Oct. 26, 1971 J. FEINMAN ET AL 3,615,083

FLUIDIZED BED METHOD AND APPARATUS FOR CONTINUOUSLY QUENCHING COILED ROD AND WIRE

Filed July 2, 1969

FIG. 1.

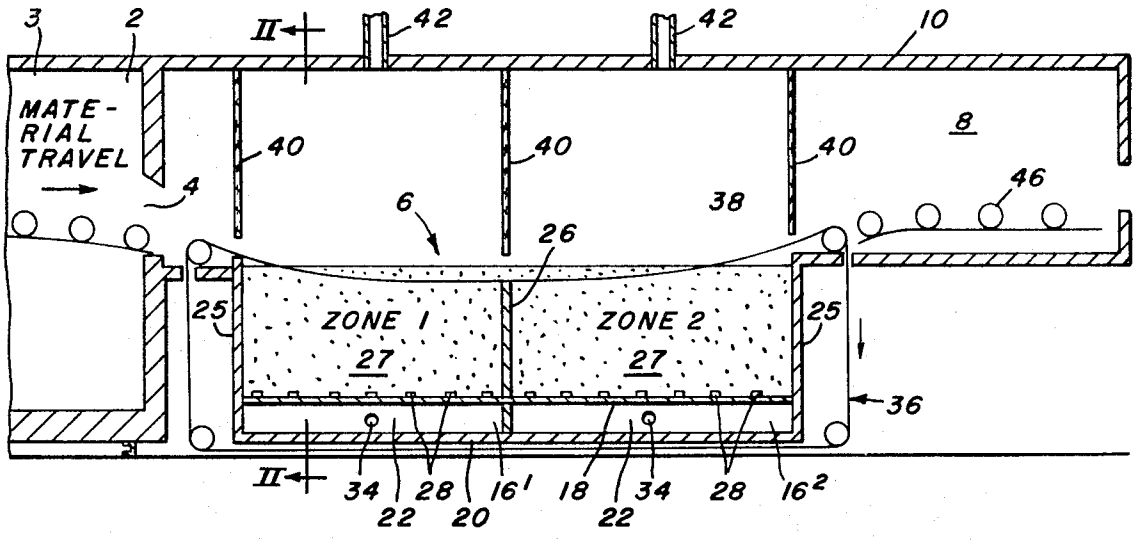


FIG. 3.

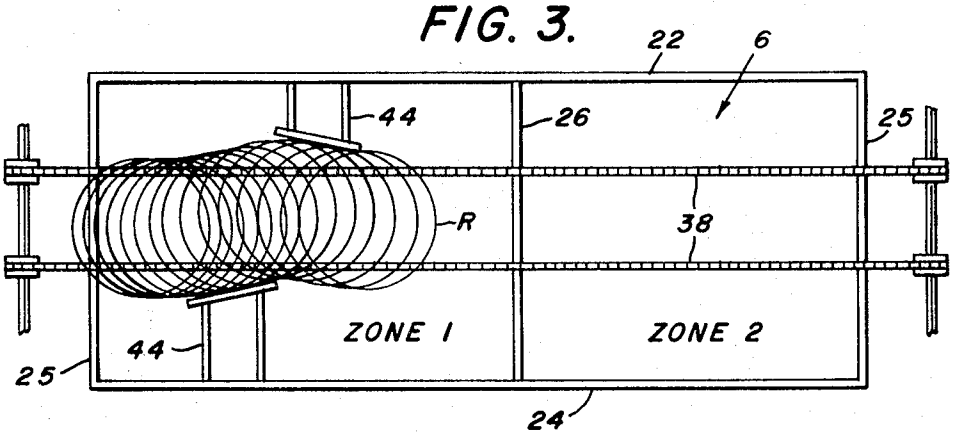


FIG. 2.

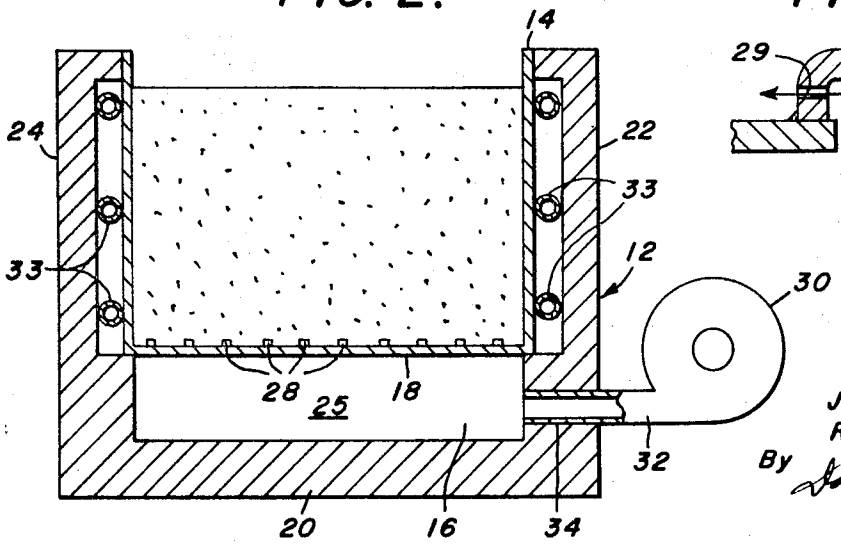
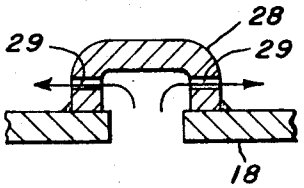


FIG. 4.



INVENTORS.
JEROME FEINMAN &
RICHARD L. SALLO
By Donald S. Ferito
Attorney

United States Patent Office 3,615,083 Patented Oct. 26, 1971

3,615,083

FLUIDIZED BED METHOD AND APPARATUS FOR CONTINUOUSLY QUENCHING COILED ROD AND WIRE

Jerome Feinman, Monroeville, and Richard L. Sallo, Greensburg, Pa., assignors to United States Steel Corporation

Filed July 2, 1969, Ser. No. 838,562
Int. Cl. C21d 9/56
U.S. Cl. 266—3 R 3 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus consisting of a chamber having a two-zone fluidized bed is utilized for quenching rod or wire in open-coil, continuous loop form to obtain a metaliurgical patented structure consisting of fine pearlite, some coarse pearlite, and very little free ferrite in high carbon steel rod or wire.

BACKGROUND OF THE INVENTION

The present invention relates to an improved apparatus and method for quenching steel rod and wire after patent annealing and, more particularly, to quenching steel rod or wire by means of a two-zone fluidized bed.

Prior to our invention, steel rod and wire patenting processes have historically been continuous, multiple-strand operations in which strands of the rod or wire were pulled through a heating furnace and quenched in air or molten lead. Recently developed processes modified this operation and included the steps of recoiling the hot rod into open-coil, continuous loops, commonly termed Spencerian coils, as it exited from the rod mill and then cooling the rod with forced air as it was conveyed in Spencerian form to a take-up station. This method produced satisfactory patented product in steel of low carbon range (approximately 0.20 to 0.65% carbon) but the cooling rate of the Spencerian coils of rod was not rapid enough to obtain the desired properties in steel of high carbon range (0.65% and above). The original multiple-strand, lead-quench, straight-line patenting process produced a satisfactory product in steel of such high carbon range.

In another method of processing to obtain patented product, the rod or wire was conveyed in Spencerian form through a gas-fired, roller hearth furnace and then through a forced-flow, atmosphere-gas quench zone. This method was also unsatisfactory since its cooling rate was not rapid enough to obtain the desired patented properties in steel of high carbon range.

Both of the above described methods in which the product was processed in Spencerian form were limited in cooling capacity and therefore produced a material which contained an excessive amount of coarse pearlite and network ferrite. This resulting metallurgical structure limited the amount of allowable cold working that could be done to the product and, consequently, produced a material with a lower tensile strength and ductility.

SUMMARY OF THE INVENTION

The present invention pertains to an apparatus and method for providing a controlled, relatively rapid cooling rate by means of a two-zone fluidized bed to produce a high carbon steel product having a metallurgical patented structure comprising primarily fine pearlite with a minimum of coarse pearlite and network ferrite.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical sectional view of the apparatus of the invention;

FIG. 2 is a cross-sectional view taken substantially along the line II—II of FIG. 1;

FIG. 3 is an enlarged schematic plan view showing product in Spencerian coil form being conveyed through the two-zone fluidized bed of the apparatus of the invention; and

FIG. 4 is an enlarged sectional view of a distributor head of the apparatus of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawing, reference numeral 2 designates the exit end of a rod heat-treating furnace 3 which communicates by means of a discharge opening 4 with the fluidized bed apparatus 6 of the invention. A cooling vestibule 8 is provided on the exit end of the fluidized bed chamber 6. A roof 10 covers the exit end of the furnace, the fluidized bed 6 and the vestibule 8.

The fluidized bed apparatus of the invention comprises an elongated channel shape vessel 12 with a substantially U-shape inner shell 14 fitted therein in such a manner that a plenum chamber 16 is defined by the bottom plate 18 of the inner shell 14, the bottom 20 of the channel 12, vertical walls 22 and 24 of the vessel 12, and the end walls 25 of the vessel 12. A heat insulating wall 26 projects upwardly from the bottom of the vessel 12 intermediate its length through the bottom plate 18 to a point short of the top of the inner shell 14 to form two zones, labeled zone 1 and zone 2, in the inner shell 14 and two respective compartments 16^1 and 16^2 in the plenum chamber 16. Each of the zones 1 and 2 is filled with a particulate medium 27 such as silica sand to a height above the top of insulating wall 26.

The bottom plate 18 of the shell 14 is perforated to enable air to pass from the two compartments of the plenum chamber 16 upwards into the beds of silica sand. Each of the perforations in the plate 18 is covered with a distributor head 28 for laterally diverting the air that passes through the plate 18. Radial air passageways 29 which are provided in each of the distributor heads 28 are dimensioned and arranged to provide a uniform flow of gas into the beds and prevent backflow of the medium 27.

A blower 30 is disposed outside the wall 22 of each of the zones 1 and 2 of the vessel adjacent the respective compartments 16^1 and 16^2 of the plenum chamber thereof. A conduit 32 from each blower communicates by means of a horizontal inlet 34 in wall 22 with the compartment of the plenum chamber under each of the zones 1 and 2. The blower 30 connected with plenum compartment 16^1 under zone 1 normally supplies fluidizing gas under pressure at ambient temperature to zone 1. A combustion chamber or other gas heating means (not shown is interposed between plenum compartment 16^2 and its respective blower 30 so that hot fluidizing gas under pressure is supplied to zone 2. It will be understood that other means such as heating tubes disposed between the shell 14 and the vessel 12, a direct gas flame introduced into the plenum compartment 16^2, or immersion heating tubes in the silica sand medium, may be used to heat zone 2 of the fluidized bed. Peripheral cooling tubes 33 and cooling immersion tubes may be utilized to cool zone 1 if desired. Additional cooling of zone 1 may be obtained by introducing a water spray directly into the medium 27 from a water source (not shown) positioned above zone 1 of the fluidized bed.

Normally the apparatus of the invention is arranged in combination with a controlled-atmosphere heating furnace with zone 1 adjacent to the exit end 2 of the furnace from which rod is conveyed in Spencerian form. However, it will be understood that the apparatus of the invention is not restricted to use with a heating furnace but may also be used in conjunction with a rod rolling mill, for

example, from which the rolled rod is conveyed in Spencerian form.

An open-chain type conveyor **36** surrounds the vessel **12** with the load-bearing upper flight **38** of the conveyor positioned longitudinally across the top of the vessel **12** with the majority of its length immersed in the medium **27**. The insulating wall **26** which separates zones **1** and **2** may support the upper flight **38** of the conveyor **36** so that the pass line of the conveyor is maintained at a constant elevation in the adjacent areas of zones **1** and **2**. Vertical insulating curtains **40** suspended from the roof **10** may be provided to minimize heat losses.

The apparatus of the invention may also be used in combination with furnace **3** to accommodate the use of a common protective atmospheric gas such as exothermic gas. Such gas would be continuously circulated by blowers **30** through inlets **34** into zones **1** and **2** and then into outlets **42** provided in the roof **10**. The outlets would be connected with the blowers **30** so as to provide circulation of the gas. If a common atmospheric gas is used, the use of a direct gas flame as a source of heat in the plenum compartment **16²** of zone **2** and of a water spray to cool zone **1** are precluded.

As best shown in FIG. 3, stationary guides **44** may be provided affixed to the upper portions of the inner walls of the shell **14** in zone **1**. The guides project inwardly toward the upper flight **38** of the conveyor **36** and terminate slightly short of contact therewith. The stationary guides **44** cause the loops of rod traveling in Spencerian form to shift laterally as they are conveyed through zone **1**. Such shifting allows a more uniform quench by exposing previously overlapped portions of the rod loops.

In operation, rod R is conveyed in Spencerian form from the exit end **2** of the furnace **3** and into zone **1** of the fluidized bed apparatus of the invention. Prior to being conveyed into zone **1**, rod R has been heated in furnace **3** to approximately 1750° F. for a sufficient time to allow carbon in the rod to go into solid solution. As the rod in Spencerian form enters zone **1**, it is at or above the critical temperature, approximately 1400° F., at which temperature transformation begins. The temperature of the fluidized medium **27** in zone **1** must be maintained in a range between 200 and 600° F. to obtain a maximum quench rate through the critical temperature range between 1400 and 1000° F. Transformation can be retarded up to 60 seconds by rapid quench through the aforementioned critical temperature range but the temperature of the rod should be maintained above approximately 500° F. since undesirable martensite may form at temperatures below 500° F. The rod in Spencerian form is then conveyed by the upper flight **38** of the conveyor through zone **2** wherein transformation occurs under controlled time-temperature conditions, which may vary from 60 seconds at 850° F. to 10 seconds at 1000° F. The rod is then discharged from conveyor **36** onto a conveyor **46** which carries the rod through the vestibule **8** where it cools at an uncontrolled rate to ambient temperature.

The speed of conveyor **36** must be compatible with the material feed rate through the furnace **3**. The conveyor speed and the feed rate through the furnace dictate the length of the fluidized bed of the apparatus required to meet the desired time-temperature conditions. For example, a 3000-pound-per-hour capacity furnace will process a 0.228 inch diameter rod at a strand speed of 360 feet per minute. A conveyor speed of approximately 7 feet per minute is required to accommodate this amount of material in Spencerian form of 36 inch diameter continuous loops with a 2 inch offset between loops. A fluidized bed having two equal zone lengths of a total effective length of 8 feet provides approximately 34 seconds of quenching time and an equal time for transformation. For a size range of 0.100 to 0.300 inch diameter, the times in each zone vary from 13 seconds to 53 seconds which is within the time-temperature requirement when operating at the normal 1000° F. transformation temperature. When operating at a capacity of 3000 pounds per hour, approximately 700,000 B.t.u./hr. must be extracted from zone **1** and approximately 300,000 B.t.u./hr. must be added to zone **2**.

In laboratory tests to verify the effectiveness of the quenching apparatus and method of the invention to obtain a desirable metallurgical patented structure, two 20 inch square, 13½ inch deep fluidized bed zones were used. 50-mesh banding sand was the fluidizing medium, and the fluidizing gas was air. The bed zones were heated by electrical globar elements mounted externally on two sides of the bed shell. Zone **1** of the bed was operated at 400° F. flow velocity through each zone of the bed was maintained and zone **2** of the bed was operated at 970° F. The air at 0.4 feet per second. The test material was 0.228 inch diameter rod of AISI 1065 stock. The test material was heated to 1750° F. before quenching. The following results were obtained:

Quenching method	Time	Ultimate tensile strength, p.s.i.	Percent reduction of area	Structure
Fluidized bed	{Zone 1, 30 sec / Zone 2, 60 sec}	154,000	54.8	Fine pearlite, some coarse pearlite, very little free ferrite.
1,000° F. lead	60 sec	153,000	54.3	Fine pearlite, some coarse pearlite, some free ferrite.
Air (70° F.)		134,000	48.0	Coarse pearlite, some fine pearlite, free ferrite.

Although the apparatus and method of the invention have been described as used for producing an optimum metallurgical patented structure containing essentially fine pearlite, other beneficial results may be achieved. For example, rapid cooling of a low carbon rod in Spencerian form after hot rolling results in a minimum formation of scale thereon. Such scale consists essentially of the lower oxide of iron (FeO), which is easily removed chemically or by reverse-bend descaling.

Overlapping of continuous individual loops of rod conveyed in Spencerian form causes a concentration of metal along the outside edges. Such overlapping produces a shielding effect which causes the heat transfer rate to be lowered at the outside edges. To offset this effect the heat transfer rate can be increased by increasing the gas flow through the fluidized beds above that required for minimum fluidization. Such increased gas flow rate induces more movement within the fluidized medium which tends to separate the loops at the crossover points and to allow the medium to flow between the loops.

Thus it will be seen that the method and apparatus of the invention provide a rapid and controlled quenching of steel rod and the like as the rod is continuously conveyed in Spencerian form through a two-zone fluidized bed to produce high carbon product containing essentially fine pearlite and a minimum of scale, composed primarily of FeO.

We claim:

1. Apparatus for quenching steel rod and the like comprising a substantially closed chamber having an entry aperture at one end and an exit aperture at its other end, a fluidized bed in said chamber between said entry aperture and said exit aperture, a first zone in said fluidized bed adjacent said entry aperture, a second zone in said fluidized bed between said first zone and said exit aperture, a heat-insulating wall in said chamber upstanding between said first and second zones of said fluidized bed,

said wall projecting upwardly from the bottom of said chamber and terminating short of the upper surfaces of said fluidized bed zones, an endless conveyor having a load-bearing upper flight disposed for travel of said upper flight through said chamber from said entry aperture to said exit aperture, a portion of said upper flight of said conveyor being disposed below the upper surfaces of said fluidized bed zones and above said insulating wall as it travels through said chamber.

2. Apparatus as defined by claim 1 in which the bottom of each of said fluidized bed zones is formed of a perforated plate, the perforations in said plates each being capped by a distributor head having radially directed air passageways therethrough.

3. Apparatus as defined by claim 1 including separate heat transfer means connected with said first and second zones of said fluidized bed.

References Cited

UNITED STATES PATENTS

3,522,936	8/1970	Geipel et al.	266—3 R
3,525,507	8/1970	Geipel et al.	266—3 R
3,547,421	12/1970	Hoffmann et al.	266—3 R
3,550,922	12/1970	Geipel	266—3 R

GERALD A. DOST, Primary Examiner

U.S. Cl. X.R.

148—143; 266—2 R

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,615,083 Dated October 26, 1971

Inventor(s) Jerome Feinman, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 22, after "400°F", delete "flow velocity through each zone of the bed was maintained"; line 24, after "air" insert -- flow velocity through each zone of the bed was maintained -- ; line 36, change "54.3" to read -- 54.5 -- .

Signed and sealed this 31st day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.