

[54] **METHOD AND APPARATUS FOR FEEDING FINELY DIVIDED SOLIDS TO A PRESSURIZED GAS OR GAS-LIQUID-SOLIDS SYSTEM**

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[58] Field of Search..... 222/373, 394, 395; 302/20, 53, 55, 66

[56] **References Cited**
UNITED STATES PATENTS

3,001,652 9/1961 Schroeder et al. 214/17 D

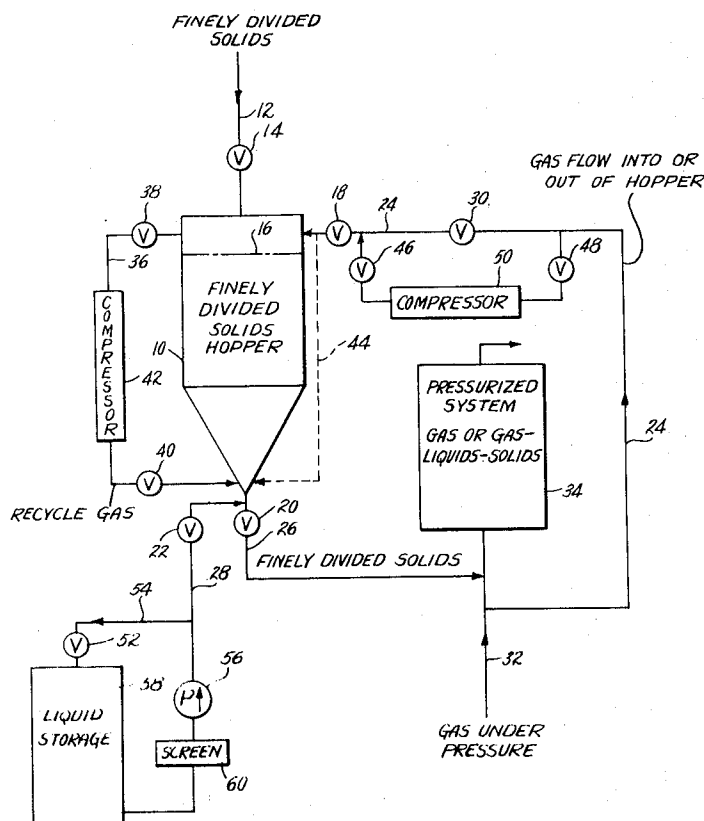
3,093,420 6/1963 Levene et al. 302/53
3,393,944 7/1968 Reintjes 302/55

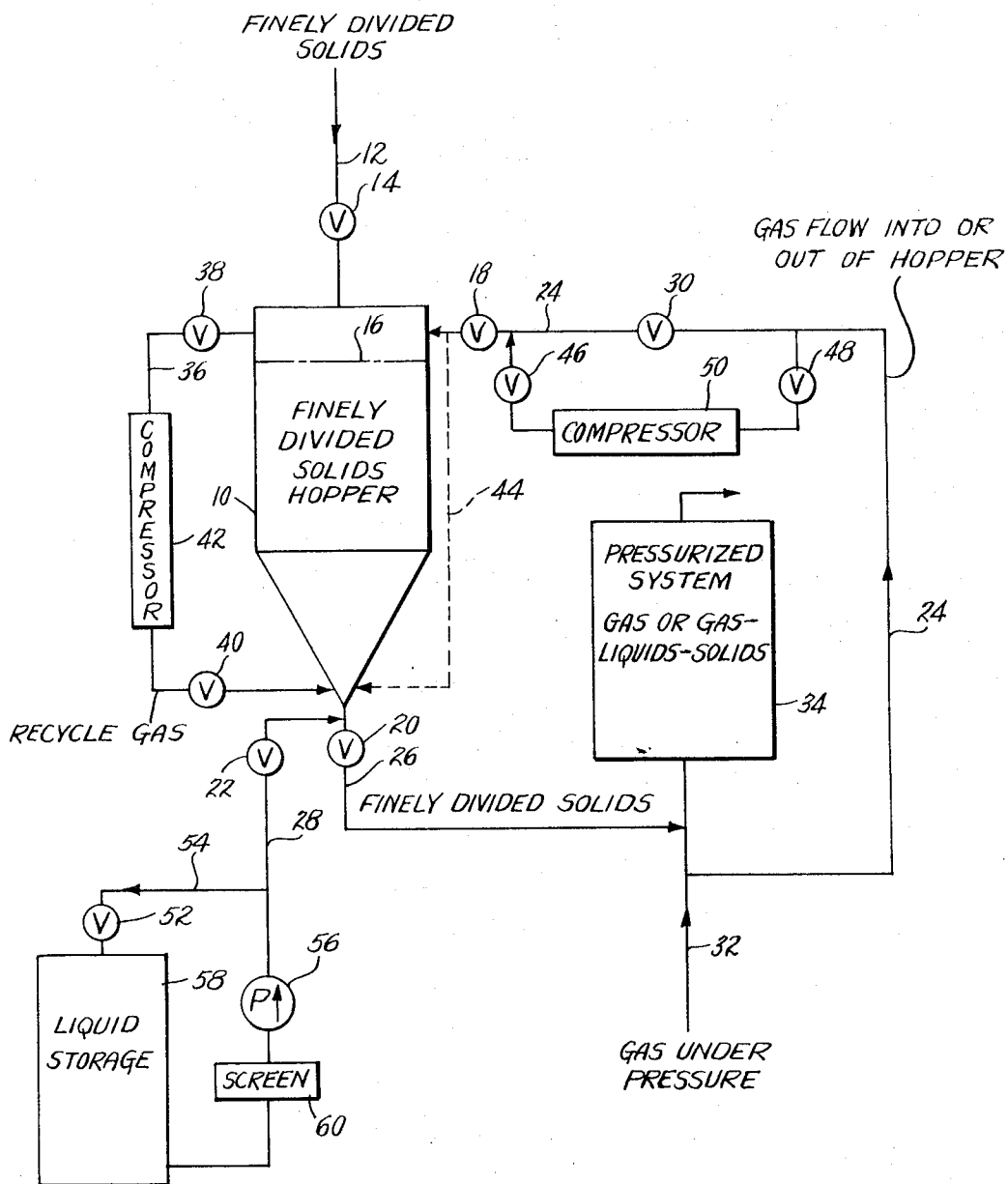
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[57] **ABSTRACT**

Finely divided solids are fed into a gas pressurized system from a gas pressurized hopper, the gas remaining in the hopper after the solids are exhausted is forced into the pressurized system by pumping liquid into the hopper to displace the gas, the liquid is withdrawn, the hopper is replenished with finely divided solids and repressurized by gas from the pressurized system. Means are provided for accomplishing these steps. There is no loss of pressurizing gas and no energy loss due to expansion and repressurizing of gas for the feed hopper.

11 Claims, 1 Drawing Figure





METHOD AND APPARATUS FOR FEEDING FINELY DIVIDED SOLIDS TO A PRESSURIZED GAS OR GAS-LIQUID-SOLIDS SYSTEM

RELATED APPLICATION

This application is related to my copending application Ser. No. 268,201, filed on June 30, 1972 and entitled "Hydrogenation of Coal."

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for feeding finely divided or pulverized solids to a gas pressurized gas or gas-liquid-solids system and is particularly adapted for use in connection with systems operating at pressures above about 500 psig. The necessity for special methods and devices for the feeding of finely divided solids to high pressure systems arises, for example, in the feeding of pulverized coal with hydrogen to hydrogenation systems which may operate at pressures of 500 to 6000 psig., the feeding of catalysts with reactant gas to catalytic reactors, the feeding of pulverized fuels with primary air to high pressure combustion processes, and the like.

Heretofore, various means have been utilized to feed finely divided solids to zones of high pressure. Hoppers pressurized to the same pressure as the system have been employed so that the finely divided solids would feed by gravity to the system. It has also been proposed to employ a closed hopper in which the finely divided solids are fluidized by a gas at a higher pressure than the system. The hopper is discharged to the system by blowing the finely divided solids through a pipe located at the bottom of the hopper. Such apparatus possess several serious disadvantages. First, when the hopper is empty, the high pressure gas, which occupies the entire volume of the hopper, must be vented before the hopper again can be filled, thereby resulting in loss of energy and waste of gas. Secondly, the pressure differential between the hopper and the system often fluctuates so that regulation of the quantity of finely divided solids discharged to the system is very difficult.

Another method of introducing finely divided solids into a pressurized system has been to mix or slurry the finely divided solids with a liquid and pump this slurry into the pressurized system. This creates difficult problems of suitable pump valves to handle slurries of solids and liquids and the problems of wear and corrosion caused by solids going through high pressure pumps. It also may introduce a liquid into the system which would otherwise be unnecessary or undesirable.

Feed devices calculated to solve these problems are disclosed in U.S. Pat. Nos. 3,001,652 and 3,093,420. These devices impose frictional and sealing difficulties due to moving parts within the feed chambers.

SUMMARY OF THE INVENTION

In accordance with the present invention, finely divided solids are introduced into a feed hopper, the hopper is closed when filled with solids and is gas-pressurized by gas from an adjacent high pressure system. The finely divided solids under gas pressure at least equivalent to that in the high pressure system are fed into such system from the hopper until the hopper is exhausted of solids. Means are provided for gas agitation of the solids in the hopper and for increasing the gas pressure above that in the adjacent high pressure system. When the hopper is exhausted of solids, the gas

remaining in the hopper is forced back into the high pressure system by pumping liquid into the hopper to displace the gas, the connection between the hopper and the high pressure system is then closed, liquid is withdrawn from the hopper, the hopper is replenished with finely divided solids and repressurized with gas from the pressurized system. Several hoppers may be used to supply a continuous stream of solids to the high pressure system. There is no loss of gas from the hopper, no energy loss due to expansion and repressurizing of the gas in the feed hopper, and no mechanically moving parts in contact with the feed solids.

An object of the invention is to provide an improved method and apparatus for supplying finely divided solids to a high pressure system.

Another object of the invention is to provide a method and means for using gas from a high pressure system to create an initial pressure in a finely divided solids feed hopper and to maintain this pressure while the solids flow from the hopper into the pressurized system.

Another object is to provide a method and means for varying the gas pressure in a finely divided solids feed hopper connected to a gas pressurized system while using gas from the system.

A further object of the invention is to provide a method and apparatus for moving of gas from a gas pressurized feed hopper without loss of gas pressure from the pressurized system.

A still further object of the invention is to provide a method and means for feeding finely divided solids to a pressurized system from a gas pressurized hopper and for recovery of the gas from the hopper when it is emptied of finely divided solids, which does not allow the gas in the hopper to expand to lower pressure, thereby reducing energy requirements to restore the gas to the pressurized system.

An additional object of the invention is to provide a method and apparatus for returning gas from a gas-pressurized feed hopper which is empty of solids back into a pressurized system while using a minimum amount of energy and avoiding loss of gas or pressure.

These and other objects and advantages of the invention will be more readily understood from the following detailed description taken in conjunction with the drawing, wherein:

The sole FIGURE of the drawing is a diagrammatic illustration of a finely-divided solids feeder and adjacent pressurized system.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawing, there is shown a finely-divided solids hopper 10 connected to a valved solids inlet line 12, a valved gas-solids feed line 26, a valved liquid inlet and outlet line 28.

Finely divided or pulverized solid is charged into hopper 10 through line 12 and valve 14 until the solids reach the upper solids level shown at 16. Valves at 18, 20 and 22 in lines 24, 26 and 28, respectively, are closed during this charging operation.

When charging of the hopper 10 is completed the valve 14 is closed. Valve 18 is then opened to admit high pressure gas through line 24 and valve 30 from line 32 which supplies gas under pressure to a pressurized system shown diagrammatically at 34. This may be a coal hydrogenation system, catalytic reactor system or the like. This brings hopper 10 up to full system pres-

sure. When the gas pressure in hopper 10 and system 34 is equalized, valve 20 is opened to permit the flow of solids from hopper 10 through line 26 into line 32 and into the pressurized system. Valve 20 may be used to control the rate of flow of solids from hopper 10 if desired. It is to be understood that other means may be used to control the rate of flow of solids, such as a screw feeder or star feeder (not shown) in line 26.

A circulating line 36 containing valves 38 and 40 and compressor 42 is provided to allow gas to be circulated from the top of the hopper 10 to the bottom to agitate the solid if desired. Normally very little or no additional compression of the gases by compressor 42 is needed.

The agitation of the finely divided solids in hopper 10 may also be accomplished by allowing part or all of the gas from the pressurized system to enter near the bottom of the hopper, as through the optional line shown at 44. This can be used as a means of eliminating the recycle compressor 42.

The hopper 10 may be maintained at a higher pressure than the pressurized system 34, which may assist in feeding the solids, by closing valve 30 in line 24 and opening valves 46 and 48 in by-pass line containing compressor 50. Compressor 50 can then be used to provide the necessary increase in pressure. Optionally, gas can also be bled into the hopper 10 from the high pressure system 34 through line 24 and the valves therein as the hopper 10 is emptied of solids.

When the finely divided solids in the hopper 10 have been exhausted, valve 20 is closed. The hopper 10 now contains high pressure gas. Valves 18 and 30 are opened after valves 46 and 48 have been closed and the valves 38 and 40 to the recycle compressor 42 are also closed. Valve 52 in liquid circulating line 54 is then closed. Liquid pump 56 in line 28 is started and liquid is pumped from storage tank 58 at the necessary pressure through open valve 22 into the hopper 10 to force the gas back through the gas line 24 into the pressurized system. It will be noted that this return cycle is accomplished by displacing gas at systems pressure back into the system. No energy is lost by allowing the gas to expand and recompressing it. Likewise there is no loss of gas from the system.

Any suitable and pumpable liquid for the hydraulic system may be used, such as water or oil. A screen 60 is provided in this system to prevent solids from entering the liquid pump 56.

When discharge of the gas from hopper 10 is completed, i.e. the liquid has reached the approximate level shown at 16, the liquid pump 56 is stopped, valve 18 is closed and valve 52 is opened. This allows the liquid to discharge from the hopper 10 back to liquid storage tank 58. If desired, a small amount of gas from the high pressure system 34 may be admitted through valves 18 and 30 to hasten this discharge.

It is to be noted that liquid used in the system is circulated in and out of storage. This eliminates the use of large amounts of liquid and any discharge from the system of liquid which may contain solids.

When the liquid is discharged into tank 58 valve 22 is closed. If valve 18 has been opened slightly it is also closed. The hopper 10 is then recharged with finely divided solids by opening valve 14. When the hopper 10 is charged, valve 14 is closed and valves 18 and 30 opened to bring the hopper 10 up to systems pressure. The feed system is again ready to feed finely divided solids to the pressurized system 34.

To secure a continuous flow of solids to the pressurized system at least two hoppers connected to the necessary control and pumping system may be used. More than two hoppers can of course be used.

Other variations and modifications such as will be apparent to those skilled in the art may be employed without departing from the spirit and scope of the invention.

I claim:

1. A method for feeding finely divided solids into a gas pressurized system comprising filling a feed hopper with said finely divided solids, closing said feed hopper, admitting gas from said gas pressurized system into said feed hopper until gas pressure in the feed hopper is at least substantially equal to that in said pressurized system, feeding finely divided solids from said hopper into said pressurized system until the hopper is emptied of solids, and then forcing the gas remaining in the hopper back into the pressurized system by displacing said gas in the hopper with a liquid, withdrawing the liquid from the hopper, and repeating the filling, pressurizing and feeding operations.

2. The method of claim 1, wherein the pressure of the gas in the hopper is increased above that in the gas pressurized system to facilitate the feeding operation.

3. The method of claim 1 wherein gas from the gas-pressurized system is used to agitate the finely-divided solids in the hopper.

4. The method of claim 1 wherein gas in the gas pressurized hopper is withdrawn, further compressed and reintroduced into the hopper to agitate the finely-divided solids in the hopper.

5. The method of claim 1 wherein the liquid is recycled to the hopper after completion of each feed cycle to force gas back into the pressurized system prior to each refilling operation.

6. The method of claim 1 wherein gas from the pressurized system is fed into the hopper during the finely divided solids feeding operation to maintain the gas pressure in the feed hopper.

7. Apparatus for feeding finely divided solids into a high pressure system comprising a gas pressurizable hopper free from internally moving parts, valved inlet means for introducing particulate solids into said hopper, valved inlet means for introducing high pressure gas from said high pressure system into said hopper, valved outlet means for feeding gas and solids from said hopper to said high pressure system, and means for pumping a liquid into said hopper to displace high pressure gas contained therein back into said high pressure system.

8. The apparatus of claim 7 wherein said valved inlet means for introducing high pressure gas from said high pressure system into said hopper include means for increasing the pressure of the gas introduced into the hopper above that of said high pressure system.

9. The apparatus of claim 8 wherein said means for increasing the pressure of the gas introduced into the hopper comprises a valved by-pass line containing a gas-compressor.

10. The apparatus of claim 7 wherein said hopper is provided with means for circulating gas from the top to the bottom of the hopper to thereby agitate the solids within the hopper.

11. The apparatus of claim 10 wherein said gas circulating means comprise a valved gas line containing a gas compressor.

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