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Method of Shock-Reduced Pneumatic Plug Conveyance of Bulk Materials and Device for Implementing the Method

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a method of slowly conveying bulk, particularly plug-like, material pneumatically in accordance with the preamble of claim 1 as well as to a device for implementing the method in accordance with the preamble of claim 9.

2. Description of the Prior Art

Methods of piping high bulk concentrations by thrust are known in which the bulk material is conveyed in the form of a closed rod thereof or in the form of discrete plugs (plug conveyance). Whilst good results have been achieved for plug or slow conveyance in small to medium pipe diameters and short to medium lengths thereof, considerable problems may be encountered where longish conveyance distances and/or large pipe diameters are involved, depending on the properties of the bulk material concerned.

The reason for this is the near instant expansion of the compressed volume of gas between the plug just about to leave the pipe and the plug following it. This dynamic expansion process produces strong acceleration and an increase in the velocity of the plug following, due to the absence of any counter-pressure at the front end thereof. As a result of this, transient blockages materialize at the diverting positions in the conveying line and at temporary pile-ups (strands) in horizontal pipe sections which are transmitted as jolts to the piping system, the function modules thereof as well as to the bearing and supporting structure of the system. The dynamic stress in these modules, bearings and supporting structures may lead at critical positions to joints or components of the piping

system becoming loose and possible to malfunctioning due to fatigue fracture. The inner dynamic action triggered by the dynamic expansion results in turn in haphazard deposits, sporadic fluctuating conveyance and thus in the shock forces being aggravated. These acceleration and deceleration actions in the piping system produce excessive mass forces and elevated friction forces due to added compression of the bulk material in the plug and thus result in additional energy losses as compared to a smoother means of conveyance. For the above reasons higher attrition and thread percentages materialize than is the case with a smoother, shock-reduced plug or slow means of conveyance.

From DE 40 39 496 A1 a method is known of continuously conveying bulk material, in which the bulk material is charged from a catchment vessel via a rotary vane feeder and transported by means of a conveying medium into a conveying pipe, the conveying medium being introduced into the conveying pipe via a pneumatic pipe. With the aid of a regulating means the ratio of bulk throughput and conveying medium is maintained constant in the conveying pipe, the intention being to maintain conveyance constant despite the leakage air flow escaping via the rotary vane feeder. In a variant specially devised for plug conveyance the conveying medium is supplied intermittently and the conveying pipe features a syphon-type bend following the feed point, because this assists forming the plug.

Despite this "pulsing" at the start of the conveying pipe an unwanted dynamic expansion of the end of the pipe materializes with this method and the means thereof, too. This method prevents the dynamic expansion actions only at the end of a short conveying pipe length. When longer piping is involved specific dynamic relationships of plug length, plug spacing and pile-ups automatically materialize as a function of the piping diameters, the properties of

the bulk material involved and the conveying distance, i.e. practically independently of the conditions existing at the start of the piping.

SUMMARY OF THE INVENTION

It is thus an object of the invention to reduce the high-energy and abrupt, dynamic expansion of the volume of the conveying medium between the plug being discharged and the one following it and to reduce the resulting aforementioned effects.

This object is achieved by the features of claim 1 relating to the method concerned and the by the features of claim 9 relating to the device concerned.

Advantageous embodiments are evident from the sub-claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained with reference to FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 plugs of bulk material 1 are conveyed pneumatically by means of a compressible conveying medium 2 spaced away from each other through an e.g. 200 m long conveying pipe until they attain the horizontal end portion 12a thereof. Here, the bulk plugs 1 are introduced with next to no shock via a bend 3 or a diverting flared piece into a preferably right cylindrical expansion piece of the pipe 4, because they lose their consistency due to lack of packing force in the downwards movement at the strands 1a and the lack of friction at the wall of the pipe. The bulk material collects in a junction piece 5 and/or in a diverter piece 6 which is preferably formed as a bend of small radius. By means of a correspondingly dimensioned reduction in the cross-section and/or a gate 7 and/or a degassing valve 8 or similar means a backup level pulsating between the levels H1 and H2 is achievable by setting the

aforementioned control members preferably once-only. The minimum level H1 prevents shock expansion upstream through the pipe, and the maximum level H2 prevents an excessive increase in pressure and thus a blockage. Instead of a once-only setting operation may be achieved with a variable setting depending on the backup level and/or the pressure increase due to open or closed loop control of the gate 7 and/or the degassing valve 8. The diverter piece 6 is followed by a vertical pipe section 12b to cause smaller plugs 1' having a lesser spacing from each other to materialize downstream of the diverter piece 6.

Depending on the properties of the bulk material and the pipe dimensions it is possible, if required, to dispense with generating and maintaining a continuous buffer level of the bulk material within the limits H1 and H2 or with providing the gate 7 and/or the degassing valve 8, since after being diverted into the vertical, smaller plugs 1' having a lesser spacing from each other materialize so that both the differences in pressure with respect to the external pressure and the volume 2' of the compressed conveying medium between plugs in sequence are reduced. Since this also results in the complete amount 2' of the compressed conveying medium between plugs in sequence as well as its absolute pressure being reduced, much less energy is liberated on expansion of this compressed conveying medium 2 at the end of the pipe 10 than when the plug 1 of bulk material were to leave the end portion 12a e.g. at the bend 3. By this arrangement the decompression of the previously compact plug is "stuttered" so that the shock forces in the vertical pipe as well as the spacing between plugs and thus also the advancing decompression volume thereof, due to the extension of the dwell time of this train of partial plugs, are all reduced. As a result of this the shocks at the inlet to the converter, which have already been damped by the pipe extension 4 in any case, as well as the shocks possible still further upstream

in the straight pipe section 1a are prevented or further reduced.

The degassing valve 8 may also be used to decompress part of the volume in the intermediate space from the pipe extension 4, a reduction in the velocity of the conveying medium and thus also of the plug velocity in the pipe section following the converter then materializing, apart from the aforementioned conversion of the plug. At the same time, the reduction in the velocity of the conveying medium in this region helps in further increasing the dwell time of the partial plugs and thus in reducing the shock tendency of the decompression from the region 12b into the region 12a. Another possibility of reducing the flow velocity of the conveying medium consists of increasing the diameter of the vertical pipe section 12b. On exit of the size-reduced plug 1' of bulk material in the receiving vessel 11 an also size-reduced volume 2' of compressed conveying medium, extending from the moment of plug exit to the following plug 1', is able to expand.

Optionally the connecting port 8a of the degassing port 8 may also be connected to the vertical pipe by a bypass pipe 8b.

In the drawing the pipe flare 4 is depicted as a cylindrical pot having a center line inclined roughly 45° to the perpendicular. Instead of this a vessel may also be used having a vertical center line and a funnel-type bottom.

Furthermore, instead of the gate 7 some other means of throttling, e.g. a butterfly valve may be employed which e.g. is arranged to immediately follow the aforementioned vessel and which changes the opening of the throttling gap by open or closed loop control so that the filling level in the vessel is maintained between a minimum and a maximum level.

What is claimed is:



1. A method of conveying bulk material with the aid of a compressible conveying medium and in the form of discrete plugs (1) of the bulk material in a pipe, a specific amount (2) of compressed conveying medium existing in each case between said plugs (1) which takes up a specific volume between a sequence of plugs, characterized in that the amount (2') of compressed conveying medium existing in each case between plugs (1') in sequence in the downstream end portion (12b) of the pipe as compared to the amount (2) of compressed conveying medium (2) existing between plugs (1) in sequence in the region (12a) of the pipe (12) upstream of the end portion (12b) is reduced, resulting in the energy liberated on expansion of the compressed conveying medium at the exit (10) from the pipe being reduced.
2. The method as set forth in claim 1, characterized in that to reduce the amount (2') of compressed conveying medium between plugs (1') in sequence in said end portion (12b) of said pipe said plugs (1) are converted into plugs (1') of less length and less spacing between plugs.
- ✓ 3. The method as set forth in claim 2, characterized in that for converting said plugs (1) into said plugs (1') of less length and less spacing between plugs the plugs (1) are conveyed through a syphon-type pipe section (6).
- ✓ 4. The method as set forth in claim 3, characterized in that said plugs (1) are conveyed upstream of said syphon-type pipe section (6) through a pipe section (4) having a flared cross-sectional area and a renewing portion of said bulk material is deposited and discharged delayed in said pipe section (4).
- ✓ 5. The method as set forth in claim 4, characterized in that the level of said deposited portion of the bulk



material is held in said pipe section (4) between a minimum level (H1) and a maximum level (H2).

✓ 6. The method as set forth in claim 5, characterized in that for adjusting the filling level of the bulk material a degassing device (8) at the upstream end of said pipe section (4) and/or a gate (7) or some other means of throttling the cross-section at the downstream end of said syphon-type pipe-section (6) is/are adjusted, the discharging flow of gas being directed via a pipe (8a) into the atmosphere or in said vertical pipe (via 8b) or in a silo.

7. The method as set forth in any ^{one} of the preceding claims, characterized in that to reduce the amount (2') of compressed conveying medium between plugs (1') in sequence of reduced length and reduced spacing, conveying medium is allowed to discharge in the end portion (12b) of the pipe upstream of the outlet opening (10).

8. The method as set forth in claim 7, characterized in that the conveying medium is allowed to discharge only between two plugs (1') of reduced length and reduced spacing.

9. A device for conveying a bulk material by means of a compressible conveying medium, the material being conveyed passing through the pipe in the form of discrete plugs (1) of a given, but variable length and a given, but variable amount (2) of the compressed conveying medium being present between the plugs in each case, said amount taking up a given, but variable volume between said plugs (1) in sequence, characterized in that said device comprises a means of reducing in each case the amount (2') of compressed conveying medium between plugs (1') in sequence in the end portion (12b) of said pipe.

THIS SHEET HAS BEEN
REPLACED



10. The device as set forth in claim 9, characterized in that said means for reducing the amount (2') in each case comprises a means of converting said plugs (1) into plugs (1') of reduced length and reduced spacing in the end portion of said pipe.