinc vapor and refluxing of molten zinc approximate the top of the charge column, passing the zinc vapor bearing smelting gases continuously through a condensing chamber having a body of molten zinc in the bottom thereof, hurling by centrifugal action a substantially continuous and upwardly-directed shower of said molten zinc of such violence as to provide by itself and by its splashing against the confining upper portion of the condensing chamber turbulent sheet-like showers of molten zinc through which the gaseous stream passes, withdrawing the worked-off charge from the bottom of the retort through a depending extension thereof sealed from the atmosphere at its bottom, and introducing into said extension a combustion supporting gas in amount of 2 to 3 times that required to insure an upward draft in the retort, said amount being sufficient to supply by its combustion with carbon in the charge a substantial amount of internal heating of the charge in the retort with attendant substantial dilution of the zinc vapor bearing smelting gases.

ERWIN C. HANDWERK.
GEORGE T. MAHLER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,647,381	Tharaldsen	Nov. 1, 1927
1,688,426	Lannon, Jr.	Oct. 23, 1928
1,712,132	Breyer et al.	May 7, 1929
1,884,088	Miller	Oct. 25, 1932
1,922,274	Bunce et al.	Aug. 15, 1933
1,927,763	Wejnarth	Sept. 19, 1933
1,941,569	McCraven	Jan. 2, 1934
1,983,025	Ginder et al.	Dec. 4, 1934
2,096,779	Bartholomew et al.	Oct. 26, 1937
2,348,194	Crane et al.	May 9, 1944

FOREIGN PATENTS

Number	Country	Date
55,473	Sweden	May 24, 1922