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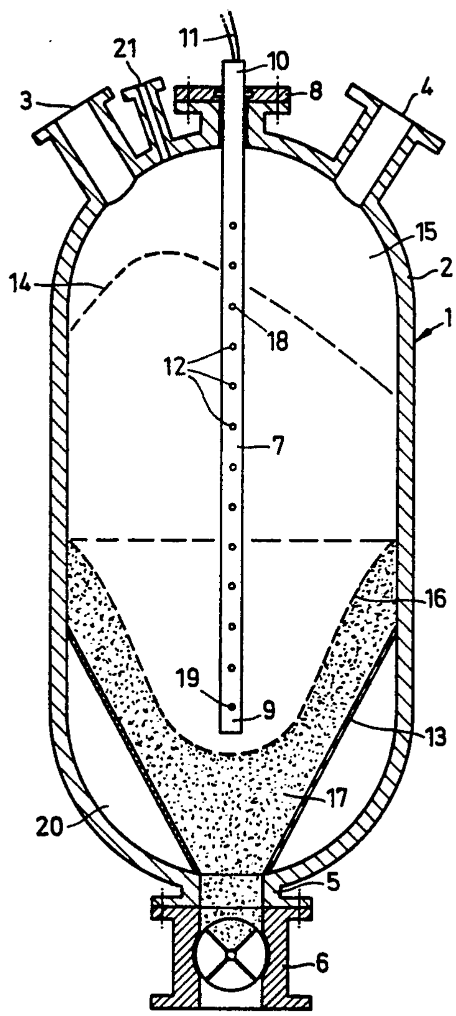
(54) Indicating level of powdered material

(57) In a pressure-resistant container for storing fine-grain solid fuel (17) for gasification under elevated pressure, a temperature sensor (7) is so disposed that the level of filling of the fuel is ascertained by detecting the temperature in the interior of the container. The sensor is in the form of a rod or bar which extends into the container in coaxial relationship with the longitudinal axis thereof, at least as far as the halfway point of the axial height of the container. The sensor preferably comprises a plurality of thermocouple elements (12) disposed on the bar or rod at axial spacings from each other and providing a temperature detection effect in a stepped fashion.



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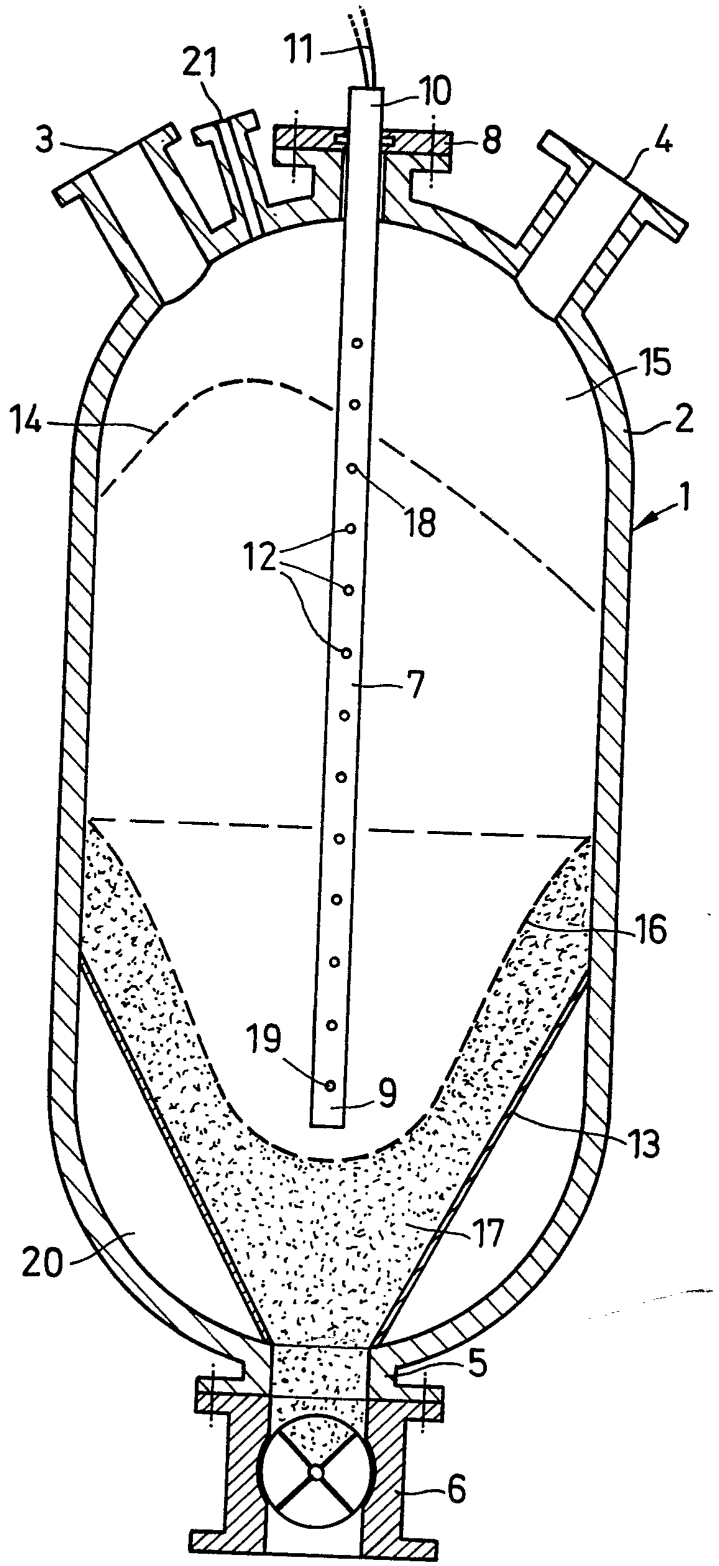

SPECIFICATION

Pressure-resistant container for bulk materials

This invention relates genrally to a pressure-resistant container and more particularly such a container for receiving and storing and subsequently delivering bulk material, more especially fine-grain solid bulk materials, for example predried brown coal or lignite, which may possibly be at an elevated temperature and under an increased pressure and an inert gas. Such material is usually stored in such a container only for a short period of time.

Pressure-resistant containers for receiving, storing and delivering solid bulk materials, on a short-term basis, are required for example in installations in which fuel is gasified under elevated pressure, the container being used as a prestorage or collector container between a charging system and a gasification reactor. That system is operative for continuously or discontinuously introducing the fuel into the gasification reactor. An aspect of particular significance in this connection is the hydrogenating gasification of coal such as brown coal or lignite, which is carried out under elevated pressures of the order of magnitude of 80 to 120 bars. The amount of fuel to be introduced in each charging operation, in present installations, is approximately 3000 kg. For the purposes of introducing the fuel into the gasification reactor, a charging container is firstly filled with the fuel under normal atmospheric pressure. After that filling operation, the filling connection of the container is pressure-tightly closed off and the container is then put under a pressure which corresponds at least to the pressure in the gasification reactor. The outlet of the container is then opened, whereupon the batch of fuel is introduced into a prestorage or collector container which is still upstream of the gasification reactor. The discharge opening of the charging container is then closed and the procedure involving relieving the pressure in that container, filling it with material and putting it under pressure is then repeated. The fuel in the collector container is uniformly and continuously conveyed therefrom into the reactor for example by way of a bucket wheel-type charging valve.

Having regard to the amounts of fuel to be introduced and also the high gasification pressures involved, it is necessary for such charging and collector containers to be of a comparatively thick-walled construction. Existing collector containers have an inside diameter of 1800 mm and an axial length of 5900 mm, for example, with a material-accommodation volume of 7.5 m3. In view of the high internal pressures in such arrangements, wall thicknesses of up to 100 mm are required. In the gasification of brown coal or lignite, the latter is introduced into the collector container in a condition of having been predried to a residual moisture content of from about 1 to 15%, at an elevated temperature of approximately 120°C. As in such a condition the brown coal or lignite already has a tendency to react with oxygen in the air, it is necessary for all containers of the system to have an inert gas atmosphere therein. Nitrogen or, for reasons of cutting costs, possibly also carbon dioxide, are conventionally used for that purpose, while such gases are also used for pressuring the interior of the containers.

In such a collector container for the hydrogenating gasification of brown coal or lignite under high pressure, it is necessary in all circumstances to ensure that there is always fuel in the container. For that purpose, it is conventional practice to use radioactive preparations as a means for measuring the condition or level of filling of the container. Those preparations are disposed on the outside of the container and radiate through the container so that the radiation passing through the container can be measured at the opposite side from the radiation soruce. However, in order to radiate through the thick-walled container, that system must use radioactive preparations which have a very high energy content, and the use thereof is not unrestrictedly permissible, for reasons of environmental protection.

Apart from the use of the above-mentioned radioactive preparations for measuring the condition of filling of such containers, there were hitherto no ways of detecting the level of filling of material within the container with the same degree of accuracy and reliability, when using other means. Besides the harmful radiation however, the system which involves using radioactive preparations for measurement purposes also suffers from the disadvantage of the degree of absorption of the radioactive radiation by the inert gas within the container often varying greatly with fluctuating pressures so that the measuring devices are always having to be re-set. Furthermore, the difference in absorption of the radioactive radiation by the fuel and the inert gas becomes progressively less with increasing pressure, and that disadvantage resulted in radioactive measuring devices with a high level of sensitivity and radiation intensity being designed.

An object of the present invention is to provide a pressure-resistant container for fine-grain solid bulk material, which permits the degree of filling thereof to be ascertained with a high degree of accuracy and reliability.

Another object of the invention is to provide a simplified but accurate means for measuring the level of filling of a thick-walled container with bulk material, without giving rise to environmental hazards.

A further object of the invention is to provide a pressure-resistant vessel with an accurate means for measuring the degree of filling thereof, which enjoys long-term accuracy without the need for continual re-setting thereof.

These and other objects are achieved according to the present invention by providing a pressure-resistant container or vessel for fine-grain solid bulk material such as pre-dried brown coal or lignite, comprising a temperature sensor therein for measuring the temperature of the material in the container, thereby to ascertain the level of filling thereof.

Thus, the invention proposes that the operation of measuring the level of filling in respect of a fine-grain solid fuel within a pressure-resistant container is carried out by means of a temperature sensor, making use of the fact that the material or fuel introduced into the container is at an elevated temperature. When the container is filled up for example with carbon dioxide as the inert gas, the temperature of which is lower than the temperature of the fuel, there is a temperature drop or difference between the fuel and the inert gas in the interior of the container, that is utilised to determine the level of filling thereof. At the same time the temperature of the fuel is detected and monitored by means of the sensor in the form for example of a thermocouple element so that, when considering the hydrogenating gasification of oal, the fuel can be kept at a temperature level which is suitable for its being subsequently introduced into the gasification reactor. In situations where the fuel has to be heated or cooled, that is to say, when heat is to be supplied to or removed from the fuel by means of a heat exchanger fitted into the reactor, the thermocouple element serves at the same time for measuring the temperature, besides also measuring the condition of filling of the container. In comparison with the above-discussed operation for measuring the level of filling by means of a radioactive preparation, wherein the nitrogen which is conventionally used as the inert gas in the container has the same absorption capability in respect of the radioactive radiation as the fuel or coal which is to be gasified, the system of the invention provides an advantageous simplification and increase in measuring reliability insofar as a temperature difference which can be clearly detected by means of the thermocouple element almost always occurs between the fuel and the inert gas in the container. Moreover, detecting the temperature difference in that way at the same time also provides the possibility of ascertaining the location of the level of filling of the container when the thermocouple element is of a suitable configuration.

Consequently, the system of the invention also provides the possibility of arranging the temperature sensor in the container in coaxial relationship with the longitudinal axis thereof and forming the temperature sensor as a rod or bar which is introduced at least as far as half its axial height into the interior of the container. This arrangement is a particularly advantageous one as, by virtue of the fact that the surface of the material in the container forms a conical configuration, more specifically being a positive conical configuration during the container-filling operation and a negative configuration during the container-emptying operation, the greatest fluctuations in the height of the material in the container will thus occur in the region of the longitudinal axis thereof. By virtue of the temperature sensor being of a suitable design configuration therefore, the system provides in a particularly simple and advantageous manner that the level of filling is measured at that location which shows the greatest differences in regard to measured values.

As a particularly simple and inexpensive construction, in relation to a tempserature sensor which provides for temperature sensing or pick-up in a stepped or graduated fashion, in a preferred embodiment of the invention a plurality of thermocouple elements is disposed at spaced intervals along the longitudinal axis of a bar or rod and are electrically connected to a measuring amplifier in such a way that the temperatures respectively obtained at the tips of the individual thermocouple element can be successively picked up and measured. In a construction with stepped or graduated temperature detection of this nature, the temperature sensor is installed in a pressure-tight and fixed manner in the pressure-resistant container and has electrical connections which are taken to the outside, for connection to the measuring amplifier. In another embodiment of the invention an individual thermocouple element is used which element is preferably disposed at the end of a rod or bar arranged in the container so as to be displaceable in the direction of the longitudinal axis thereof so that displacement of the bar or rod enables measurement values to be successively obtained at different axial levels in the interior of the container.

Other objects, features and advantages of the present ivention will become apparent from the following description of a preferred embodiment.

The accompanying drawing is a simplified diagrammatic view in longitudinal section of one embodiment of a pressure-resistant container according to the invention.

Referring to the drawing, a pressure-resistant prestorage or collector container 1 in the form of a cylindrical vessel with its longitudinal axis extending vertically, is closed at its top and bottom and has a wall 2 of substantial thickness to resist the internal pressures involved. At its upper end, the container 1 has first and second openings 3 and 4 through which material such as coal is alternatively introduced into the container 1. At its lower end, the container 1 has a discharge opening 5 which is connected to a bucket wheel-type valve arrangement 6. From the upper end of the container, a temperature sensor 7 in the form of an elongate rod or bar projects into the interior of the container 1. The temperature sensor 7 is connected in a fixed and pressure-tight manner to the container 1 at a flange 8 and extends inwardly coaxially with respect to the longitudinal axis of the container 1.

The lower end 9 of the temperature sensor 7 projects into the interior of the container 1 to a point beyond the halfway point of the axial length of the container, while the axially upper end 10 of the temperature sensor 7 is extended out of the container 1 and has electrical connections 11 for a temperature measuring sensor 7 is formed as a thermocouple element assembly with stepped or graduated temperature detection or pick-up, that is to say, a plurality of thermopcouple elements 12 are disposed along the longitudinal axis of the rod or bar 7 in axially spaced relationship, terminating on the surface of the rod or bar 7. By means of the connections 11 and the measuring device (not shown), the temperatures occurring at each of the individual thermocouple elements 12 can successively be ascertained.

Furthermore, in its lower part the container has a funnel means 13 which facilitates the discharge flow of bulk material through the discharge opening 5 while in its upper part the container 1 has a pressure-tight connection 21 for introducing an inert gas.

In use, the pressure in the container 1 is maintained at a level slightly higher than the pressure for example in a gasification reactor (not shown) to which the container 1 is connected for the gasification of coal. The charging wheel of the valve 6 rotates in order to introduce a continuous flow of coal into the reactor. Thus, in operation of a hydrogenation installation for example fine-grain predried brown coal or lignite is discontinuously introduced into the container 1 from a charging container (not shown) by way of the connection 3 or 4, approximately up to the upper filling level which is indicated by the broken line 14. By way of the pressure-tight connection 21, a suitable inert gas such as nitrogen or carbon dioxide is introduced under pressure, and at a lower temperature than that of the brown coal or lignite, into the space 15 which remains in the container above the filling level 14. In that way, a pressure is maintained in the container 1 which is slightly higher than the pressure in the gasification reactor, being therefore for example somewhat more than the gasification pressure of 80 to 120 bars. The required amount of solid fuel is drawn from the container 1 by way of the charging valve 6 until the material reaches a lower filling level which is indicated by the broken line 16. The lower filling level 16 corresponds to the minimum admissible content in the container 1 of fuel 17 which is to be supplied therefrom. During the emptying phase also, in which the material goes from the upper filling level 14 to the lower filling level 16, the pressure in the container 1 is maintained substantially at the above-indicated value, although it will be appreciated that during the emptying phase the space 15 above the material in the container increases in size. Further inert gas is introduced into the container by way of the connection 21, corresponding to the amount of fuel 17 removed, in order thereby to maintain the pressure in the container 1.

The filling openings 3 and 4 are preferably of such a configuration that they can be alternately fed with fuel.

The temperature sensor according to the invention, by measuring the temperature in the container 1 by way of the individual thermocouple elements 12, makes it possible reliably and precisely to ascertain the axial level within the container which is reached by the fuel 17, between the filling level lines 14 and 16. In that respect, the system makes use of the fact that the temperature of the fuel 17 in the container is some degrees Centrigrade higher than the temperature of the inert gas in the space 15, that is to say, there is a temperature difference between the fuel and the inert gas. When the fuel reaches the filling level 14 which is detected by interrogating the thermocouple element 18, the feed of fuel 17 through the connection 3 or 4 is cut off. Inert gas is introduced into the container by way of the connection 21. When the fuel reaches the lower filling level 16 which is ascertained by means of the thermocouple element 19, the container is freshly filled with fuel 17 by way of the connection 3 or 4 until it reaches the upper filling level 14. The respective level to which the container is filled with fuel is detected at any time by means of the thermocouple elements 12 which are disposed between the thermocouple elements 18 and 19. On the basis of that data, fresh fuel 17 can be introduced into the container in good time by way of the connection 3 or 4.

By virtue of the temperature in the interior of the container 1 being measured for the purposes of detecting the respective level of filling of the fuel therein, at the same time and in addition thereto the system ensures, by measuring the absolute temperature, that the fuel 17 is at any time at the temperature level required for the gasification operation. If the temperature of the fuel 17 should rise above or fall below the necessary temperature level, a cooling or heating agent may be introduced by way of a further connection (not shown) for example into the annular space 20 formed by the funnel means 13, whereby the fuel 17 is adjusted to the required temperature.

Various modifications and alterations may be made in the above-described construction without thereby departing from the spirit and scope of the present invention.

CLAIMS

1. A pressure-resistant container for accommodating fine-grain solid bulk material including a means for detecting the level of filling of the bulk material in the container, that is in the form of a temperature sensor to measure the temperature within the container.

2. A container as claimed in claim 1, wherein said container is of an elongate configuration and said temperature sensor is disposed in the container in coaxial relationship with the longitudinal axis thereof and is of an elongate configuration extending into the interior thereof at least as far as the halfway point of the axial dimension of the container.

3. A container as claimed in claim 1 or 2, wherein said temperature sensor is formed as a thermocouple element and is fixedly and pressure-tightly connected to the container.

4. A container as claimed in any of claims 1 to 3, wherein said temperature sensor is provided with a means for detecting temperatures in the container at spaced locations along an axis thereof.

5. A pressure-resistant container for receiving and subsequently discharging a bulk material therefrom comprising a vessel of elongate configuration and adapted to withstand elevated internal pressure and temperature, feeding means on said vessel for introducing said material into said vessel, discharge means on said vessel for discharging said material therefrom, an elongate carrier member extending into the interior of, and substantially along, the longitudinal axis of said vessel to a position at least halfway along the axial dimension of the interior of said vessel, and a plurality of temperature-sensing elements disposed on said carrier member in spaced relationship along the length thereof.

6. A container as claimed in claim 5 and further including means on said vessel for introducing an inert gas therein.

7. A container as claimed in claim 5 or 6 and further including a measuring device operatively connected to said temperature-sensing elements for processing sensing signals therefrom.

8. An installation for processing fine-grain solid fuel which comprises a pressure-resistant container as claimed in any of claims 5 to 7.

9. A pressure-resistant container as claimed in claim 1, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

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