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(54) METHODS OF FABRICATING CONDUITS FOR CONVEYING PRESSURIZED STREAMS OF GAS ENTRAINED PARTICLES

(71) We, THE BABCOCK & WILCOX COMPANY, a corporation of the State of Delaware, United States of America, of 161 East 42nd Street, New York, New York 10017, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to methods of fabricating conduits for conveying pressurised streams of gas entrained particles.

In the optimum operation of pneumatic transport systems, gas velocities must be maintained above the level which produces settling of the entrained matter and below the level which results in excessive frictional pressure loss and extensive wear of the conduit; and these limits must be reconciled with the higher velocities resulting from the increase in volume due to frictional pressure loss in the gas as it moves through the conduits. A problem arises, however, in the case of long distance conduits where, due to the length of the conduit, a gas moving at minimum required velocities at the inlet end of the conduit may reach velocities at the outlet end which are in excess of the level set for acceptable frictional pressure loss and normal wear of the conduit.

The present invention discloses a method of fabricating a conduit structured for maintaining gas velocities well within the limits prescribed for optimum operation.

According to the present invention there is provided a method of fabricating a conduit for conveying a pressurised stream of gas entrained particles, the method comprising the steps of assembling a plurality of sections in consecutive fashion in the direction of conveyance, each succeeding section in the direction of conveyance having a cross-sectional flow area greater than that of the preceding section, sizing the length of each section so that frictional pressure loss therein results in a desired gas volume increase at the end thereof, sizing the cross-sectional flow area of each succeeding section to accommodate the increase in gas volume resulting from frictional pressure loss in the preceding section so as to achieve desired gas velocities through the succeeding section, and fixedly flow-connecting adjoining sections of said conduit.

The increase in conduit cross-sectional flow area in the direction of conveyance or transport, which accommodates the increases in gas volume due to frictional pressure losses, can also maintain gas velocities and frictional pressure losses within prescribed limits.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a blast furnace pulverized fuel preparation and transport system including a conduit embodying the invention; and

Figure 2 is a fragmented sectional view of the conduit depicted in Figure 1.

A conduit embodying the invention is herein described in conjunction with the preparation and conveying of air borne pulverized coal to a blast furnace. It should be recognized, however, that the disclosed conduit may also be used in conjunction with other systems for the distribution of any pneumatically transported particle-form material.

Figure 1 illustrates a coal preparation and transport system of the character generally disclosed in U.S. Patent No. 3,689,045 and includes a raw coal bunker 10 which discharges through an outlet conduit 12. A gate valve 14 is installed in the conduit 12 and, when open, allows coal to gravitate to a feeder 16, the latter regulating the flow of coal to a mill 18 in response to system demand. The mill 8 grinds the coal to a consistency suitable for pneumatic transport to a blast furnace 20. Air is supplied to the mill 18 by a primary air fan 22. The air is passed through a heater 24 and is preheated prior to its entry into the mill 18. The heated air, passing through the mill 18, dries the pulverized coal and conveys it through an outlet conduit 26 to a cyclone type separator 28. The coal-air mixture entering the separator 28 is centrifugally separated and the coal gravitates to a storage tank 30 via discharge conduit 32, the latter being provided with a rotary valve 34. The minute coal fines which remain entrained in the primary air are carried along with the air, through a vent conduit 36 to a bag-filter house 38, or other functionally similar apparatus, and collected therein. The cleaned primary air leaving the bag-filter house 38 is vented to atmosphere while the collected fines gravitate to the storage tank 30 via a discharge conduit 40, the latter being provided with a rotary valve 39.

If desired, a plurality of pulverized coal preparation units can be operated in parallel to supply coal to the storage tank 30 since with multiple units, intermittent operation, maintenance, or emergency servicing of any single unit can be accommodated without necessitating a shutdown of the delivery system. In lieu of spare pulverizing capacity afforded by multiple coal preparation units an auxiliary storage tank, not shown, can be provided. The auxiliary tank could be suitably connectd to the conduits 32 and 40 to receive some or all of the pulverized coal output in excess of the then current needs of the blast furnace 20. The tank 30 is suitably vented through a conduit 42 so as to operate at atmospheric pressure and serves to provide sufficient storage of pulverized coal to supply a plurality of feed tanks 44A, 44B and 44C through correponding distribution conduits 46A, 46B and 46C. The conduits 46 A-C are provided with shutoff valves 48A, 48B and 48C, respectively, which, when open, allow the individual tanks 44 A-C to be filled with pulverized coal.

The feed tanks 44 A-C communicate with a lower segment 50A of a pneumatic transport conduit 50 through corresponding outlet conduits 52A, 52B and 52C provided with respectively shutoff valves 54A, 54B and 54C which can be selectively opened to permit coal in dense phase fluidized form to flow from selected tanks 44 A-C, one at a time, to the segment 50A and closed to isolate, from the segment 50A, those tanks 44 A-C other than the one currently selected to supply pulverized coal in the blast furnace 20.

Inert gas is used for pressurizing and aerating the feed tanks 44 A-C and also for aerating the storage tank 30. The choice of an inert gas is favoured since it precludes the possibility of coal ignition within the storage and feed tanks. The inert gas is delivered by a compressed gas source 78 through a supply conduit 80 at a pressure sufficient to maintain coal flow from any given feed tank 44 A-C into and through the segment 50A at maximum anticipated blast furnace demand rate and against the combined transport system pressure drop and the pressure within the hearth 76. The gas supply conduit 80 includes a control valve 81 and a check valve 83. The aeration of the storage tank 30 is accomplished through a conduit 82 which connects the tank 30 with the gas supply conduit 80 and includes a control valve 84. The venting of the storage tank 30 is accomplished through the conduit 42 which connects the tank 30 with the vent conduit 36 and includes a control valve 88. The pressurization of the feed tanks 44 A-C is accomplished through corresponding conduits 90A, 90B and 90C which connect the tanks 44 A-C with the gas supply conduit 80, respectively, and include control valves 92A, 92B and 92C. The aeration of the feed tanks 44 A-C is accomplished through corresponding conduits 94A, 94B and 94C which connect the tanks 44 A-C with the gas supply conduit 80 and, respectively, include control valves 96A, 96B and 96C. The venting of the feed tanks 44 A-C is accomplished through corresponding lines 98A, 98B and 98C which connect the tanks 44 A-C with a main vent conduit 100 and, respectively, include control valves 102A, 102B and 102C. The conduit 100 vents into the storage tank 30.

The pneumatic transport conduit 50 includes an upper segment 50B having an increasing cross-sectional flow area in the direction of transport.

A disperser 55 is fixedly interposed between the conduit segments 50 A-B to effectuate a smooth transistion of the coal from dense to dilute phase fluidized form. The pressurized air required for transition of the coal from dense to dilute phase and for conveyance to the blast furance 20 is supplied to the disperser 55 through a conduit 58 which is connected to a compressed air source 56 and includes a control valve 60 and a check valve 62. The disperser 55 discharges into the segment 50B of the transport conduit 50. The segment 50B is, in turn, connected for discharge into one or more distributors 64 from which a plurality of feed conduits 66 lead to individual tuyeres 70 of the blast furnace 20 in a manner similar to that described in U.S. Patent No. 3,204,942. The number of distributors 64 as well as the number of tuyeres 70 served by each distributor 64 can be varied according to the requirements of the blast furnace 20. The blast air supplied through the tuyeres 70 is heated in regenerative type stoves, not shown, to a temperature of about 1800°F and passes via a conduit, not shown, to a torus shaped bustle 72 and thence to the individual tuyeres 70 by way of gooseneck conduits 74. The coal-air stream from each feed conduit 66 is directed by corresponding nozzles 68 into the hearth 76 of the blast furnace 20 so that each stream is projected into the high temperature blast air being injected through the corresponding tuyere 70.

In the operation of the system, each of the feed tanks 44 A-C is alternately filled, pressurized, and emptied to feed and blast furnace 20 in a predetermined cyclical sequence. For example, when the tank 44A is feeding the blast furnace 20, the tank 44B is on standby status, filled with coal and pressurized with inert gas, while the tank 44C is being filled with coal from the storage tank 30.

The aeration valves 96 A-C are preferably left open during operation of the system to ensure satisfactory fluidization of the coal within the respective tanks 44 A-C.

The quantity of pulverized coal being delivered to the blast furnace 20 is regulated through the pressurization valves 92 A-C and the vent valves 102 A-C associated with whichever tank is feeding coal. In the event that the actual coal flow rate is less than the demand rate, the pressurization valve will open thereby raising the feed tank pressure to increase the coal flow rate. Conversely, should the coal flow rate be greater than the demand rate, the vent valve will open thereby reducing the feed tank pressure to decrease the coal flow rate.

The pressurized air delivered to the disperser 55, to effect the transition of the coal from dense to dilute phase fluidized form and to convey the coal from the disperser 55 to the blast furnace 20, is regulated through the control valve 60 to provide the acceleration and uniformity of particle dispersion required from a smooth transition from dense to dilute phase and to maintain conduit velocities which will ensure steady flow and prevent the settling of coal while minimizing the quantity of relatively cold air being thus introduced into the blast furnace 20. The coal in dilute phase fluidized form is conveyed through the transport conduit segment 50B to the distributor 64 which divides it into a plurality of dilute phase effluent streams of substantially equal coal-air density and coal quantity. The coal-air streams leaving the distributor 64 are conveyed through respective conduits 66 to corresponding nozzls 68 for injection into the hearth 76 of the blast furnace 20. The hot blast air, which is introduced through the gooseneck conduits 74 into the tuyeres 70, mixes with the dilute phase coal streams to promote rapid combustion of the coal.

Referring to Figure 2, the present invention is embodied in the upper segment 50B which represents a long distance conduit that is subdivided into consecutively disposed sections I, II, III, IV and V, with each section being preferably of uniform circular cross-section throughout its length. The cross-sectional flow area of each succeeding section in the direction of transport is greater than that of the preceding section. A relatively short transition member 51 is appropriately sized to fixedly interconnect adjoining conduit sections and is suitably flared to provide a smooth transition therethrough. It should be recognized that a conduit embodying the invention may be subdivided into a greater or lesser number of sections than that of the conduit herein described.

In the operation of the invention, a coal stream in dense phase fluidized form, i.e., an approximate density greater than 20 lb./cu. ft., flows from the conduit segment 50A to the disperser 55 wherein it is intercepted by pressurized air supplied from the conduit 58 and is thereby converted to dilute or light phase fluidized form, i.e., an approximate density of less than 4 lb./cu. ft., and is discharged into the segment 50B of transport conduit 50. The dilute (light) phase fluidized coal stream experiences frictional pressure losses and corresponding increases in volume as it moves through the conduit segment 50B. The increasing cross-sectional flow area of the conduit segment 50B accommodates the increases in gas volume thereby maintaining conduit velocities and frictional pressure losses within the limits consistent with economically acceptable compressor pressures and normal conduit wear. The coal stream discharging from the conduit segment 50B flows into the distributor 64 and thence to the feed conduits 66 for injection into the blast furnace.

In fabricating the multi-sectioned conduit described above, the length of each section of conduit is calculated to give the desired frictional pressure loss which would result in an increase in volume that would produce the desired minimum velocity in the next succeeding section. The exit velocities for each section are the result of the gas volume at the end of that section. The conduit will generally comprise sections of standard pipe of required dimension with the sections being seal-weldably united through suitably sized transition members.

Tables A and B contain calculated data based on the movement of 24 short tons per hour of coal in dilute (light) phase fluidized form through a distance of approximately 310 feet and are illustrative of the advantages of a conduit embodying the present invention. Table A contains data relating to different size conduits structured in terms of the prior art and Table B contains data relating to the conduit embodying the present invention.

TABLE A

Conduit length, ft.	310	310
Conduit internal diameter, in.	3.068	3.626
Feed tank pressure, psi.	102.8	91.6
Coal rate, t/hr.	24	24
Transport gas flow, std. cu.ft./min.	950	1389.1
Velocity entering conduit, ft./min.	2580	3000
Velocity leaving conduit ft./min.	5452	5363.8

TABLE B

Feed tank pressure, psi.	80				
Coal rate, t/hr.	24				
Transport gas flow std. cu. ft./min.	760				
Sections	I	II	III	IV	V
Conduit length, ft.	138.8	41.7	39.6	33.3	58.7
Conduit I.D., in.	3.068	3.364	3.438	3.548	3.626
Vel. entering conduit, ft./min.	2580	2820	2900	2950	3000
Vel. leaving conduit, ft./min.	3391	3031	3142	3127	3500

A comparison of the data set forth in Tables A and B shows that the conduit embodying the present invention requires only 80 psi. feed tank pressure and 760 std. cu. ft./min. to transport 24 t/hr. of light phase fluidized coal across a distance of 312.1 feet while maintaining velocities within the range of 2580 to 3500 ft./min. In contrast, the prior art conduits of Table B show that transporting light phase fluidized coal at the same rate and across a like distance requires, through the conduit at column 1, 102.8 psi. feed tank pressure and 950 std. cu. ft/min. at velocities ranging frm 2580 to 5452 ft./min. and, through the conduit of column 2, 91.6 psi. feed tank pressure and 1389.1 std. cu. ft./min at velocities ranging from 3000 to 5353.8 ft./min.

WHAT WE CLAIM IS:-

1. A method of fabricating a conduit for conveying a pressurised stream of gas entrained particles, the method comprising the steps of assembling a plurality of sections in consecutive fashion in the direction of conveyance, each succeeding section in the direction of conveyance having a cross-sectional flow area greater than that of the preceding section, sizing the length of each section so that frictional pressure loss therein results in a desired gas volume increase at the end thereof, sizing the cross-sectional flow area of each succeeding section to accommodate the increase in gas volume resulting from frictional pressure loss in the preceding section so as to achieve desired gas velocities through the succeeding section, and fixedly flow-connecting adjoining sections of said conduit.

2. A method according to claim 1, including the step of maintaining a substantially uniform cross-sectional flow area throughout each section.

3. A method according to claim 1 or claim 2, including the step of inserting a transition member between adjoining sections, and transition member having an increasing cross-sectional flow area in the direction of transport.

4. A method according to claim 1, substantially as herein described.

5. A conduit fabricated by a method according to any one of the preceding claims.

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1567954 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

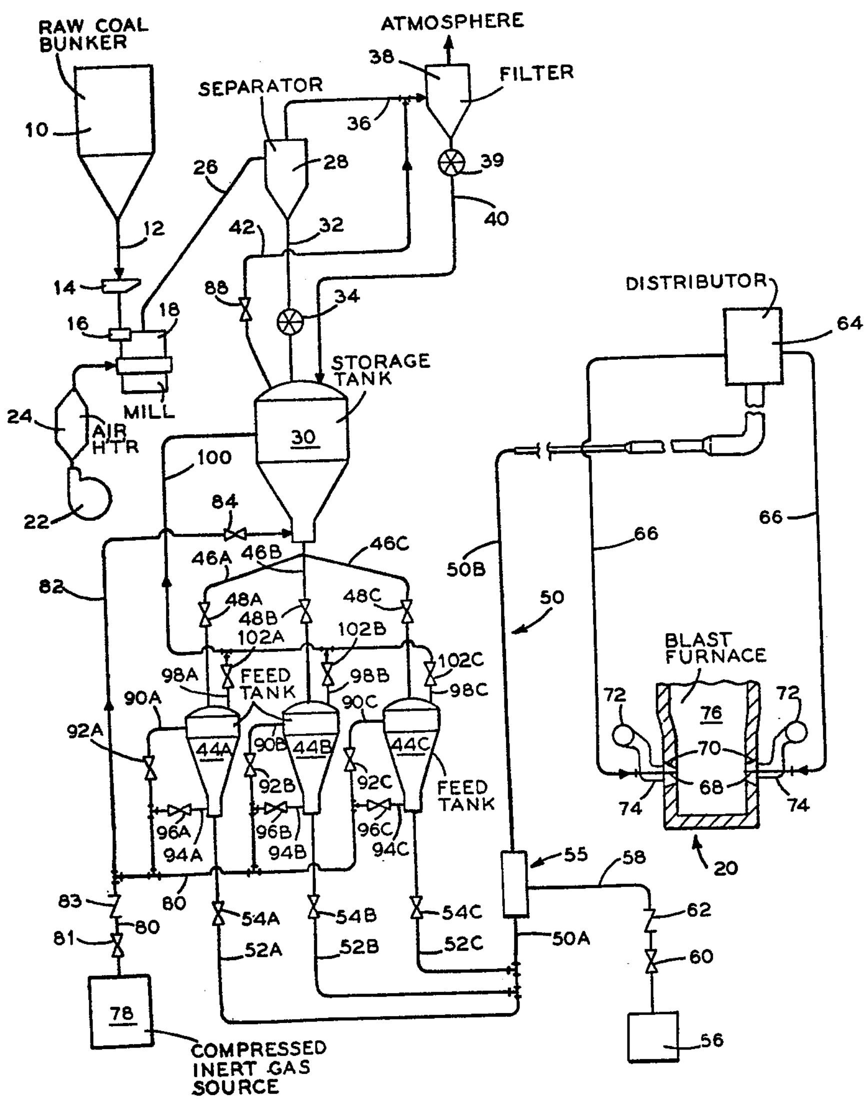

FIG. 2