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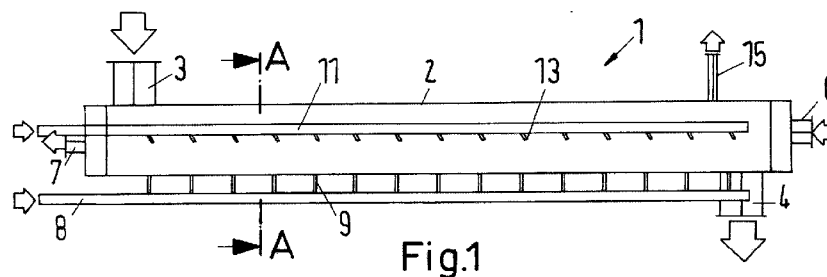
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(54) Title: GAS SLIDE HEAT EXCHANGER



(57) Abstract: A heat exchanger (1) for treating bulk material comprises an elongated pipe (2) having an inlet (3) for introducing the bulk material at one end and an outlet (4) for withdrawing the bulk material at the other end. A plurality of heat exchange tubes (5) extends along the longitudinal direction of the pipe (2), and a plurality of fluidization nozzles (9, 9a) for introducing a fluidizing gas is provided at the bottom (10) of the pipe (2).

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Gas Slide Heat Exchanger

5 The invention relates to a gas slide heat exchanger for treating bulk material comprising an elongated pipe having an inlet for introducing the bulk material at one end and an outlet for withdrawing the bulk material at the other end.

10 In plant engineering, bulk material often has to be conveyed and cooled or heated at the same time. For this purpose screw conveyors are known as described in document DE 15 51 441. Such a heat exchanger comprises a stationary elongated housing having an inlet for the material to be treated at one end and an outlet at the other end as well as one or more screw rotors provided in the housing and extending along the length thereof. The rotor comprises a central
15 shaft and a worm gear provided on the outer surface of the shaft. Within the shaft a conduit is provided which is connected to a steam supply. The bulk material is introduced through the inlet into the housing and conveyed therethrough by the rotating movement of the screw conveyor. At the same time the bulk material is heated by the steam flowing in the central conduit of the
20 shaft as well as by steam flowing in the double wall of the housing.

Another heat exchanger comprising a screw conveyor is known from document DE 534 988, wherein a heating or cooling medium flows through the hollow screw conveyor to heat or cool the bulk material transported through the hous-
25 ing. Other screw conveying heat exchangers are known from documents DE 17 51 961 or DD 288 663 A5.

The design of screw conveyors is complex and cost intensive. Further, the conveyors require a separate drive and are limited in length due to bearing and
30 torque impacts.

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It is also been known to perform the heat exchange in a fluidized bed. Document AT 507 100 B1 describes a process and apparatus for heat exchange wherein a bulk material is fluidized by introducing a fluidizing gas and wherein the bulk material is additionally agitated by a stirrer. Stirring arms are rotated between layers of heat exchange tubes provided in horizontal planes within the housing.

Document DE 10 2011 078 954 A1 describes another bulk heat exchange apparatus having a feed section, a heat exchanger section and a bulk material discharge section. The bulk material feed section is divided by a bulk partition in a conveyor flow supply chamber and a counter flow supply chamber. The bulk material partition continues to the bulk heat exchanger section. Thereby, a conveyor flow region and a counter flow region are formed of the heat exchanger section. After passing through the heat exchanging section, the heated particles are circulated within an upper chamber of the apparatus and fall back into an annular bed to be withdrawn. This system also is quite complex and requires a specific regulation of the fluidization air.

In common gas slides without heat exchanging elements as known e.g. from WO 2010/147771 A, fluidizing gas is injected via nozzles or membranes at the lower part of the gas slide. The amount of injected gas is kept in a range that the bulk material is flowing but not expanding or circulating as it is desired for example in a fluidized bed cooler.

It is the object of the present invention to provide a gas slide heat exchanger with improved heat exchange capabilities and an easy structure.

According to the invention there is provided a heat exchanger comprising the features of claim 1. A plurality of heat exchange tubes extends along the longitudinal direction of the pipe, wherein a plurality of fluidization nozzles for intro-

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ducing a fluidizing gas is provided at the bottom of the pipe. The bulk material is fluidized and slowly flows along the elongated pipe. At the same time heat is exchanged with the heat exchange medium flowing through the heat exchanging tubes. In comparison to a screw conveyor the heat exchanger elements of the gas slide heat exchanger according to the present invention can be designed with a greater surface/volume ratio. Multiple single heat exchange tubes can be integrated to a bundle with a much greater surface than the cylindrical surface of the screw shaft and the screw conveyor casing used in the prior art. Simultaneously, the heat exchange is promoted by the expanded surface of the bulk material fluidized by the fluidizing gas. This is not possible in the standard screw conveyor.

In a preferred embodiment of the invention, the fluidization nozzles are directed perpendicular to the conveying direction of the bulk material. Thereby, it is ensured that the bulk material is sufficiently fluidized when passing the nozzles. "Perpendicular" in the context of the present invention refers to an orientation of the fluidization nozzles within a range of 85 to 95°, in particular about 90°, relative to the major conveying direction of the bulk material along the pipe.

If some of the fluidization nozzles extend from the bottom of the pipe into the upper region of the pipe, it is possible to ensure the expansion and conveying of the material also in cases of bulk material that tends to generate holes rather than expand when fluidized. This happens in particular if the bulk material is very fine.

Preferably, the pipe is tilted downwards in the conveying direction of the bulk material, preferably at an angle of 5 to 10 degrees or more preferably at an angle of 6 to 8 degrees. In such a pipe, the fluidized bulk material automatically flows down the pipe towards the outlet.

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In order to increase the heat exchange within the heat exchanger, the pipe preferably comprises a double wall for receiving a heat exchange medium. Accordingly, heat is exchanged not only between the longitudinal heat exchange tubes within the fluidized material but also from the outer wall.

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In a further embodiment, the pipe wall may be formed from a plurality of smaller pipes for receiving a heat exchange medium. Thereby, the heat exchange surface is increased. In addition or alternatively, a plurality of smaller pipes may be provided within the pipe for receiving the heat exchange medium.

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In order to promote the transport of the bulk material through the pipe, it is within the scope of the present invention to provide transport nozzles which enter into the pipe at a location distanced from the bottom of the pipe to introduce additional transport gas. Preferably, the openings of the transport nozzles are located in a region extending between about 25 and 75% of the height of the pipe.

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According to an embodiment of the invention, the transport nozzles are inclined downwards at an angle of 30 to 60°, preferably 40 to 50° and in particular about 45°.

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In addition, the invention provides that the transport nozzles are inclined in the conveying direction of the bulk material in order to promote the conveyance of the material. Usually, the transport nozzles are inclined at an angle of 30 to 60°, preferably 40 to 50° and in particular about 45°.

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According to an aspect of the present invention, the fluidization and/or transport nozzles are located in respective rows along the longitudinal direction of the pipe, wherein preferably common supply pipes are provided for supplying fluidizing gas to each row of nozzles.

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According to the invention, the flow rate of the fluidization and/or transport nozzles can be regulated, wherein preferably the fluidizing gas is injected through the transport nozzles with a low velocity in conveying direction to ensure just a proper bulk material flow.

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The other part of the fluidizing gas can instead be injected perpendicular to the conveying direction through the fluidization nozzles with a comparatively higher velocity obtaining an expansion of the bulk material and hence a great material surface and improved heat exchange.

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The heat exchange medium may be directed counter-currently or co-currently to the conveying direction of the bulk material depending on the specific needs of the process and material.

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The invention will now be described in more detail on the basis of preferred embodiments and the drawing. All features described and/or illustrated form the subject matter of the invention *per se* or in any combination, independent of their inclusion in individual claims or their back reference.

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In the drawing:

Fig. 1 is a cross section of a heat exchanger according to the present invention,

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Fig. 2 is a cross section of a first embodiment taken along line A-A in Fig.1;

Fig. 3 is a cross section of the first embodiment of the invention wherein the heat exchange tubes are not shown, while the distribution of the bulk material within the pipe cross section is shown;

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Fig.4 is a cross section similar to Fig. 3 of a second embodiment of the invention taken along line A-A in Fig. 1;

5 Fig. 5 is a cross section similar to Fig. 3 of an alternative embodiment of the present invention taken along line A-A in Fig. 1.

A gas slide heat exchanger 1 according to the present invention as shown in Fig. 1 includes a pipe 2 having an inlet 3 for introducing a bulk material at a first end, and an outlet 4 for withdrawing the bulk material at the other end of pipe 2. The pipe 2 is slightly downwards tilted at an angle of 6 to 8 degrees in the direction of the outlet 4. A plurality of heat exchange tubes 5 (Fig. 2) extends along the longitudinal direction of pipe 2. A heating medium is introduced into the heat exchange tubes 5 via a supply port 6 and withdrawn through outlet port 7 at the other end of pipe 2. The wall 2a of pipe 2 is designed as a double wall to receive additional heat exchange medium.

In the embodiment shown in Fig. 1, the heat exchanging medium, preferably water, boiler feed water or thermo oil, is directed counter-currently to the flow of the bulk material. In an alternative embodiment, the heat exchange medium can just as well be directed co-currently to the conveying direction of the bulk material in accordance with the specific requirements of the heat exchange process and the material to be treated.

25 Below the pipe 2 a supply pipe 8 for fluidizing gas is provided. From said supply pipe 8 a plurality of fluidization nozzles 9 extends in an upward direction towards pipe 2. As evident from Fig. 2, the fluidization nozzles 9 enter the pipe 2 at its bottom 10 at approximately the center of the bottom region of pipe 2.

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Further, supply pipes 11, 12 extend along the major part of the length of pipe 2 and comprise transport nozzles 13, 14 which enter into pipe 2 in a region located at 25 to 75%, in particular 30 to 40% of the height of pipe 2. As evident from Fig. 2, the transport nozzles 13, 14 are inclined downwards at an angle of approximately 45°. As evident from Fig. 1, the transport nozzles 13, 14 further are inclined in the conveying direction of the bulk material at an angle of also about 45°. The fluidization gas, in particular air, that is introduced (continuously or as a pulsed stream) into the pipe 2 through the fluidization nozzles 9 and the transport nozzles 13, 14 fluidizes the bulk material within pipe 2 and flows together with the bulk material along pipe 2 until it exits through a gas outlet 15 provided at the end of pipe 2.

The heat exchanger according to the first embodiment of the present invention as shown in Fig. 1 and 2 is basically constructed as described above. Next, its operation and advantages shall be described.

Bulk material, such as ore fines, aluminium hydrate, ash or the like, is introduced into pipe 2 through inlet 3. The bulk material is fluidized within pipe 2 by fluidization gas introduced through the fluidization nozzles 9 and the transport nozzles 13, 14 and flows along pipe 2 until it is withdrawn from pipe 2 through outlet 4. A part of the fluidizing gas is injected with a low velocity in conveying direction through the transport nozzles 13, 14, while the other part of the fluidizing gas is injected with a comparatively higher velocity through the fluidization nozzles 9 in a direction perpendicular to the conveying direction of the bulk material. Thereby, the bulk material is fluidized and expanded to obtain a great material surface and an improved heat exchange. The velocities of the fluidizing gas introduced through the transport nozzles 13, 14 and the fluidization nozzles 9, respectively, depend on the grain size and other properties of the bulk material. If the bulk material is fluidizable, the velocity of the fluidizing gas introduced through the fluidization nozzle 9 is typically smaller than 0,2 m/s (related to the

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longitudinal cross section) In case the bulk material is not fluidizable, e.g. because it is too fine or too heavy, and the transport mechanism is not based on gravity flow, the amount of fluidizing gas introduced through the transport nozzles 13, 14 is higher than the amount of fluidizing gas introduced through nozzle

5 9.

The concept of the fluidization is illustrated in Fig. 3 wherein the bulk material is primarily transported in transport zone 20 while zone 21 indicates an area with enlarged material surface due to the expansion of the bulk material. For the sake of convenience, the heat exchanging tubes 5 are not illustrated in Fig. 3 to

10 5.

In particular for bulk material that tends to generate holes upon the introduction of fluidization gas rather than to expand, Fig. 4 shows an embodiment, wherein the transport nozzles 13, 14 are arranged at a higher region of the pipe 2 so that an increased zone 21 with enlarged material surface is created. A similar effect is achieved in the embodiment shown in Fig. 5 if some of the fluidization nozzles 9a do not open at the bottom 10 of pipe 2 but extend into the upper region of the pipe 2 to create a zone 21 with enlarged material surface. The transport nozzles 13, 14 and the extended fluidization nozzles 9a may be combined in a heat

20 exchanger 1.

The flow rate of the fluidization air supplied through fluidization nozzles 9, 9a and transport nozzles 13, 14 can be regulated in order to provide for adequate fluidization and transport conditions of the bulk material within pipe 2.

25 Based on information of screw conveyor suppliers and operation experience with fluidized bed coolers, it can be assumed that the heat transport can be approximately quadrupled using a gas slide heat exchanger according to the present invention instead of the standard screw conveyor. This is possible by

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expanding the bulk material in a range that can be reasonably realized in a gas slide heat exchanger.

5 In comparison with a screw conveyor a gas slide heat exchanger according to the present invention is less complex to manufacture, provides a greater heat exchange surface at approximately same main dimensions and provides for an improved heat transfer due to an expanded bulk material surface.

10 The present invention is suitable for heating the bulk material by employing heated heat exchange media, but may also be used for cooling the bulk material with cold heat exchange media.

List of reference numbers

	1	heat exchanger
	2	pipe
5	2a	double wall
	3	inlet
	4	outlet
	5	heat exchange tube
	6	supply port
10	7	outlet port
	8	supply pipe
	9, 9a	fluidization nozzle
	10	bottom
	11, 12	supply pipe
15	13, 14	transport nozzle
	15	gas outlet
	20	transport zone
	21	zone with enlarged bulk material surface
20	22	bulk material level (without fluidization)

Claims:

1. Heat exchanger (1) for treating bulk material comprising an elongated
5 pipe (2) having an inlet (3) for introducing the bulk material at one end and an outlet (4) for withdrawing the bulk material at the other end, **characterized by** a plurality of heat exchange tubes (5) extending along the longitudinal direction of the pipe (2), wherein a plurality of fluidization nozzles (9, 9a) for introducing a fluidizing gas is provided at the bottom (10) of the pipe (2).
- 10 2. Heat exchanger according to claim 1, **characterized in** that the fluidization nozzles (9, 9a) are directed perpendicular to the conveying direction of the bulk material.
- 15 3. Heat exchanger according to claim 1 or 2, **characterized in** that at least some of the fluidization nozzles (9a) extend from the bottom (10) of the pipe (2) into the upper region of the pipe (2).
- 20 4. Heat exchanger according to any of the preceding claims, **characterized in** that the pipe (2) is tilted downwards in the conveying direction of the bulk material, preferably at an angle of 5 to 10°.
- 25 5. Heat exchanger according to any of the preceding claims, **characterized in** that the pipe (2) comprises a double wall (16) for receiving a heat exchange medium.
6. Heat exchanger according to any of the preceding claims, **characterized in** that the pipe (2) is formed by a plurality of smaller pipes for receiving a heat exchange medium.

7. Heat exchanger according to any of the preceding claims, **characterized in** that transport nozzles (13, 14) enter into the pipe (2) at a location distanced from the bottom (10) of the pipe (2), preferably by about 25 to 75% of the height of the pipe (2).

5

8. Heat exchanger according to claim 7, **characterized in** that the transport nozzles (13, 14) are inclined downwards at an angle of 30 to 60°.

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9. Heat exchanger according to claim 7 or 8, **characterized in** that the transport nozzles (13, 14) are inclined in the conveying direction of the bulk material.

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10. Heat exchanger according to any of the preceding claims, **characterized in** that the fluidization and/or transport nozzles (9, 9a, 13, 14) are located in respective rows along the longitudinal direction of the pipe (2).

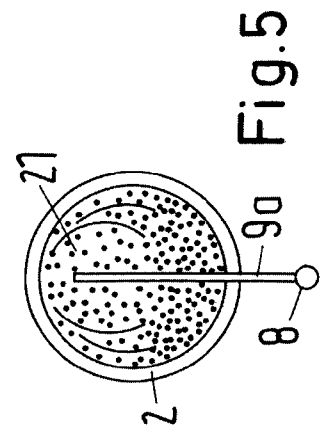
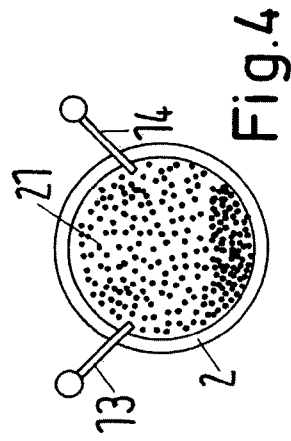
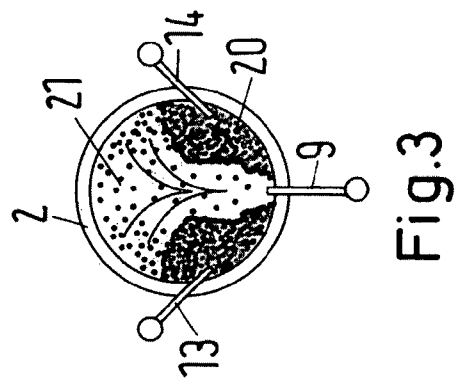
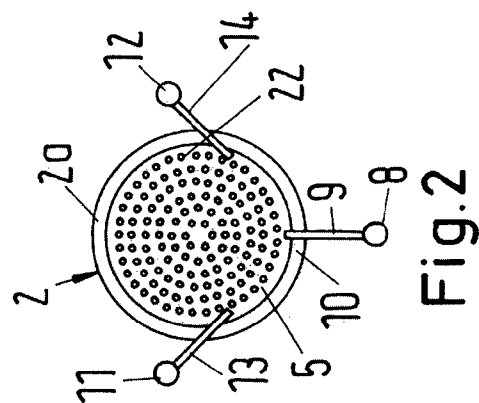
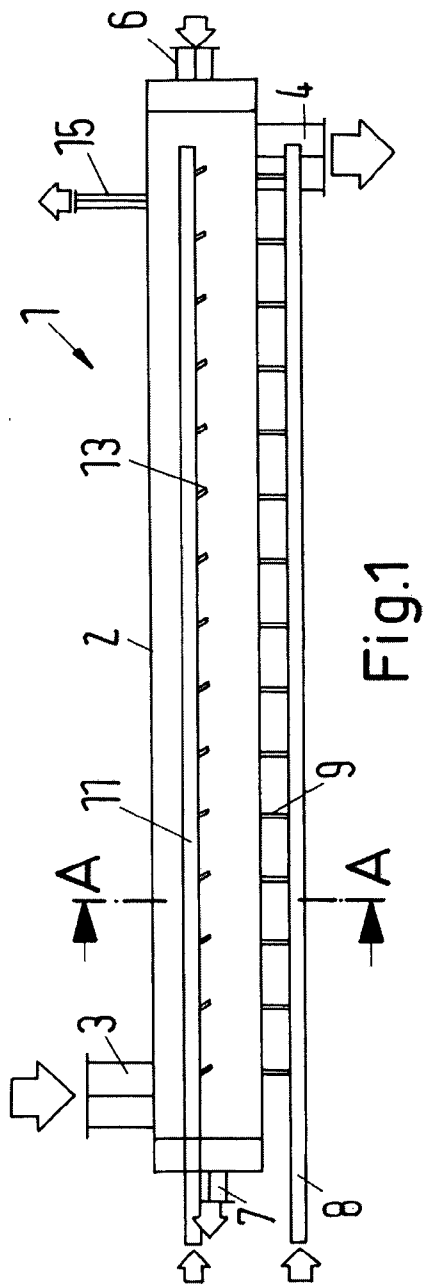
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11. Heat exchanger according to claim 10, **characterized in** that common supply pipes (11, 12) are provided for supplying fluidizing gas to each row of nozzles (9, 9a, 13, 14).

12. Heat exchanger according to any of the preceding claims, **characterized in** that the flow rate of the fluidization and/or transport nozzles (9, 9a, 13, 14) can be regulated.

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13. Heat exchanger according to any of the preceding claims, **characterized in** that a heat exchange medium is directed counter-currently or co-currently to the conveying direction of the bulk material.



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/057491

A. CLASSIFICATION OF SUBJECT MATTER

INV. F28C3/16 F28D7/16 B65G53/16
ADD. F28D7/00 F28D7/10

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)

F28C F28D B65G F26B F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

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Y	column 3, line 5 - column 4, line 23;	5
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
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