Abstract: Systems for performing a wellbore operation include a flexible walled silo for containing powder or fibrous material therein, where the powder or fibrous material is dischargeable from the flexible walled silo under gravitational force into a mixing system. In some aspects, the flexible walled silo is an extendable silo, or even a telecopically extendable silo. In some cases, the system includes a plurality of such flexible walled silos disposed on a transportable frame. The transportable frame may be a telecopically extendable frame. The powder or fibrous material may be discharged from the flexible walled silo into an eductor as part of the mixing system, and in some instances, the powder or fibrous material is discharged from the flexible walled silo into a receiving hopper prior to introduction into mixing system.
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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FLEXIBLE WALLED AND SCALABLE SILO FOR DRY BULK MATERIAL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/220,621 filed September 18, 2015 (entitled "Fabric Silo for Powdered Material" - Attorney Docket No. IS1 5.1 093-US-PSP) and U.S. Provisional Application No. 62/269,941 (entitled "Bulk Handling of Cement, Powder and/or Granular Material" - Attorney Docket No. IS15.1 093-US-PSP filed December 19, 2015, both of which are incorporated herein in their entirety by reference.

FIELD

[0002] The present disclosure is related in general to wells equipment such as oilfield surface equipment such as pressure pumping equipment, mixing equipment and the like, downhole tools and assemblies, coiled tubing (CT) tools and assemblies, slickline tools and assemblies, wireline tools and assemblies, and the like.

BACKGROUND

[0003] This section provides background information to facilitate a better understanding of the various aspects of the disclosure. It should be understood that the statements in this section of this document are to be read in this light, and not as admissions of prior art.

[0004] Wellbore drilling operations may be performed by drilling tools suspended by a drilling rig and advanced into subterranean formations to form a wellbore. A mud pit may be used to draw drilling mud into the drilling tools via a flow line or the like for circulating drilling mud down through the drilling tools, then up the wellbore and back to the surface. The drilling mud is usually filtered and returned to the mud pit and powdered material may be utilized to form the drilling mud and may be stored at the surface during the drilling operation. A circulating system may be used for storing, controlling, or filtering the flowing drilling mud.

[0005] When the wellbore has been drilled, it is often desired to isolate the various producing zones form each other or from the well itself in order to stabilize the well or prevent
fluid communication between the zones or shut off unwanted fluid production such as water. This isolation is typically achieved by installing a tubular casing in the well and filling the annulus between the outside of the casing and the wall of the well (the formation) with cement. The cement is usually placed in the annulus by pumping a slurry of the cement down the casing such that it exits at the bottom of the well and passes back up the outside of the casing to fill the annulus.

[0006] In a variety of downhole cementing operations, a slurry, such as a cement slurry is mixed at a well site via a cement mixing system. The cement slurry is then delivered to a pumping system which is used to pump the cement slurry downhole into a wellbore. For example, the cement slurry may be delivered to a downhole location and forced under pressure into the annular space between a well casing and a surrounding wellbore wall. Upon curing, the well casing is cemented in place within the wellbore and the space between the well casing and the surrounding wellbore wall is sealed. When the cement slurry is mixed, delivery and handling of the powder cement blend and slurry fluid prior to delivery to the pumping system can have a substantial impact on the quality and consistency of the slurry.

[0007] The components of the slurry are formed by a combination of a liquid and a cement, powder, or a granular material. Improvements in the storage and handling of the powder may provide commensurate improvements in the quality of the blended slurry.

[0008] While it is possible to mix the cement as a batch prior to pumping into the well, it has become desirable to effect continuous mixing of the cement slurry at the surface just prior to pumping into the well. This has been found to provide better control of cement properties and more efficient use of materials.

[0009] The cement slurries used in such operations comprise a mixture of dry and liquid materials. The liquid phase is typically water and so is readily available and cheap. The solid materials define the slurry and cement properties when added to the water and mixed and such solid materials may be formed of a powder material and may be stored at the surface during the cementing operation. To facilitate the recovery of hydrocarbons from oil and gas wells, the
subterranean formations surrounding such wells may be hydraulically fractured. Hydraulic fracturing may be used to create cracks in subsurface formations to allow oil and/or gas to move toward the well. The formation is fractured by introducing a specially engineered fluid, sometimes referred to as fracturing fluid or fracturing slurry, at high pressure and high flow rates into the formation through one or more wellbores. The fracturing fluids may be loaded with proppant which are sized particles that may be mixed with the liquids of the fracturing fluid to help form an efficient conduit for production of hydrocarbons from the formation to the wellbore. Proppant may comprise naturally occurring sand grains or gravel, man-made proppants, e.g. fibers or resin coated sand, high-strength ceramic materials, e.g. sintered bauxite, or other suitable materials. The proppant collects heterogeneously or homogeneously inside the fractures to prop open the fractures formed in the formation. Effectively, the proppant creates planes of permeable conduits through which production fluids can flow to the wellbore.

[0010] At the well site, proppant and other fracturing fluid components are blended at a low-pressure side of the system. The oilfield materials often are delivered from storage facilities to a blender by pneumatic systems which blow the oilfield materials. Water-based liquid is added and the resulting fracturing fluid is delivered downhole under high pressure. However, handling of the proppant prior to blending tends to create substantial dust as the proppant is moved to the blender via blowers. As a result, dust control devices, e.g. vacuums, are employed in an effort to control the dust. The variety of equipment used in the process also tends to create a large footprint at the well site, and operating the equipment is generally a manually intensive process.

[0011] It remains desirable to provide improvements in oilfield surface equipment and/or downhole assemblies such as, but not limited to, methods and/or systems for improvements in storage devices, facilities, and/or methods for powder material such as cement, proppant, granular material, and the like.
SUMMARY

[0012] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0013] In a first embodiment according to the disclosure, systems for performing a wellbore operation include a flexible walled silo for containing powder or fibrous material therein, where the powder or fibrous material is dischargeable from the flexible walled silo under gravitational force into a mixing system. In some aspects, the flexible walled silo is an extendable silo, or even a telescopically extendable silo. In some cases, the system includes a plurality of such flexible walled silos disposed on a transportable frame. The transportable frame may be a telescopically extendable frame. The powder or fibrous material may be discharged from the flexible walled silo into an eductor as part of the mixing system, and in some instances, the powder or fibrous material is discharged from the flexible walled silo into a receiving hopper prior to introduction into mixing system. The flexible walled silo may also include one or more of a radiation heater, a dust filter system, a semi-closed air fluffing apparatus, and one or more of valves and augers disposed on the bottom of the flexible walled silo.

[0014] According to some other embodiments, a cement powder mixing system includes a silo for containing cement powder material therein, and a cement mixer, where the powder material is dischargeable from the flexible walled silo under gravitational force into the cement mixer in an on-the-fly operation, and the silo is a flexible walled silo or a telescoping walled silo. In some aspects, the system includes a plurality of such silos disposed on a transportable frame, and in some cases, the transportable frame is a telescopically extendable frame.

[0015] Yet some other embodiments are methods for performing a wellbore operation with at least one system for bulk storage handling of powder. Some methods involve providing at least one flexible walled silo for containing the powder material therein, providing a mixing system, discharging the powder material from the flexible walled silo under gravitational force into a mixing system in an on-the-fly manner, mixing the powder material with a liquid medium.
to form a slurry, and pumping the slurry into a wellbore at sufficient pressure to perform the wellbore operation. The powder may be one of cement powder or other oilfield granular material, such as proppant for stimulation and material for drilling fluids. In some aspects, the at least one flexible walled silo is a plurality of flexible walled silos disposed on a transportable frame, and the transportable frame may be a telescopically extendable frame.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0017] FIG. 1 shows a perspective schematic illustration of a portion of a mobile plant system including a trailer upon which flexible-walled vertical silos are erectably mounted, in accordance with an aspect of the disclosure;

[0018] FIG. 2 shows a perspective schematic illustration of a telescopic frame which retains a flexible walled silo retracted therein, in accordance with an aspect of the disclosure;

[0019] FIG. 3 shows a perspective schematic illustration of a telescopic frame from which a flexible walled silo is extended there from, in accordance with an aspect of the disclosure;

[0020] FIGS. 4 through 6 show use of silos which are fixed and not extendable, in accordance with some aspects of the disclosure;

[0021] FIG. 7 shows a perspective schematic illustration of a portion of a mobile plant system including a trailer upon which flexible-walled vertical silos are erectably mounted, and the trailer includes a hinge system, in accordance with an aspect of the disclosure;

[0022] FIGS. 8 and 9 show some possible orientations of equipment using a trailer with a hinge system, in accordance with aspects of the disclosure;
FIGS. 10A through 10D show some embodiments of how materials are discharged by gravitational force from the silo into on-the-fly mixing systems, in accordance with aspects of the disclosure;

FIG. 11 shows a perspective schematic illustration of an aeration air recirculation system used with some silos, in accordance with an aspect of the disclosure;

FIG. 12 shows a radiation heater to prevent condensation in a silo, in accordance with an aspect of the disclosure;

FIG. 13 shows a perspective schematic illustration of a portion of a mobile plant system including a trailer upon which flexible-walled vertical silos are erectably mounted, and the trailer includes a centralized hopper, in accordance with an aspect of the disclosure; and,

FIGS. 14 through 15 show some embodiments of erectable with scissor type raising structures, in accordance with some aspects of the disclosure;

**DETAILED DESCRIPTION**

The following description of the variations is merely illustrative in nature and is in no way intended to limit the scope of the disclosure, its application, or uses. The description and examples are presented herein solely for the purpose of illustrating the various embodiments of the disclosure and should not be construed as a limitation to the scope and applicability of the disclosure. In the summary of the disclosure and this detailed description, each numerical value should be read once as modified by the term "about" (unless already expressly so modified), and then read again as not so modified unless otherwise indicated in context. Also, in the summary of the disclosure and this detailed description, it should be understood that a numerical range listed or described as being useful, suitable, or the like, is intended that any and every value within the range, including the end points, is to be considered as having been stated. For example, "a range of from 1 to 10" is to be read as indicating each and every possible number along the continuum between about 1 and about 10. Thus, even if specific values within the range, or even no values within the range, are explicitly identified or refer to
only a few specific, it is to be understood that inventors appreciate and understand that any and all values within the range are to be considered to have been specified, and that inventors had possession of the entire range and all points within the range.

[0029] Unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by anyone of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0030] In addition, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of concepts according to the disclosure. This description should be read to include one or at least one and the singular also includes the plural unless otherwise stated.

[0031] The terminology and phraseology used herein is for descriptive purposes and should not be construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited.

[0032] Also, as used herein any references to "one embodiment" or "an embodiment" means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily referring to the same embodiment.

[0033] The disclosure provides various embodiments of a system and/or method for providing bulk storage and/or handling of dry material such as cement, powder, and/or granular and, fibrous, bricks or otherwise consolidated material. This includes bentonite, barite, or other dry material used for mixing the drilling fluid. The systems shown may include a mobile plant that is able to continuously meter material from a series of storage locations, such as bins, silos or the like, to a common delivery screw disposed below each of the storage locations,
which is further connected directly to a manifold on or adjacent a continuous mixer. Some embodiments also include equipment for containing dust from fluffing.

[0034] The individual bins or silos may be fitted with metering screws, which feed into the conveying screws. In an embodiment wherein only a single bin or silo is to deliver at any time, the main conveying screw may be variably controlled to serve as the metering screw. In an embodiment, the silos or bins may or may not be a part of the plant trailer and the main conveying screw may discharge from either the front or rear of the trailer.

[0035] Metering for the individual silos or bins may be accomplished by numerous devices and/or methods such as, but not limited to, augers, positive displacement rotary devices, etc. In an embodiment, the system or plant may be telescoped for gravity feed for different metering strategy other than augers. In some embodiments, a valve, such as but not limited to a gate valve or clam shell valve, is disposed under each compartment / silo which may be used to select which material flows into a main conveyor below. In some aspects, the valve may also be used to meter material flow rates, and a main conveyor below is used only for transferring at a target rate.

[0036] In an embodiment, the system comprises a mobile plant that is able to bulk blend cement, powder, and/or granular components. Individual components may be loaded in separate silos, and material may be transferred between silos until the components are well mixed, eventually moving the total blend into the minimum number of silos required to store the ultimate mixed material. This mobile plant can also be used for storage, metering, and transfer of pre-blended materials. In some embodiments, the mobile plants may also be used to blend a final mix on the fly.

[0037] In an embodiment, a receiving point for the system is disposed on the opposite end of the discharge point of the system, thereby enabling multiple units to be fed in series. In an embodiment, two (or more) units such as the unit or system, may be placed side by side, with one system arranged to discharge to the conveying screw of the other. Such an arrangement would enable increased volume delivery to a single point.
In an embodiment, the bins may move with the bottom conveyor, but in another embodiment, an erecting trailer places the bins or silos on the conveyor.

The systems may use a flexible, extendable walled silo. An advantage of flexible material for a silo or bin is that it is very light, which would enable the delivery of several silos and the conveying base in a single trip. In an embodiment, the flexible material may be engineered to be capable of holding fine particulate matter and/or to enable pneumatic loading and dust filtration. In addition, the fabric may work in conjunction with an external weatherproofing layer to protect the fabric against environmental forces, such as ultraviolet rays from the sun, wind, snow, rain, etc. Sections of fabric may also work to function as a dust collection device, allowing excess air to pass through, but retaining desired fine powders.

In an embodiment, the material is fed by drop loading from the bottom of the silo, or drop loaded from the side of the silo. Embodiments of the system(s) of the present disclosure may provide volumes up to about 8000 cubic feet, may provide multiple compartments on the same combined plant, may provide a hard metal bottom with elastomers, cloth or fabric sides that collapse for transit, and which then extend upward for storage of the cement, powder, and/or granular material. Embodiments of the system(s) of the present disclosure may provide the ability to transport while carrying up to about 50,000 pounds of material.

Embodiments of the system(s) of the disclosure provide the ability to feed cement, by gravity, directly into a mixing system, e.g., an on-the-fly oilfield mixing system such as, but not limited to, directly into an eductor, or into a receiving hopper.

Embodiments of the system(s) of the disclosure provide much storage capacity that may be able to be transported on public highways or the like and the bottom of the silo may be configured as high as necessary based on the equipment to which the silo or bin will discharge. In some cases, the silo(s) may be transported to a job site partially filled, and thereafter further filled on location after erected.

Embodiments of the system(s) of the disclosure provide gravity conveyance which may prevent the problems of pneumatic conveying. It is likely that some fluffing of the cement
at the outlet of the silo may assist in helping the cement, powder, and/or granular material flow out of the silo and down any subsequent chutes. The pressure required for this fluffing is much less, and may be accomplished with a centrifugal blower rather than a positive-displacement blower or compressor. Also, much less dust is generated when discharging by gravity but any dust generated would still be contained. Further, with use of positive volumetric feed devices, such as augers or belts, in conjunction with gravity, dust generation is minimal if not eliminated at this point in the process.

[0044] In some aspects, systems are provided for bulk storage of and mixer delivery substantially dry material which may be a powder or granular material such as cement, proppant, gravel packing material, and the like. In some embodiments according to the disclosure, mobile plant systems include several bins connected by a bottom conveyor, discharging to further processing such as a cement mixer, or any suitable solids/liquid mixing device. The system also includes a flexible-walled large vertical silo formed from a flexible or otherwise collapsible material, such as a fabric, cloth, plastic sheeting, rubber sheeting, composites and the like. In some cases, the large vertical silos discharge substantially dry material by gravity to an integral elevating/metering screw, or directly into such a device integrated with a mixer, such as a cement mixer. In some other aspects, a pneumatic bulk trailer is used to haul material to, and hold additional material, on location. In yet other aspects, a gravity-unload bulk trailer is used which is able to haul material to, and hold additional material on location. The systems may also include means of aerating a silo without introducing moisture, or even devices for stopping condensation inside the silo.

[0045] Now referencing FIG. 1, a portion 100 of a mobile plant system includes a trailer 102 upon which flexible-walled vertical silos 104 (four shown) are erectably mounted. Vertical silos 104 are generally formed of a lower section 106 and flexible walled upper section 108. In some embodiments, a flexible silo includes hard metal as the bottom lower section 106, and flexible sides as the upper section 108 that collapse for transit, and then extend upward for storage.
[0046] Vertical silos 104 are depicted in an erected state, but are collapsible/erectable with telescoping struts 110 (four shown), which may be disposed around the silos in such way as to collapse or erect vertical silos 104. Portion 100 of the mobile plant system may further include extendible platforms 112 (two shown) for stability when vertical silos 104 are erected and/or filled with material. In some cases, the silos 104 telescope upwards while the struts telescope or swing downwards (and/or maybe outwards) to lift the whole plant high enough to allow, for example, for gravity fed into a mixer backing there under. For additional stability, extended outriggers can also be incorporated into the system. In other embodiments, the trailer chassis can be lowered to the ground through the use of appropriate suspension systems, to create a greater surface area contact and hence stability.

[0047] The large vertical silos 104 discharge substantially dry material by gravity to an integral elevating/metering conveying screw system is included which has a horizontal portion 114 and tilted portion 116 for conveying material discharged from vertical silos 104 to a mixer 118. Accordingly, the mobile plant system may be able to continuously meter material from the series of storage/silos to a common delivery screw that is connected directly to the manifold on a continuous mixer. Silos 104 may further include valves and/or feeder screws 120 (four shown) for controlling discharge of material. Possible use of such valves and/or feeder screws as a component of any of the silos described herein is within the scope of the disclosure.

[0048] The main conveying screw may discharge from either the front or rear of the trailer 102. In some aspects, a receiving point will be on the opposite end of the discharge point, so that multiple units can feed in series. Two units like that depicted could be placed side by side, with one discharging to the conveying screw of the other. This allows increased volume delivery to a single point.

[0049] In some aspects, the individual silos, or bins, may be fitted with metering screws which feed into the conveying screws. In some cases, if only one bin is to deliver at any time, the main conveying screw in the conveying screw system could be variably controlled to serve as the metering screw. In some other aspects, the silos 104 may or may not be integrated part of the plant trailer 102. In some embodiments, metering for silos can be accomplished by any
of numerous suitable devices, such as augers, positive displacement rotary devices, and the like.

[0050] In some embodiments, the flexible silos may be formed of a fabric, cloth, plastic sheeting, rubber sheeting, and the like, which is suitable for powder material, such as cement or the like, and granular material such as proppant or barite. In an embodiment, the disclosure provides an extendable fabric type silo for powder, such as cement or the like. The fabric type silo may be engineered and/or constructed to be suitable for outdoor use such that the silo is suitable over a wide range of temperature from very low operational temperatures to very high temperature applications. The silo may be engineered and/or constructed to be ultraviolet (UV) ray resistant and/or tear resistant. The silo may be engineered and/or constructed to be weatherproof, waterproof and/or powder-proof, but in some cases, the silo is preferably not an air-tight silo. Engineering and/or constructing the silo not to be air-tight allows for air flow across the fabric of the silo, which may help to reduce dust generation during pneumatic filling of the silo, as well as reduce risk for moisture condensation within the silo. Flexible-walled silo embodiments according to the disclosure may also be shape engineered to minimize or eliminate any dead spots and/or rat-holing of the substantially dry material, and thereby encourage flow for the hardest-to-flow products.

[0051] In an embodiment, the silo includes an extendable fabric silo with a telescopic frame of struts, such as that shown schematically in FIG. 1. In an embodiment, the telescopic frame 202 which retains silo 204 may be retracted (as shown in Fig. 2) during transport and extended (as shown in FIG. 3) during rig-up. When extended, silo 204 is pulled up by telescopic frame 202 as strut 206 is moved out of strut 208.

[0052] In alternate embodiments, shown in FIGS. 4 through 6, the silo is fixed and not extendable. As shown in FIG. 4 fabric silo 402 is not extended as frame 404 is fixed, and not telescopic. This is also the case for embodiments shown in FIGS. 5 and 6.

[0053] Embodiments of the present disclosure provide a flexible silo whose overall weight is lower than a steel silo of like capacity and/or function. The frame, therefore, may not need
to be as sturdy and a storage/space ratio will be maximized for the silo. In some aspects of the disclosure the silo may be provided with or without a fabric bottom. In some of these cases, the bottom of the silo may be live and may include aeration pads, an agitator/thumper, etc. Silo embodiments of the disclosure may also be transported separately or incorporated into a storage trailer to minimize the number of trips and/or the number of rig-ups/downs.

[0054] In some aspects, embodiments of the disclosure may facilitate the use of load cells integrated with the silos, in operation. As the weight of material forming the flexible silo is lower than steel, or other typically used metals, the measurement and/or turn down for the resolution and accuracy is superior to that of a silo formed of heavier weight material such as steel. With regards to dimensions of silos according to the disclosure, flexible silo embodiments provide a compact footprint, such as no wider than about 7 feet to about 8 feet. Capacity of the flexible silos is, in some embodiments, from about 1050 to about 2100 cubic foot capacity for a single silo. A plurality of silos could provide a much larger capacity, such as up to about 8000 cubic foot, or larger. In an embodiment, a flexible silo unit that is able to delivery cement powder flow to a mixer at a rate up to 3 tonnes per minute via gravity feed. In some embodiments, a trailered plurality of silos have the ability to carry up to 50,000 lbs material while being transported, which enables avoidance of another vendor having to provide materials to a well site.

[0055] Flexible silo embodiments of the disclosure may be suitable for outdoor usage and/or in harsh environments, such as, but not limited to, from about -40 deg C to about +80 deg C. The silos may be rain, snow, wind, UV and/or high tear resistant both to external and internal forces (where the material may sometimes be abrasive). In addition, the material forming the flexible silo could work in conjunction with an external weatherproofing layer to protect it against environmental forces (UV, wind, snow, rain etc).

[0056] In some aspects, the silo design may be able to provide no or very little risk of condensation in the powder product. Often, powder products may be very fine and/or hygroscopic, in comparison to guar and/or flour, and the product may become very sticky when wetted. Embodiments of the disclosure may also be designed to not allow bridging of even the toughest to flow product, and use of simple low energy and reliable external systems (e.g.,
vibration-based) are acceptable. In some aspects, the flexible silos are able to be filled pneumatically with little to no generation of dust, as well as emptied pneumatically or by gravity.

[0057] Embodiments of the disclosure provide a flexible silo that may be easy to clean and thereby reduce risk of cross contamination if different products are used for same silo. Furthermore, the flexible silos may be easily cleans if wetted cement product (i.e. from condensation) are accumulated on the inner surface of the flexible silo. Additionally, embodiments of the disclosure provide a flexible silo that may be easily foldable and unfoldable repeatedly.

[0058] Embodiments of the disclosure provide a flexible silos and instrumentation that are robust and suitable for mobile off-road applications where the silos and instrumentation are transported to remote well sites. Embodiments may also utilize silos that will not be loaded with material during transport, but may be required to store any leftover material (which is a small amount) on the transport trip back to base. In some aspects, material could be fed into the flexible silo by drop loading from the bottom, the top, or even drop loaded from the side of the silo.

[0059] Now referencing FIG. 7, which depicts a portion 700 of a mobile plant system similar to that shown and described in FIG. 1. The system includes trailer 702 upon which flexible-walled vertical silos 704 (four shown) mounted, and may be collapsible below legal transport height, shown at A, and erected there above for operational use. Trailer 702 further includes a hinge system 706 to enable portions 708 and 710 of the trailer to be orientated in different ways depending upon operational requirements.

[0060] FIG. 8 illustrates one possible orientation, in a bottom view, of trailer portions 708 and 710 where the portions are adjacent one another, which allows the flexible-walled vertical silos 704 to be positioned over receiving hopper 712 and mixer 714 as shown. FIG. 9 illustrates another possible orientation, in a bottom view, of trailer portions 708 and 710 where the portions are orientated at a 90 degree angle relative one another, allowing the flexible-walled vertical silos 704 to be positioned adjacent receiving hopper 712 and mixer 714 as shown.
Referring now to different flexible walled silo delivery systems, FIGS. 10A through 10D show some embodiments of how materials are discharged by gravitational force from the silo into on-the-fly mixing systems, such as cement mixing equipment. Material could be delivered via auger mounted on the silo, or drop loaded from the bottom, or drop loaded from the side of the silo. In the embodiment depicted in FIG. 10A, material, such as substantially dry cement powder, resident in flexible walled silo 1002 is discharged under gravitational force and from the side of silo 1002 using auger system 1004. For the embodiment depicted in FIG. 10B, material drop loaded from the bottom of silo 1012. FIG. 10C shows an embodiment where material is discharged under gravitational force from silo 1022 into receiving hopper/auger system 1024, and transferred to mixer 1026, which may be mounted on a trailer. In the embodiment depicted in FIG. 10D, material is discharged under gravitational force from silo 1032 to receiving hopper 1034, then transferred to mixer 1036 via auger 1038. A dust filter system 1040 may be integrated with receiving hopper 1034 to minimize dust generation in operation.

According to some aspects of the disclosure, substantially dry cement powder is directly fed by gravitation force into a mixing system, e.g. on-the-fly oilfield mixing system, via an eductor or receiving hopper. Typically, cement powder is stored in pressurized bottles, from whence it can be pneumatically conveyed to another silo or to a mixing point. However, moisture may be introduced from the compressed air used for conveying and/or moisture flowing backward from the mixing system. Further, hoses may plug to lack of flow for too long a period, or from denser components of a blend settling out on the bottom. Also, damage to friable components of the blend being conveyed, such as hollow glass spheres or fly ash, can occur using pneumatic conveyance. Use of gravitational transfer of cement powder according to the disclosure overcomes such shortcomings. Furthermore, there is much less dust generated when discharging by gravity, but any dust generated must still be contained.

In some cases, where used, the receiving hopper of the mixer will be connected to the flexible walled silo via a weatherproof conduit/seal. In order to further dispel air as the product falls from silo to the receiving hopper, a dust filtration system can be put in place on
the enclosed system. This may consist of one or more filter cartridges which allow air to escape but not dust. To prevent clogging, strategically placed and timed air bursts can be used to free the cartridges of excessive build up. The filtration system may be weatherproof, for example guards to protect from rain and wind.

[0064] Systems according to the disclosure may also include other components, such as pneumatic bulk trailers that are able to haul material and/or hold additional material on location. Because of the density of cement, only about 500 cu. ft. can be hauled within weight limits. Cement weighs about 100 lb.cu ft, so 500 cu ft weighs 50,000 pounds. An air slide weighs about 10,000 pounds and a tractor about 20,000 pounds, making up the 80,000 pound highway limit. In an aspect, an approach is to haul as much weight as can be legally carried in a very large bulk trailer, then leave it on location. This trailer may be modified with aeration pads and larger discharge lines and whatever else is needed to achieve the desired discharge rates. Additional trailers could blow material into the delivery trailer. Dust collectors may be incorporated, such as dust socks.

[0065] In another aspect, a gravity-unload bulk trailer that is able to haul material and hold additional material on location may be used. Such a bulk trailer may be similar in function to a pneumatic system. The need for gravity means that the storage volume must be arranged to deliver to a common point. In some cases, the trailer bulk bin is much shorter in length than the overall trailer length. Also, the bin may be expandable to a maximum volume that can be used to haul material, and haul as much weight as legal.

[0066] Systems and apparatus according to the disclosure may also include means for aerating or fluffing material a silo without introducing moisture to induce material flow/movement. Alternatively there could be means for providing a "kickstart" of high pressure air burst to get the material to start flowing, after which aeration is not required. Notwithstanding either approach, assistance to induce material flow from the flexible silos is used according to some aspects. Where aeration means is used, pressure may be increased by flowing air in from pads at the bottom of the silo.
[0067] Any introduction of ambient air into the system also carries a moisture content, which should be minimized if not remediated. In one aspect, the aerating air is recirculated using a blower in a closed loop system. Any moisture in the air initially may be absorbed into the cement or other material, but no more moisture enters the system. Such a system is depicted in FIG. 11. Recirculation system 1100 includes plenum 1102 attached to blower 1104, which is fluidly connected to bottom portion 1106 of flexible walled silo 1108. Aerating air is introduced into flexible walled silo 1108 by blower 1104, and builds up pressure. Excess air passes through filter 1110, and into recirculation conduit 1112, as well as plenum 1102. When aerated, material resident in silo 1108 may the exit via discharge 1114. If more air is needed in the system, for example to replace air and material being discharged, then more can be drawn in through the plenum 1102. If air needs to be discharged for any reason, but for example if more material is blown in from a bulk transport vessel while operating, then air can exit through plenum 1102.

[0068] In some aspects, a system for resisting or preventing moisture from condensing in a silo is included in embodiments of the disclosure. Silos often include have vents, which can allow moisture to diffuse inward. If moisture inside a silo condenses, a gradient is set up where there is less moisture content of the air inside the silo compared to the ambient air outside of the silo. Due to diffusion, water molecules will diffuse through any vent pipe into the silo. Suitable means for preventing condensation inside a silo is also within the scope of the disclosure.

[0069] In an embodiment of the disclosure, a radiation heater is disposed on top of the flexible walled silo to warm the air inside the silo and thereby maintain a temperature above the dew point. One example of such a radiation heater is a Watlow heater, shown in FIG. 12, which maintains an air temperature above that of the dew point. Such a device would prevent the water from condensing out of the air inside the silo.

[0070] Referring again to FIG. 7, which depicted a portion 700 of a mobile plant system which included a hinge system 706 to enable portions 708 and 710 of the trailer to be orientated in different ways depending upon operational requirements. In some embodiments of the
disclosure, such as that depicted in FIG. 13, the system does not include a hinge system, but rather a central compartmentalized rigid hopper is disposed below the flexible silos. The system 1300 in FIG. 13 includes trailer 1302 upon which flexible-walled vertical silos 1304 (four shown) mounted, and may be collapsible below legal transport height, shown at A, and erected there above for operational use. Trailer 1302 further includes a central compartmentalized receiving hopper 1306 above which the flexible silos 1304 extend. In some aspects, an auger/conveyor may reside on the unit itself, for feeding directly into a mixer.

[0071] Now referencing FIGS. 14 and 15, which depict some other embodiments where the silo is erected by structures other than telescopic frames. In FIG. 14, a plurality of silos are shown in a collapsed state on a mobile trailer. In a collapsed state, the silos may be transported as necessary, and then erected on a job site, or other facility. In FIG. 15, the plurality of silos are shown in a erected state, where scissor like structures are used to guide the silos into the erected state, and stabilize as well. Such silos may be raised by any suitable device, such as a crane or hydraulic system.

[0072] In some other embodiments according to the disclosure, wall of the silo are not necessarily flexible, but rather telescoping, thus providing a telescoping silo. For example, these are scalable silos where telescopic sections (bin within a bin) can be raised to increase storage. The interfaces between the telescopic sections are sealed.

[0073] The foregoing description of the embodiments has been provided for purposes of illustration and description. Example embodiments are provided so that this disclosure will be sufficiently thorough, and will convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the disclosure, but are not intended to be exhaustive or to limit the disclosure. It will be appreciated that it is within the scope of the disclosure that individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the
disclosure, and all such modifications are intended to be included within the scope of the disclosure.

[0074] Also, in some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail. Further, it will be readily apparent to those of skill in the art that in the design, manufacture, and operation of apparatus to achieve that described in the disclosure, variations in apparatus design, construction, condition, erosion of components, gaps between components may present, for example.

[0075] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0076] Spatially relative terms, such as "inner," "outer," "beneath," "below," "lower," "above," "upper," and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.
Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.
CLAIMS

We claim:

1. A system for performing a wellbore operation, the system comprising a flexible walled silo containing powder or fibrous material therein, wherein the powder or fibrous material is dischargeable from the flexible walled silo under gravitational force into a mixing system.

2. The system of claim 1, wherein the flexible walled silo is an extendable silo.

3. The system of claim 2, wherein the flexible walled silo is a telescopically extendable silo.

4. The system of claim 1, wherein the system comprises a plurality of flexible walled silos disposed on a transportable frame.

5. The system of claim 4, wherein the plurality of flexible walled silos are telescopically extendable silos.

6. The system of claim 4, wherein the transportable frame is a telescopically extendable frame.

7. The system of claim 4, wherein the material is discharged from one flexible walled silo at a time.

8. The system of claim 4, wherein the material is discharged from at least two silos of the plurality of flexible walled silos to blend blending a few materials together on the fly.

9. The system of claim 1, wherein the powder or fibrous material is dischargeable from the flexible walled silo into an eductor comprised in the mixing system.
10. The system of claim 1, wherein the powder or fibrous material is discharged from the flexible walled silo into a receiving hopper prior to introduction into mixing system.

11. The system of claim 1, wherein the flexible walled silo comprises a radiation heater.

12. The system of claim 1 further comprising a dust filter system.

13. The system of claim 1 further comprising a semi-closed air fluffing apparatus.

14. The system of claim 1, wherein the flexible walled silo further comprises one or more of valves and augers disposed on the bottom of the flexible walled silo.

15. A cement powder mixing system comprising a silo for containing cement powder material therein, and a cement mixer, wherein the powder material is dischargeable from the flexible walled silo under gravitational force into the cement mixer in an on-the-fly operation, wherein the silo is a flexible walled silo or a telescoping walled silo.

16. The cement powder mixing system of claim 15, wherein the silo is a telescopically extendable silo.

17. The cement powder mixing system of claim 15, wherein the system comprises a plurality of silos disposed on a transportable frame.

18. The cement powder mixing system of claim 17, wherein the plurality of silos are telescopically extendable silos, and wherein the transportable frame is a telescopically extendable frame.
19. The cement powder mixing system of claim 15, wherein the silo comprises a radiation heater for preventing condensation in the silo.

20. The cement powder mixing system of claim 15, further comprising a dust filter system.

21. A method for performing a wellbore operation with at least one system for bulk storage handling of powder, the method comprising:

- providing at least one flexible walled silo for containing the powder material therein;

- providing a mixing system;

- discharging the powder material from the flexible walled silo under gravitational force into a mixing system in an on-the-fly manner;

- mixing the powder material with a liquid medium to form a slurry; and,

- pumping the slurry into a wellbore at sufficient pressure to perform the wellbore operation.

22. The method of claim 21, wherein the powder is one of cement powder or other oilfield granular material, such as proppant for stimulation and material for drilling fluids.

23. The method of claim 21, wherein the at least one flexible walled silo is a plurality of flexible walled silos disposed on a transportable frame.

24. The method of claim 21, wherein the plurality of flexible walled silos are telescopically extendable silos, and wherein the transportable frame is a telescopically extendable frame.
A. CLASSIFICATION OF SUBJECT MATTER

E21B 33/13(2006.01)i, E21B 41/00(2006.01)i, B65D 88/16(2006.01)i, B65D 88/54(2006.01)i, BOIF 3/12(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B 33/13; B65D 33/14; B65D 35/56; E21B 43/25; B65B 1/04; B65G 3/00; B65D 88/66; E21B 41/00; B65D 88/16; B65D 88/54; B01F 3/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: wellbore, flexible walled, silo, mix, powder

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 2009-0010573 Al (KOSICH , MARK MICHAEL) 08 January 2009 See paragraphs [0045] ; [0072] ; and figures 1-8-9B .</td>
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<td>US 3664072 A (LIECKFELD , WERNER) 23 May 1972 See column 1 , line 70 - column 2 , line 69 ; and figures 1-4 .</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

Date of the actual completion of the international search
27 December 2016 (27.12.2016)

Date of mailing of the international search report
02 January 2017 (02.01.2017)

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### INTERNATIONAL SEARCH REPORT

**Information on patent family members**

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<td>MX 2014010638 A</td>
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<td>30/01/2014</td>
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<td>CA 2876016 Al</td>
<td>30/01/2014</td>
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<td>EP 2874916 Al</td>
<td>27/05/2015</td>
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<td>24/06/2015</td>
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<td>MX 2015001054 A</td>
<td>14/07/2015</td>
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<td>US 2014-0020892 Al</td>
<td>23/01/2014</td>
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<td>13/08/2013</td>
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<td>US 8668430 B2</td>
<td>11/03/2014</td>
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<td>WO 2014-018236 A2</td>
<td>30/01/2014</td>
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<td></td>
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