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The present invention relates to a coke handling system or, more broadly, to a system for handling particulate coke and various other types of finely divided solids. It relates particularly to a system for handling hot solids or combustible materials, such as small, ground, hard, dry petroleum coke. The invention has a special application to the disposal of product coke from a fluidized solids hydrocarbon conversion system where finely divided, granular coke is produced. However, it is not necessarily limited to the handling of hydrocarbon coke products and it has obvious applications to other finely divided solid materials.

A primary object of the present invention is the convenient and economical handling of finely divided solid particles, especially combustible particles, so as to avoid losses thereof or pollution of atmosphere, injury to neighboring properties, due to wind or to combustion and the like.

A further object is to provide a means for the efficient handling of finely divided petroleum coke from a coking process, e.g. a fluidized solids process, to facilitate shipment and disposal of the carbonaceous product.

Another object is the withdrawal of and return to a coking system of finely divided coke or analogous solids employed in the operation thereof, e.g., in starting up a fluidized coke unit which has been shut down.

An additional object is to make it possible to store finely divided coke and the like as it comes from a coking production process and, using largely the same equipment, to be able to reload the coking system for subsequent operation.

A further object is the protected storage of a large volume of finely divided solids with provision for subsequent loading of these solids from storage to vehicles or, with part of the same apparatus, to be able to reload the producing system for subsequent operation, to minimize apparatus requirements.

Other objects will be readily apparent as this description proceeds. Accordingly, reference will be made to the accompanying drawings wherein:

Figure 1 is a diagrammatic front view of a coke handling system embodying the present invention.

Figure 2 is a side view, also diagrammatic, of the system shown in Fig. 1, taken approximately from line 2—2 of Fig. 1.

Figure 3 is a sectional view on an enlarged scale of part of the apparatus, as seen from line 3—3 of Fig. 2.

Figure 4 is a sectional view, also on a considerably enlarged scale, taken substantially along the line 4—4 of Fig. 2.

Figure 5 is an enlarged detail view, partly in section of part of the apparatus seen in Fig. 1.

Figure 6 is a diagrammatic front view of a modified system.

Referring now in detail to the drawings, there is shown in Figs. 1 and 2, a system wherein hot finely divided petroleum coke from a reactor or from the burner vessel of a fluid coking system is supplied through a line 11 to a hot coke receiver 13. The coke producing system per se forms no part of the present invention but may be of the general type shown in the application of Piefker et al., Serial No. 375,088, filed August 8, 1953. The vessel 13 per se likewise forms no part of the present invention but is preferably of the general type described and claimed in an application of Spitz et al., Serial No. 424,668, filed April 11, 1954, now U. S. Patent No. 2,779,719.

Thus, hot finely divided coke at a temperature which may be as low as about 750°F. or as high as about 1300°F. or higher, comes into the vessel 13. If this material were to be exposed to the open air at such temperatures, it probably would ignite and cause loss or damage. Since it constitutes a fire hazard and since its further handling must be carried out at lower temperatures, it is preferably quenched or cooled to a temperature well below its ignition point. For this purpose a quenching liquid, such as water, is introduced through a line 15 with the result that steam or other vapors are formed. The vapors may flow upwardly through the coke and in a preferred embodiment they strip therefrom the finer particles and return them through a line 17 to the coker for further use. Coarser particles, cooled to a safe temperature, remain in vessel 13.

The quenched coke, now cooled to a temperature preferably below about 300°F. and usually below actually about 400°F., or lower, flows downwardly by gravity through a line 19 to a pneumatic transfer line 21. At this point a conveying fluid, i.e., a gas, usually air, is introduced through line 23 at a suitable pressure and velocity to carry the finely divided material through a 3-way valve 25, a second valve 27, and a line 29 into the top of a coke storage vessel 31. As a rule, gas pressure and velocity will be such as to convey this material at a velocity of 50 to 150 feet per second, or more. At such velocities, the solid particles may cause erosion of the lines, particularly if the bends in the lines are of short radius. It is preferred that the bends in the pneumatic line 21, 29 have a radius of at least 10 times and preferably 20 times or more greater than the inside diameter of the line. This not only reduces erosion but also facilitates movement of the solid particles.

The vessel 31 is preferably a thin walled storage tank, such as an oil tank. It is desirable to load this tank at its center, and also to unload it at the center, to avoid large eccentric forces which might possibly damage vessel 31. Where the vessel 31 has a central supporting column 32, it is desirable to divide the coke into lines 33 which distribute it evenly around the column. This is important if tank 31 is large. With a small storage tank, it may not be necessary.

Within vessel 31 the coke piles up and can, of course, remain in storage for some time if desired. A vent 36 allows trapped gases to escape from tank 31. In plants of the character referred to above, however, the daily production of coke may run into hundreds of tons. Hence, storage over a long period of time usually is not feasible. Usually storage of only a few days' production is adequate. Hence, means are provided for removing the coke from the lower part of storage vessel 31 at a rate that is preferably several times the rate of input, to minimize loading time to receiving vessels.

In the lower part of vessel 31, there is installed an aerated slide of a type well known in the art per se. This slide, as better shown in Fig. 3, is adapted to convey a stream of finely divided coke, agitated or fluidized so that it flows much like water, down a gentle incline to a receiving pit from which it may be further conveyed by apparatus to be described.

Referring further to Fig. 1 and to Figs. 2, 3, 4, the bottom of tank 31 is shown at 34 with a tunnel shaped
housing member 35 extending from one side of the tank to a position fairly near the center thereof. This housing member has at its inner end a bulkhead 37, Fig. 3, comprising an access panel 39 which is removable for access to the inner end of the aerated or fluidized solids slide 41, the lower part of which projects through an opening 43 in the bulkhead 37.

Referring to Figs. 3 and 4, there are shown two aerated slides 31 by side, although only one may be used. The number may be greater where required.

The aerated slide 41 comprises a lower channel member 45 and an upper channel member 46 both of which are impervious to gas. A gas line, preferably an air line 47, extends along and above the aerated slides 41 and is connected thereto at points 49 preferably near the inner end of the slide. By this means, aerating gas is supplied to the lower portion of each slide.

Spaced above the bottom of the aerated slide, that is, above the member 45, as seen in Figs. 3, 4, is a perforated screen 51 through which the gas supplied through line 47 can pass freely. These screens are made of heavy canvas, wire mesh, or finely perforated or porous sheet metal, etc. An adjustable gate 52 controls flow of coke onto the slide, through the bulkhead.

The finely divided coke flows by gravity into the upper end of the aerated slide at the lower right in Fig. 2. Here it is buoyed up and fluidized to some extent by the gases passing through the screen 51 and it slides very freely, much like a flowing liquid, down the slope to the left. By this means, as is well known in the art, a large volume of solids may be transported at low cost and with relatively small equipment.

Thus a stream of coke is conveyed out of the central part of the bottom of the storage vessel 31 where it falls by gravity down a chute 56 into hopper 58. The conveying means 41 is adapted to remove the solids from vessel 31 at a rate that is at least several times, and preferably 10 or more the maximum production rate of the coke. Hence, the delivery apparatus does not need to be operated more than a fraction of the time the coke operates.

A suitable elevator, such as a bucket elevator 57, or rather a pair of such elevators 57, 57a in the present instance, is arranged above the pit 55, each preferably being enclosed in a housing 59 to prevent loss or dispersal of the fine coke by air currents. The particular form of elevating apparatus is not of great consequence and, for example, a pneumatic or other conventional lift may be substituted. The bucket elevator is usually a most economical lift. With two slides 41, two elevators are shown, but one will suffice in many instances. One of these, 57a arranged to discharge into a loading spout 59 which may be swung from the loading position near a truck, railroad car, etc. The other discharges to further conveying mechanism and is described next. An automatic control device 60 shuts off air to the line 47 if the boot 56 becomes overloaded. Similar means, not shown in detail, control the elevator and subsequent conveying. The solids are discharged laterally from the top of the elevator 57 as indicated at 61, Fig. 2. Here they may be carried further by an aerated slide or system of slides shown generally at 63, 64, 65. The latter (Fig. 2) is pivoted for lateral movement and discharges into a truck or carloading chute 66. If the slope is insufficient the solids may flow by gravity without aeration. A funnel or hopper 62 is preferably arranged so that the solids may be discharged either onto slides 63, etc., or alternatively may be loaded onto a lateral slide or conveyor 67, Fig. 1. From the latter, they may be carried on to the slat 68 and discharged into a hopper 69, or they may be carried to the end of the line and discharged into a loading nozzle or funnel 71. From the latter, they may be loaded conveniently into railroad cars, trucks or other transportation media.

Since the solids flow much like a liquid, a simple gate, not shown, is adequate for diverting the stream into the hopper 69 or on to the loading funnel 71, Fig. 1.

In operations involving fluidized solids, it is frequently desirable to return from storage a substantial mass of the solids to the source or to the vessel from which they were first withdrawn. For example, in the operation of a fluidized coker for converting heavy petroleum oil to lighter products and coke, it may be necessary to have many tons of the coke in the operating vessels for use as a heat carrier and as nuclei for coke deposits. The system also may be applied in a very similar fashion to the handling of finely divided catalytic solids for catalytic conversions in fluid solids units, for catalytic treatment of hydrocarbons and/or other organic materials.

Accordingly, provision is made for returning finely divided solids from storage in tank 31 to an operating unit. According to the present invention, this is accomplished by conveying solids from the storage vessel 31 along the aerated slide 41 and up the elevator 57. From here they are carried via the slide 67 and diverted into the receiving hopper 69 previously mentioned. From the hopper 69 solids may be passed through a control valve 72 into a vessel 74 adapted to fluidize and pressurize the solids and return them to the coker. The vessel 73 per se is known in the art and forms no part of the present invention. Hence, it will be described only briefly. See particularly Fig. 5. Valve 75 is operated by suitable means, e.g. a pneumatic piston 74 in a cylinder 75. The vessel is alternately filled with solids, gas being vented through a vent line 76 controlled by valve 77, and then compressed gas is introduced, valves 72 and 77 being closed. When valves 72 and 77 are open, the solids flow into the vessel until they have reached a desired level whereupon a compressed gas, usually air, is supplied from a suitable source 78 through a storage vessel 79, Fig. 1, through line 80 controlled by valve 81, so as to put the solids under pneumatic pressure. A pair of spaced baffles 82 is arranged inside the vessel 73 so that the solids can flow between them at their outer periphery, and the pneumatic pressure tends to push the solids upwardly into a dome of the cavity separating the two baffles. Aeration gas is introduced here through line 80 to aerate the solids between the baffle members 83 and so as to build up pressure in vessel 73. The fluidization of the solids between these baffles makes it possible for them to flow, under the pneumatic pressure head, like a liquid through an outlet line 85 controlled by a valve 86 and thence through line 87 and a 3-way valve 25 into line 21. From here, when the valve 27 is closed on line 29, the solids may be passed through line 14 back to the coker. Alternatively, by means of valves 93 and 95 the solids may be passed through a branch line 97 to storage in vessel 31.

From the foregoing description, it will be understood that the line 19, 21, which commonly is extensive in length, compared to the other lines of the system, may be used for conveying the finely divided solids in either direction. The system has considerable flexibility and makes it possible to handle hot product coke (or catalyst heating inert, etc.) from a petroleum conversion operation in large quantities. The solids may be stored; they may be conveyed to shipping vehicles such as railroad cars, trucks, boats, etc., and when needed, the conversion system may be replenished by returning solids from storage through the same main conveying line through which they were withdrawn.

The tunnel housing 35 mentioned above provides ready means of access to the central part of the storage tank 31. By this means, the aerated slide 41 and parts associated therewith may be kept in working condition without unloading the storage vessel and without undue interference from its contents.

Referring to Fig. 6, there is shown a modification which can be used in lieu of the embodiment shown in
Figs. 1 to 5, inclusive. Here a storage vessel, such as a metal tank 131 of the liquid storage type, is filled by a supply line 135 which branches from a main solids conveying line 137 controlled by suitable valves 139, 141. For a small vessel 131, the eccentricity of loading may not be objectionable. For a tank of large diameter, loading point 143 should be at or near the center of the tank. A vent for relief of trapped gases during filling is provided at 144. Unloading the tank, an air blower 145 is provided, with an intake line 147 and an exhaust line 149 controlled by a valve 151. When valve 151 is open, air is forced through the line 153. When valve 151 is closed or partly closed, flow is forced into a line 155 through valve 154, provided the latter is open. Line 155 terminates in a perforate or porous grid 157 so that air flowing through this line tends to aerate or fluidize a mass of granular coke below a funnel 159. The latter forms the lower end of a riser tube 161. The line 153 terminates in an upwardly directed nozzle 163. When air is flowing through both lines 153 and 155, and the velocity through nozzle 163 is sufficiently high, a stream of solids is lifted up the riser 161 and overflows into a hopper 165 on top of the vessel 131. The latter has an outlet 167 at the bottom thereof, from which solids may flow through a control valve 169 into a chute or slide 171. The latter may be aerated, if required, or, if it may have sufficient slope that solids will slide freely by gravity and without aeration.

From slide 171 the solids pass into a standpipe 173 which has an enlarged section 175 at its top. A solids level indicator 177 is provided to detect the overfilling of standpipe 173 and to regulate valve 169 to keep the standpipe full to the desired level. Solids flow down the standpipe 173 by gravity. The standpipe may be fluidized by means of aerating taps 179 supplied with suitable aerating gas, preferably air, by manifold line 181. The latter is connected through a valve 183 to a source of gas supply 185. The purpose of the standpipe is to provide a pressure head, analogous to hydraulic pressure, to help force solids through the conveying line 191.

Line 195, or an equivalent gas supply line, is connected through a branch line 197 to a venturi nozzle 199 mounted at the bottom of standpipe 173 in a solid conveying nozzle line 191. The latter is connected, through valve 141, previously mentioned, with supply line 137 through which coke ordinarily comes from the coker. By closing valve 139, coke may then be withdrawn from the storage vessel 131 through riser 161, slide 171, standpipe 173 and conveying line 191, to return it to the coke, e.g., when the latter is to be refilled for starting up. In lieu of coke, catalysts and other solids may be handled in similar fashion. When valve 141 is closed and also valve 187, solids cannot flow in the lower part of standpipe 173. However, a branch line 195, equipped with a valve 197 and a flexible or adjustable distributor nozzle 199, can be used to load coke into transportation vehicles 201 such as trucks, railroad cars, or barges.

Hence the apparatus of Fig. 6, like that hereinafter described, may be used to take solids from a supply, store them temporarily, load them into transporting vehicles, or return them to the source, as may be needed. Obviously, various features of the embodiment just described may be combined with features of the embodiment of Figs. 1 to 5. Solids may be withdrawn laterally from the lower central part of the tank (to avoid eccentric stress on the tank) by an aerated fluid solids slide, by screw conveyor, or any other means, and then elevated pneumatically or mechanically, as desired.

It will be understood that variations, changes and modifications may be made in the system described without departing from the purpose or spirit of the invention. It is intended by the following claims to cover such variations as the state of the art permits.

What is claimed is:

1. Apparatus for handing hot finely divided solid products comprising a cooling vessel, means for cooling the products in said vessel, means for withdrawing vapors and entrained solids from said cooling vessel, a gravity withdrawal line in said vessel, a first pneumatic conveyor line connected to said gravity line for carrying said finely divided solids products away from the vessel, a second pneumatic conveyor line connected in series to said first pneumatic line, a second vessel to which said first pneumatic line is connected for delivering the products, and means for withdrawing said products from said second vessel and returning them through said second pneumatic line in the opposite direction to that in which said products are carried away.

2. Apparatus according to claim 1 in which said withdrawing and returning means comprise in series an air slide, an elevator, and means for fluidizing and pressurizing the products to facilitate their return.

3. A reversible solids handling system comprising in combination, a primary reservoir of particulate solids, a storage vessel, means for conveying said solids from said primary reservoir to said storage vessel, a second means for conveying from the central portion of said storage vessel to an elevator, a tunnel shaped shield member for keeping solids away from the major part of said second conveying means and comprising a bulkhead element having an opening through which said solids are conveyed by said second conveying means while maintaining a substantial cross-sectional area of said bulkhead free of solids flow, an elevator for lifting solids conveyed out of storage to a higher level, and selectively operable means for returning said solids to the reservoir through said first named conveying means and, alternatively, for delivering said solids to a separate receiver.

4. Combination according to claim 3 wherein said first named conveying means is a pneumatic transfer line.

5. In combination, a large storage tank for finely divided solids such as coke and the like, means for delivering said solids to an upper central part of said tank, and means for removing said solids from a lower central part of said tank, said last-named means comprising an aerated slide, a tunnel-like housing over said slide, a bulkhead at the inner end of said housing and an opening in said bulkhead, through which said slide projects into the solids in the tank and through which said solids are removed from the tank.

6. Apparatus according to claim 1 wherein bends in said first conveyer line are characterized by a radius of curvature at least ten times greater than the inside diameter of said line whereby erosion difficulties are reduced and solids movement improved.

7. Apparatus according to claim 5 wherein a substantial cross-sectional area of said bulkhead is free of solids flow.

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