

Method and Apparatus for Handling Bulk Material

Field of the invention

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The invention relates to a method and apparatus for the handling of shipping containers and other intermodal devices. In particular, the invention relates to those containers used for transporting bulk material and the means by which the bulk material is removed from said container.

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Background

A particular type of container is used for bulk material, such as grain, aggregate coal etc. They are used broadly on ship to shore cranes, mobile cranes, harbour cranes, ship
15 cranes and container lifting trucks. Such bulk material containers include a head frame for engagement with the crane and engagement devices for engaging the container. Between the head frame and the engagement devices are axles for rotating the container so that the particulate matter can be poured from the container.

20 Whilst the head frame will normally have a power requirement, in the case of a bulk material container, in order to rotate the container a considerable amount of power is required. To operate the motor and rotate the container the power requirements is considerably higher than that of conventional head frame.

For instance, power requirements for this category of head frame may be in the range 18 to 25 kilowatts with a conventional head frame requiring 7½ to 11 kilowatts. Therefore, as the bulk material head frame is an electrohydraulic system, the motor required for such a head frame must be larger and therefore the cost increased. The corresponding
5 infrastructure for the motor such as power supply, cables, cable rails, circuit breakers etc. must also be increased in capacity and therefore further increase the overall cost. Whilst a new bulk material head frame will cost a great deal more for existing systems, the retrofitting of a new electric supply system in order to operate a bulk material head frame is also considerable.

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Summary

In a first aspect the invention provides a bulk material handling assembly comprising: a head frame having a pair of container engaging devices for engaging a container at
15 opposed ends of said head frame; said container engaging devices rotationally mounted to said head frame; wherein the assembly is arranged such that an axis of the rotation is below a centre of gravity of an engaged container.

Accordingly, by placing the centre of gravity above the centre of rotation, there is a
20 moment applied about the centre of rotation on any eccentric position of the container. By allowing the free rotation of the container in the direction of eccentric moment, the container will naturally rotate towards an inverted position to remove the bulk material on reaching the inverted position. Accordingly, the container may be emptied without the need for an electric supply.

In the second aspect the invention provides a system for the handling of a bulk material container, said system comprising: a head frame mounted to a crane and arranged to move from a first location to a second location; said head frame having a pair container engaging devices for engaging a container at opposed ends of said head frame; said
5 container engaging devices rotationally mounted to said head frame; a motor in communication with an energy storage device; wherein the system includes a control arranged to selectively direct load applied by the motor to the energy storage device or direct load applied by the energy accumulation system to rotate the container engaging devices.

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In the case of a conventional bulk material head frame, a motor may be selected based upon an energy storage system. As the excessive power requirements for the bulk material head frame are only required during the actual rotation of the container, the infrastructure cost is depended only upon relatively short period of time. For instance,
15 the time for rotating the container may be as little as 30 seconds. However, the entire container delivery and removal period may be several minutes. By selecting a motor and an energy storage system in communication with the motor, energy can be stored during the non-rotational period of the cycle and then applied during the rotation cycle.

In a third aspect the invention provides a bulk material handling assembly comprising a
20 head frame having a pair of container engaging devices for engaging a container at opposed ends of said head frame; said container engaging devices rotationally mounted to said head frame; said container engagement devices including selectively extendable beams intermediate the rotational mounting and the container engagement; wherein a

relative position of a centre of rotation and a centre of gravity of the container is selectively adjustable on extending or retracting said beams.

By selectively increasing or decreasing the relative position of the container and head
5 frame, an ideal position for the centre of gravity and centre of rotation can be achieved.
Given that factors affecting the centre of gravity such as the shape of the bulk material
pile, the type of bulk material, including density, moisture content and compaction, will
all affect the position of the centre of gravity in addition to the proportion by which the
container is filled. By adjusting the container and head frame these factors can be
10 mitigated in order to provide the most beneficial result.

In one embodiment there may be a reference or look-up table giving instructions as to
the extension of the beam corresponding to known parameters such as those listed
above, thus the beam may be extended and possibly pinned at predetermined locations
15 corresponding to the known parameters of the material within the container.

In a fourth aspect the invention provides a process for handling a bulk material
container, the process comprising the steps of: moving the container from a first
location to a second location; during the moving step, generating energy and storing in
20 an energy storage device; at the second location, rotating the container to remove the
bulk material, energy for the rotating step provided by the energy storage device.

Brief description of the drawings

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other
5 arrangements of the invention are possible and consequently, the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figures 1A and 1B show various views of a bulk material handling assembly according
10 to one embodiment of the present invention;

Figures 2A to 2G are schematic views of a bulk material handling assembly according to one embodiment of the present invention;

15 Figure 3A is an elevation view of a dock and ship showing a bulk material handling system according to one embodiment of the present invention;

Figure 3B is a schematic view an energy storage system according to a further embodiment of the present invention;
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Figures 4A to 4C are elevation views of a bulk material handling assembly according to a further embodiment of the present invention;

Figures 5A to 5D are isometric views of a twin bulk material handling assembly according to a further embodiment of the present invention;

Figures 6A to 6C are elevation views of the twin bulk material handling assembly of Figure 5A.

5 **Detailed Description**

Figures 1A and 1B show a bulk material handling assembly 5 according to one embodiment of the present invention. Here a bulk material head frame 10 has mounted thereto a pair of container engagement devices 15 which are engaged to a container 20.

10 The pair of engagement devices 15 engages to the container (not shown) intermediate 20 the two devices 15 through twist lock devices 25 in the conventional manner. The head frame 10 is connected to an overhead crane 35 through sheaves pins and a head block, through which the head frame and consequently the container can be moved to the desired location.

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The pair of container engagement devices 15 is mounted to the bulk material head frame 10 through a slow gear rotational connection, or axle, 30 which is arranged to rotate the container from a first position whereby the bulk material within the container is contained for transport to a second position whereby the container is to be emptied. The
20 container engaging devices may be block mounted to an axle between the head frame and the block, with twist locks at an opposed end of the block to which the container is engaged.

Figures 2A to 2G show one embodiment of the present invention whereby a powered motor is not required in order to empty a container within a bulk material head frame device.

5 Figure 2A shows a container 50 mounted to a pair of engagement devices a spreader 45 which are rotationally connected 60 to a bulk material head frame device 40. The bulk material head frame is arranged such that the centre of the rotation 60 of the container is below the centre of gravity 65. A marginal eccentric movement of the container will put the centre of gravity out of alignment with the centre of rotation creating a moment
10 about the centre of rotation leading to rotation of the container towards an inverted position. The head frame may include rails, placed longitudinally along one or both sides of the container and acting to support the container so as to ensure the container does not begin rotation until ready. The beams may then be removed, lowered or otherwise removed so as to allow rotation.

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. This can be seen in Figures 2B to 2D whereby as the centre of rotation 65, 70 is out of alignment with the centre of rotation the moment about the centre of rotation 60 will continue the rotation of the container. Figure 2E shows when the centre of gravity 75 is back in alignment with the centre of rotation. However, the momentum established by
20 the misalignment of the centre of gravity maintains the rotation of the container beyond this alignment until such time as all of the material within the container is empty as shown in Figure 2F. Thus, by arranging the container in a favorable position the container can be emptied of the bulk material located therein without the use of a motor and so avoiding excessive power supply issues. In order to reposition the container in

the empty condition may require a motor to complete the 360° rotation of the container. However, as the container no longer contains material the weight of a container may have reduced from a loaded weight of for instance 35 tons to an unloaded weight of perhaps 3 ½ tons. The consequential reduction in the size of the motor may be

5 substantial and may fall within the acceptable power supply limitations of the crane. Alternatively, an energy storage device may be connected to the assembly, such as to one of the container engagement devices, such that on rotation of the container, the momentum of the rotation is partially stored. Such a device may be a flywheel, with suitable gearing, or a hydraulic accumulator whereby pressure is added to the

10 accumulator on rotation. As the container finishes rotating, the energy storage system may then continue to the rotation of the, now empty, container.

Figures 3A and 3B show a different aspect of the present invention whereby a conventionally arranged bulk material head frame may be used. As discussed, under

15 normal circumstances a significantly larger motor may be required than would normally be used for a crane. In this case, the size of the motor used to rotate the container is determined by an action taking a relatively short period of time compared with the full cycle of the delivery of the container. If a full cycle from dock 135 to ship 165 and to return dock may be, for instance, 2½ minutes, the time taken to rotate the container and

20 dump into the ship 165 may be only a fifth of that time for instance 30 seconds.

In one aspect of the present invention, a much smaller motor may be used with the delivery system 140. Rather than having a large motor operating for a relatively short time, a smaller motor in the communication with an energy storage system 90 as seen in

Figure 3B may be continually operating for the full dock to ship to dock cycle. For instance, the time for which the motor is not rotating the container the motor 120 may be connected to an accumulator 95 via a hydraulic pump 115. The accumulator 95 and motor 120 may be connected to the bulk material head frame via a hydraulic line 125.

5 During the majority of the travel time the motor builds up energy through applying a load to the accumulator and so creating a source of potential energy within the accumulator. During the contractual rotation the motor may then be applied to the rotation of the container together with the potential energy stored in the accumulator and together may be sufficient to drive the rotation of the container for the 30 second
10 period and perhaps also for the full rotation to the upright position of the container. A control may be used to switch between the motor connected to the energy storage, and the energy storage applied to the rotation.

Alternative energy storage systems may be used including driving a fly wheel
15 connectable to the bulk material head frame by a clutch system whereby the fly wheel is gradually accelerated by the smaller motor and then on engagement of the clutch, the fly wheel applies a load to the container in order to apply a rotational load.

Other energy accumulators may be applied including electrical energy accumulators.
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As demonstrated by the energy efficient system as shown in Figures 2A to 2G the differential in position between the centre of rotation and the centre of gravity may be used in order to apply a moment to the container without the use of large capacity motors. It will be appreciated that even if the centre of gravity cannot be placed above

the centre of rotation shifting the centre of gravity proximate to the centre of rotation will reduce the required capacity of the motor for rotation if an energy efficient system is unavailable.

- 5 Factors to be taken into account therefore would be the amount of bulk material within the container which may vary from full to a small percentage. The corresponding shift in centre of gravity will therefore be significant. Further being a bulk material it may shift during transport and may be eccentrically positive in its own right and therefore shift the centre of gravity out of alignment from the desired position.

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Further still, the bulk material head frame according to the present invention may be applicable to arrange a different bulk material having significantly different density, moisture content, compaction and other factors which will affect the weight and consequently the affect centre of gravity in combination with the container itself.

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Figures 4A to 4C show a further aspect of the present invention in that the bulk material head frame includes actuators to adjust the differentiate position of the centre of rotation and the centre of gravity.

- 20 Figure 4A shows a bulk material head frame 170 with a rotational assembly 175. The rotational assembly 175 includes a motor 180 connected to a pair of container engagement devices 185 arranged to rotate the pair of container engagement devices 185 about the centre of rotation. The pair of container engagement devices 185 further includes a selectively adjustable beam 190, 200 which may be an actuator or an

extendable beam mounted to an actuator. On engagement with a container (not shown) the beam 200 can be extended 195 which will move the centre of gravity of the container relative to the centre of rotation. In this embodiment the adjustment is depended upon two predetermined positions 192, 196 whereby on extension 195 the
5 beam 190 moves from a pin location 192 to a second pin location 196.

It will be appreciated that there may be several pin locations. The location of each pin may correspond to a known proportion of bulk material within a container. For instance if the container is 25 percent or less this may correspond to a first pin position and if
10 approaching 100 percent full may be applicable to a second pin position. Intermediate pin positions may be used also for a fine adjustment based upon the proportion of bulk material in the container. It will be further appreciated that said pin positions may also correspond to a type of bulk material with one pin corresponding to a dense material such as aggregate compared to a second pin location appropriate for grain being a lesser
15 density material. The position of the pins, particularly the height, may also correspond to containers of different heights to be handled by the head frame.

In a further embodiment of the arrangement shown in Figures 4A to 4C instead of a pin location the bulk material head frame may include sensors such as an accelerometer,
20 limit switches, inclinometers which may detect the location of the centre of gravity either in absolute terms or relative to a predetermined condition based upon a measured eccentricity or weight of a container. For instance a preset procedure of small rotation of the container may generate a load characteristic of the container which may provide a detailed assessment of the location of the centre of gravity irrespective of the proportion

of bulk material within the container, the density of the material or even the presence of an eccentrically loaded bulk material.

With this information as to the location and nature of the centre of gravity a feedback
5 loop to a control system (not shown) may automatically extend or retract the beam according to a desired relative position of the centre of rotation and centre of gravity.

In a further embodiment, for the first portion of rotation of the container the moment applied by the differential position of the centre of gravity and centre of rotation may
10 cause the container to rotate without the need of an external load. In fact this self-rotation allows the use of an energy storage system such as a fly wheel or perhaps an energy storage system similar to that shown in Figure 3B whereby energy is accumulated as the container self-rotates. On reaching an equilibrium point whereby the self-rotation is no longer capable of returning the container to an upright position,
15 the energy storage during the first portion of the rotation may be applied to the empty container to complete before rotation. Thus, the weight differential of the full container for the first portion of the rotation may be collected in order to complete the rotation of the considerably lighter empty container. Thus, a combination of an energy efficiency system and an energy recovery system may permit the omission of a motor for the
20 rotation of the container completely.

Figures 5A to 5D and Figures 6A to 6C show a bulk material handling assembly, in this case having two bays to engage two containers. For convenience, this will be referred to as a twin bulk material handling assembly 205 according to a further embodiment of the

present invention. The assembly 205 includes a head frame 210 engaged with container engaging devices 235, 240, 245, 250 arranged to engage two containers in separate bays 215, 220. The containers are arranged longitudinally and separated by block 230 which permits rotation of each of the containers separately as shown in Figures 5B to 5D.

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The twin bulk material handling assembly 205 is capable of engaging either one or two containers at the same time. Figure 6A shows the two bays 215, 220 empty with Figure 6D showing the first bay 215 engaged with a container 265 and Figure 6C showing both bays 215, 220 engaged with containers 265, 270.

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It will be appreciated that the twin bulk material handling assembly according to Figures 5 and 6 may be used with the energy recovery system as described with reference to Figures 3A and 3B.

15 Further, the container engaging devices as shown in Figures 4B and 4C may replace the container engagement devices 235, 240, 245, 250 shown in Figure 5A. Thus, the ability to shift the centre of gravity of the container by extending or retracting the beams may also be achieved. It will further be appreciated that by using the container engagement devices of Figures 4B and 4C the twin bulk material handling assembly may also be
20 able to shift the centre of gravity of one container whilst leaving the other static. That is, the extendable beams of the container engagement devices of Figures 4B and 4C may allow for differential lifting and lowering of the containers within the twin bulk material handling assembly of Figure 5A. This will be particularly advantageous in

situations where the two engaged containers are of different sizes or carrying different material and therefore have substantially different locations for the centre of gravity.

Claims

1. A bulk material handling assembly comprising
 - 5 a head frame having a pair of container engaging devices for engaging a container at opposed ends of said head frame;
said container engaging devices rotationally mounted to said head frame and having a motor arranged to rotate said container;
wherein the assembly is arranged such that an axis of the rotation is below a
10 centre of gravity of an engaged container and a size of said motor being less than that required to rotate a loaded container; and
wherein the bulk material handling assembly further includes an energy storage system in communication with the rotational mounting and arranged such that on rotation of the container, momentum derived from rotation of the container is
15 stored by the energy storage system.
2. The assembly according to claim 1, wherein the energy storage system includes a flywheel connected to at least one of the container engaging devices, and arranged such that on rotation of the container, the flywheel is also rotated.
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3. The assembly according to claim 2, wherein the connection between the flywheel and container engaging device includes a gear arrangement.

4. The assembly according to any one of claims 1 to 3, further including selectively movable rails mounted parallel to the container, said rails arranged to support the container from rotation, and movable so as to permit rotation.
5. The assembly according to any one of claims 1 to 4, further including a second pair of container engaging devices rotationally mounted to said head frame for engaging a second container.