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METHOD FOR REDUCING VIBRATIONS IN A CONDUIT

FIELD OF THE INVENTION

The invention relates to a method for reducing vibrations in a conduit by means of a vibration-reducing insert.

5 The invention further relates to a conduit comprising a vibration-reducing insert.

BACKGROUND OF THE INVENTION

10 Vibrations, especially large, sudden and/or irregular vibrations, in conduits through which a gas-liquid mixture flows can cause significant problems, leading to lost production, unplanned maintenance and potential environmental and safety hazards.

15 In particular, vibrations in vertical feed supply conduits in gas treating plants or in horizontal pipelines for transporting liquified natural gas (LNG) containing a gas-liquid mixture are a serious problem. These vibrations, typically arising due to an unstable flow regime in the gas-liquid mixture in the vertical feed supply conduit or in the horizontal pipeline, can
20 cause damage to line supports and fatigue in piping joints. It is therefore desirable to have a method to suppress or remove vibrations in a conduit, especially in a vertical feed supply conduit or in a horizontal conduit, especially if such a conduit is in a gas
25 treating plant or in an LNG plant or is part of a pipeline for the transportation of LNG.

Methods for suppressing or reducing vibrations in a conduit are known in the art. These methods include the use of lining materials having vibration-dampening

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characteristics or the use of external or internal means to reduce or suppress vibrations. In US 4,045,057, a vibration barrier/structural connector adapted to be interposed in a conduit to prevent transmission of vibrations along the conduit is described. The vibration barrier device described in US 4,045,057 has vibration damping bodies composed of material having vibration damping characteristics comparable to those of asbestos-filled rubber.

A disadvantage of the vibration barrier device described in US 4,045,057 is that the use of vibration-dampening materials is expensive and cumbersome. In addition, a reduction of the available space through which a fluid can flow may occur.

We have now found a relatively simple and inexpensive method to reduce vibrations in a conduit, especially in a vertical feed supply conduit, through which a gas-liquid mixture flows. The method according to the invention does not substantially reduce the available flow space.

SUMMARY OF THE INVENTION

A method for reducing vibrations in a conduit, especially a vertical feed supply conduit, through which a gas-liquid mixture flows, the conduit having a certain wetted surface area, in which method the wetted surface area of at least part of the conduit is enlarged at least 2 times, preferably at least 6 times, more preferably at least 12 times by providing the conduit over at least part of its length with an insert.

DETAILED DESCRIPTION OF THE INVENTION

Reference herein to vibrations is to vibrations which can cause damage to the conduit, and/or to the conduit supports and/or to piping joints. Especially large,

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sudden and/or irregular vibrations are intended, especially in horizontal or vertical directions.

The phrase "reducing" as used herein refers to suppressing, either partly or to a large extent, or
5 removing altogether.

Reference herein to the wetted surface area of the vertical feed supply conduit is to the surface area inside the conduit that is in contact with the gas-liquid mixture flowing through the conduit. In the absence of a
10 vibration-reducing device, the wetted surface area equals the surface area of the inner walls of the conduit and is therefore the surface area of a cylinder with the length and internal diameter of the conduit. In the method according to the invention, the wetted surface area of at
15 least part of the conduit is enlarged by providing the conduit over at least part of its length with a vibration-reducing insert. The enlargement of the wetted surface area of at least part of the conduit is at least 2 times, preferably at least 6 times, more preferably at
20 least 12 times. Reference herein to the enlargement of the wetted surface area is to the difference in wetted surface area of the conduit comprising a vibration-reducing device relative to the wetted surface area of the conduit without the insert.

25 Suitably, the method according to the invention is applied in vertical feed supply conduits wherein the flow rates of the gas-liquid mixture are up to 25 m/s, preferably between 0.2 and 7 metres per second, more preferably between 0.5 and 5 m/s, most preferably between
30 1 and 3 m/s. At the preferred flow rates, the level of vibrations in the conduit, especially in a vertical feed supply conduit, are generally higher than what is considered as an acceptable level.

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The suitable length of the vibration-reducing insert used depends inter alia on the level of vibrations, the length and internal diameter of the conduit, the flow rate of the gas-liquid mixture and on the type of insert used. Preferably, in the method according to the invention the vibration-reducing insert extends over at least one fifth of the length of the conduit, more preferably over at least one fourth of the length of the conduit. At most, the insert extends over the whole length of the conduit.

The amount of gas in the gas-liquid mixtures influences the occurrence of vibrations and the level of the vibrations in the conduit, especially in a vertical feed supply conduit. Typically, in gas-liquid mixtures wherein the gas fraction is between 0.1 and 15 wt%, the level of vibrations is beyond an acceptable level. The gas fraction is expressed as the weight percentage of gas in the gas-liquid mixture. Preferably, the method according to the invention is used in gas-liquid mixtures with gas fractions between 0.5 and 10 wt%, more preferably between 1 and 5 wt%, because the level of vibrations is higher in these mixtures.

In a preferred method, the vibration-reducing insert is positioned at the downstream end of a vertical feed supply conduit. The level of vibrations is typically higher at the downstream end at the top of the vertical feed supply conduit than at the upstream end at the bottom of the conduit. Reference herein to the term downstream is to the part of the conduit towards which the gas-liquid mixture flows. The method according to the invention can suitably be applied in a vertical feed supply conduit in a gas treating plant, the gas treating plant comprising a regenerator. In a gas treating plant,

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vibrations can occur especially in a vertical feed supply conduit, comprising a gas-liquid mixture, which debouches into an inlet of the regenerator. The method according to the invention can reduce the vibrations in this vertical feed supply conduit.

A suitable vibration-reducing insert is an elongated device which can be placed and immobilized inside the conduit and which device increases the wetted surface area of the conduit by providing additional inner wall surface area without substantially reducing the area available for flow. Preferably the free flow area is reduced by less than 15%, more preferably less than 10%, more preferably less than 5%. Reference herein to the area available for flow is to the area within the conduit through which the gas-liquid mixture can freely flow.

Vibration-reducing inserts suitable for the method according to the invention can comprise an assembly of plates or rectangular structures or square structures or honeycomb structures or an assembly of elongated open-ended tubes aligned along the same axis. In a vertical conduit, the tubes or rectangular or square structures are aligned along a vertical axis. In a horizontal conduit, the tubes or rectangular or square structures are aligned along a horizontal axis. An insert comprising an assembly of elongated open-ended tubes aligned along the vertical axis is preferred. It is believed that due to the interstitial spaces between the open-ended tubes, a lower increase in wetted perimeter is sufficient since independent channels are established. The diameter of these tubes may be the same or different. Preferably, the diameter of the tubes is the same. Another preferred insert is an insert comprising an assembly of elongated open-ended rectangular or square structures, since these

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rectangular or square structures are easier to pack. The rectangular or square structures in the assembly may all have the same width proportions or may be of different width proportions.

5 In order to enlarge the wetted surface area of at least part of the conduit at least 2 times, preferably at least 6 times, the ratio of the diameter of the conduit to the diameter of the open-ended tubes is suitably between 20:1 and 4:1, preferably between 18:1 and 8:1,
10 more preferably between 16:1 and 10:1. The length of the tubes may be the same or different. Preferably, the length of the tubes is the same. Suitably, the ratio of the length of the tubes to the length of the conduit is at least 1:5, preferably at least 1:4.

15 The method according to the invention can be applied in any conduit through which a gas-liquid mixture flows. The method is especially suitable for a conduit through which a gas-liquid system flows in gas treating plants. The method is also suitable to apply in those conduits of
20 an LNG plant through which a gas-liquid system flows. In a typical LNG plant, a system comprising natural gas is led to a pre-cooling unit prior to being liquified. The term "natural gas" is applied to gas produced from underground accumulations of widely varying composition. Apart from hydrocarbons, natural gas generally includes
25 nitrogen, carbon dioxide and sometimes a small proportion of hydrogen sulphide. The principal hydrocarbon is methane, the lightest and lowest boiling member of the paraffin series of hydrocarbons. Other constituents are
30 ethane, propane, butane, pentane, hexane, heptane, etc. Especially in the pre-cooling section of an LNG plant, gas-liquid systems can be present, since part of the natural gas will be liquified but part will be still in

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the gaseous phase. Typically, in the pre-cooling unit of an LNG plant, the system comprising natural gas is cooled to temperatures of between 10 °C to -70 °C, preferably between -30 °C to -50 °C.

5 The invention is further related to a vertical feed supply conduit comprising a vibration-reducing insert.

10 The vertical feed supply conduit according to the invention debouches into the feed inlet of a gas-liquid contact column. The gas-liquid contact column comprises a gas outlet, a liquid outlet and a feed inlet.

Preferably, the gas outlet is located at the upper end of the column, the liquid outlet is located at the bottom end of the column and the vertical feed supply conduit extends upwardly to the feed inlet.

15 Typically, vibration levels are higher at the downstream end of the vertical feed supply conduit, which is located towards the feed inlet. It is therefore preferred that the insert is placed at the downstream end in the upper part of the vertical feed supply conduit,
20 that is to say towards or close to the position where the vertical feed supply conduit debouches into the feed inlet of the gas-liquid column.

25 Typically, the internal diameter of the vertical feed supply conduit is between 2" (5.08 cm) and 50" (127 cm), or between 4" (10.16 cm) and 40" (101.6 cm), or between 5" (12.7 cm) and 35" (88.9 cm).

The length of the vertical feed supply conduit is typically between 5 and 40 m, preferably between 10 and 30 m.

30 Examples of a gas-liquid contact column include a distillation column or a regenerator tower used in a gas treating process.

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In a typical gas treating process, a gas stream comprising for instance acidic gaseous compounds or other gaseous compounds is sent to an absorber tower. In the absorber tower, the gas stream is contacted with a liquid to absorb the acidic compounds or other gaseous compounds. The liquid can be an aqueous amine solution, optionally comprising a physical solvent. The physical solvent is preferably sulfolane.

The absorber preferably comprises internals such as trays or a packing, e.g. a random or structured packing. The pressure in the absorber tower is relatively high with typical operating pressures of between 20 and 120 bara, preferably between 40 and 80 bara. The temperature in the absorber tower is relatively low, typically between 30 and 90 °C, preferably between 40 and 80 °C. The absorber tower has a gas outlet at the top through which cleaned gas, i.e. the gas from which the acidic or other gaseous compounds have been absorbed, leaves the tower.

The gas-liquid mixture in the absorber tower comprising the absorbed gaseous acidic compounds or other gaseous compounds is referred to as fat solvent. This fat solvent is removed from the absorber tower at the lower end of the absorber tower. Typically, the fat solvent is sent to a flash vessel. The flash vessel has a lower operating pressure than the absorber tower, typically between 2.5 and 15 bara, preferably between 4 to 10 bara.

The fat solvent leaving the flash vessel is then led through a substantially horizontal conduit, via a heat exchanger to an absorber level control valve. From this valve, a horizontal conduit comprising the fat solvent is connected to a vertical feed supply conduit.

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The vertical feed supply conduit debouches into the feed inlet of a regenerator tower. In the regenerator tower, the acidic and other gaseous compounds from the fat solvent are removed and the solvent is regenerated.

5 The regenerator tower has a gas outlet, a liquid outlet and a feed inlet. The gas outlet is located at the top of the regenerator tower and vents off the gas. The liquid outlet is located at the bottom of the regenerator tower. From the liquid outlet, regenerated solvent is led via a
10 conduit to the absorber tower. The regenerator tower preferably comprises internals such as trays or a packing, e.g. a random or structured packing. The pressure in the regenerator tower is relatively low with typical operating pressures of between 2 and 4 bara. The
15 temperature in the regenerator tower is relatively high, typically between 100 and 140 °C.

In the vertical feed supply conduit, an unstable flow regime with formation of gas locks from the fat solvent can occur. The valve reduces, but does not fully prevent,
20 the formation of these gas locks.

Typically, the flow rates of the fat solvent in the vertical feed supply conduit are kept below 25 m/s, suitably between 0.2 and 7 metres per second, preferably between 0.5 and 5 m/s, more preferably between 1 and 3
25 m/s.

Due to the unstable flow regime, the vertical feed supply conduit vibrates. The extent of vibration of the vertical feed supply conduit is such, that damage to conduit supports and fatigue in piping joints can occur.

30 Typically, the vibrations occur in fat solvents with a gas content of up to 10 % gas, suitably between about 1 and 9% gas, preferably between 2 and 8% gas, calculated as weight of the gas relative to the weight of the fat

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solvent. In fat solvents with a gas content of between 1% and 5%, preferably between 1.5 and 2.5%, the vibrations are usually more severe.

5 A possible solution to the problem of vibration of a vertical conduit, especially a vertical feed supply conduit, would be to have the absorber level control valve at the upper end of the vertical conduit, especially in the case of a vertical feed supply conduit. A disadvantage of this solution is that putting the valve
10 up at higher elevations is cumbersome with respect to maintenance and with respect to construction and support, especially in view of the length of the vertical feed supply conduit and the weight of the valve. Typically, the length of this vertical feed conduit is between 5 and
15 40 m, preferably between 10 and 30 m.

Another possible solution to the problem of vibration of the vertical feed supply conduit would be to put a restriction orifice at the regenerator inlet. This has been tried in vertical feed supply conduit where
20 unacceptable vibrations were experienced. A serious disadvantage of this solution is that although the vibrations in the vertical feed supply conduit were reduced, a high velocity stream developed just up front of the regenerator inlet. This high velocity stream
25 caused serious damage to the inlet device. The method of using a vibration-reducing insert according to the present invention offers a solution to the vibration problem without damaging the inlet.

EXAMPLE 1 (comparative)

30 In a vertical feed supply conduit in a gas treating plant as described above with an unacceptable level of vibrations, a restriction orifice was placed at the regenerator inlet. Although the vibrations in the

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vertical feed supply conduit came down to acceptable levels, a high velocity stream developed just up front of the regenerator inlet. This high velocity stream caused serious damage to the inlet device.

5 EXAMPLE 2 (according to the invention)

10 In the vertical feed supply conduit described in example 1, a vibration reducing device was placed and immobilized. The vibration-reducing device comprised an assembly of elongated open-ended tubes. The ratio of the tubes to the ratio of the conduit was 8:1. The wetted surface area was enlarged 7.5 times. Vibrations of the conduit came down to the same acceptable levels as in the comparative example, but no damage was caused to the inlet device.

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C L A I M S

1. A method for reducing vibrations in a conduit through which a gas-liquid mixture flows, the conduit having a certain wetted surface area, in which method the wetted surface area of at least part of the conduit is enlarged
5 at least 2 times, preferably at least 6 times, more preferably at least 12 times, by providing the conduit over at least part of its length with an insert.
2. A method according to claim 1, wherein the conduit is a vertical feed supply conduit.
- 10 3. A method according to claim 1 or 2, wherein the insert extends over at least a fifth of the length of the conduit, preferably over at least one fourth of the length of the conduit.
4. A method according to any one of claims 1 to 3,
15 wherein the superficial flow velocity of the gas-liquid mixture is between 0.2 and 7 m/s, preferably between 0.5 and 5 m/s, more preferably between 1 and 3 m/s.
5. A method according to any of claims 1 to 4, wherein the gas fraction is between 0.1 and 15 wt%, preferably
20 between 0.5 and 10 wt%, more preferably between 1 and 5 wt%.
6. A method according to any of claims 1 to 5, wherein the insert is a device comprising an assembly of elongated open-ended tubes.
- 25 7. A method according to claim 6, wherein the ratio of the diameter of the conduit to the diameter of the tubes is between 20:1 and 4:1, preferably between 18:1 and 8:1, more preferably between 16:1 and 10:1.

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8. A method according to any of claims 1 to 7 wherein the vertical feed supply conduit debouches into a regenerator inlet of a gas treating plant.

9. A method according to claim 8, wherein the insert is positioned at the downstream end in the upper part of the conduit.

10. A vertical feed supply conduit, debouching into the feed inlet of a gas-liquid contact column, the gas-liquid contact column comprising a gas outlet, a liquid outlet and a feed inlet, wherein the vertical feed conduit comprises a vibration reducing insert, by which insert the wetted surface area of at least part of the conduit is enlarged at least 2 times, preferably at least 6 times, more preferably at least 12 times.

11. A vertical feed supply conduit according to claim 10, wherein the gas outlet is at the upper end of the column, the liquid outlet is at the bottom end of the column and the vertical feed supply conduit extends upwardly to the feed inlet.

12. A vertical feed supply conduit according to claim 10 or 11, wherein the vibration reducing insert is placed at the downstream end in the upper part of the vertical feed supply conduit.

13. A vertical feed supply conduit according to any of claims 10 to 12, wherein the internal diameter of the conduit is between 1" (2.54 cm) and 60" (152.4 cm), preferably between 2" (5.08 cm) and 50" (127 cm), more preferably between 4" (10.16 cm) and 40" (101.6 cm), most preferably between 5" (12.7 cm) and 35" (88.9 cm).

14. A vertical feed supply conduit according to any of claims 10 to 13, wherein the length of the conduit is between 5 and 40 m, preferably between 10 and 30 m.

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15. A vertical feed supply conduit according to any of claims 10 to 14, wherein the vibration reducing internal insert is a device comprising an assembly of elongated open-ended tubes.

5 16. A vertical feed supply conduit according to claim 15, wherein the ratio of the diameter of the conduit to the diameter of the tubes is between 20:1 and 4:1, preferably between 18:1 and 8:1, more preferably between 16:1 and 10:1.