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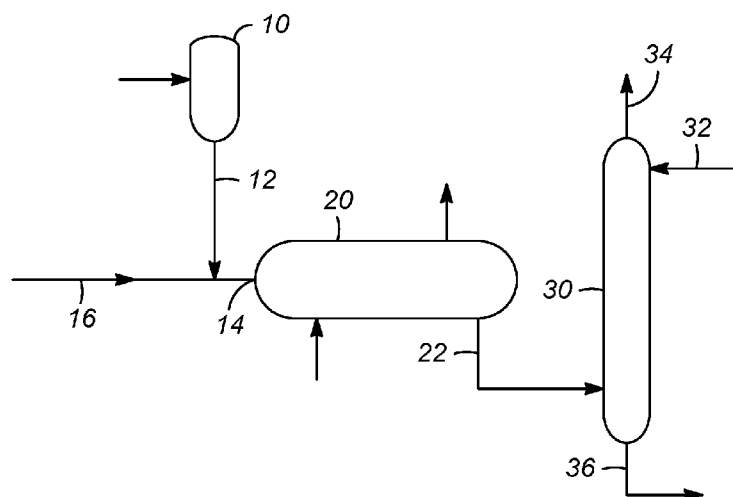


FIG. 1

(57) Abstract: A process is presented for the online cleaning of the tubes in a heat exchanger. The process includes adding an abrasive material to the gas stream to be cooled, and abrading any particles or catalyst fines that have adhered to the tube walls. The abrasive material is to be a water soluble solid to allow for the removal of the abrasive material in a quench tower.

PROCESS FOR ONLINE CLEANING OF MTO REACTOR EFFLUENT COOLER

STATEMENT OF PRIORITY

[0001] This application claims priority to U.S. Application No. 14/715898 which was filed May 19, 2015, the contents of which are hereby incorporated by reference in its entirety.

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FIELD OF THE INVENTION

[0002] The present invention relates to the cleaning of cooling units. In particular, this invention relates to the cleaning of heat exchangers wherein the surfaces can be fouled by a buildup of particulate matter.

BACKGROUND

10 **[0003]** Heat exchangers are a basic unit in the petrochemical processing industry. Heat exchangers are used in Fluid Catalytic Cracking (FCC) units and Methanol to Olefins (MTO) units for cooling flue gases to recover heat, and the flue gases often contain small particles. The small particles are often catalyst fines that pass through a system and adhere to the heat exchanger tubes. Periodically the heat exchanger tubes need to be cleaned. In order to
15 continue the use of the heat exchangers, the heat exchangers are cleaned online. In FCC and MTO units, flue gas coolers are cleaned by the injection into a flue gas stream of abrasive particles. A typical abrasive can be a hard material such as walnut shells that have been broken up to sizes in the range of 1.7 to 3.5 mm. Walnut shells are organic materials, and they burn completely before exiting the flue gas stack.

20 **[0004]** Fouling of coolers reduces the heat exchange efficiencies, and can restrict flows, which changes the contact times for the gas streams to be cooled. These loss of efficiencies can be costly and change the overall operating conditions of downstream processing units.

[0005] However, not all flue gas coolers have the same conditions, and therefore, a typical means of cleaning FCC and MTO flue gas coolers is inappropriate for cleaning other
25 types of effluent gas coolers. MTO reactor effluent coolers are not ideal for using the same materials as are used in FCC and MTO flue gas coolers. Therefore, different materials or means of cleaning MTO reactor coolers is needed.

SUMMARY

[0006] The present invention is a process for online cleaning of heat exchanger tubes.

[0007] A first embodiment of the invention is a process for cleaning effluent coolers comprising passing abrasive pellets to a blowpot; pressuring the blowpot; passing the pellets

5 in the blowpot through a transfer tube to the tube side of a heat exchanger; mixing a reactor effluent gas with the pellets; and passing the pellets through the tubes of the heat exchanger, thereby removing particle buildup in the tube side of the heat exchanger. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising generating a cooler effluent stream

10 comprising cooled effluent gas and abrasive pellets. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising passing the cooler effluent stream to a quench tower to generate a cooled and quenched effluent stream with a reduced abrasive pellet concentration. An

embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the quench tower generates a liquid quench stream that comprises cooling water and dissolved abrasive pellets. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising passing the liquid quench stream to a water recovery unit to generate a water stream and a waste water stream; and recycling the water

20 stream to the quench tower. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets comprise calcium hydroxide. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets are soluble in water. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets are sized between 1 and 4 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets are sized between 2 and 3 mm.

[0008] A second embodiment of the invention is a process for cleaning cooling tubes comprising passing a hot effluent gas to a heat exchanger; passing an abrasive material to the

30 heat exchanger, thereby generating an abrasive-effluent gas mixture; and passing the

abrasive-effluent gas mixture to a quench tower, thereby generating a quenched effluent gas, and an aqueous stream comprising the abrasive material. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive material is soluble in water. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive material comprises calcium hydroxide. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive material comprises pellets that are sized between 1 and 4 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive pellets are sized between 2 and 3 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph further comprising passing an abrasive material to a blowpot; pressuring the blowpot; and passing the abrasive material in the blowpot through a transfer tube to the tube side of a heat exchanger.

[0009] A third embodiment of the invention is a process for cleaning effluent coolers comprising passing an abrasive material to a blowpot; pressuring the blowpot; passing the abrasive material in the blowpot through a transfer tube to the tube side of a heat exchanger; passing a hot effluent gas to the heat exchanger; mixing the hot effluent gas with the abrasive material to generate a mixture; and passing the mixture through the tubes of the heat exchanger, thereby removing particle buildup in the tube side of the heat exchanger, and generating a heat exchanger effluent. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph wherein the abrasive material comprises pellets that are sized between 1 and 4 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph further comprising passing the heat exchanger effluent to a quench tower, thereby generating a quenched effluent gas, and an aqueous stream comprising the abrasive material. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph wherein the abrasive material comprises a water soluble material. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph wherein the abrasive material comprises calcium hydroxide.

[0010] Other objects, advantages and applications of the present invention will become apparent to those skilled in the art from the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWING

[0011] The Figure is a configuration for online cleaning of tubes in a tube and shell heat exchanger used in a methanol to olefins conversion process.

DETAILED DESCRIPTION

[0012] Reactor effluent coolers have a tendency to foul because small catalyst particles from the reactor are carried into the effluent coolers and adhere to the tube walls. MTO reactor effluent coolers are similar to FCC and MTO flue gas coolers, but are operated at lower temperatures, have different stream compositions, and the cooled effluent has a different process destination than FCC flue gas coolers. The use of abrasive materials used in flue gas coolers, such as walnut shells, would not be combusted or consumed and therefore would survive passing through the cooler, and enter into downstream units, such as the quench tower. The large particles of abrasive entering the quench tower can cause plugging problems in quench tower internals and in particular in nozzles and orifices.

[0013] For an MTO reactor, fresh catalyst was tried as an abrasive material, wherein the fresh catalyst was injected into the cooler, and then recovered from a quench tower bottoms stream. However, the size of fresh catalyst particles are small and were found to be ineffective due to the small particle size.

[0014] In an MTO reactor system, the reactor effluent gas passes through a heat exchanger, and is then quenched in a quench tower. The heat exchanger is a shell and tube heat exchanger with the reactor effluent gas passing through the tube side of the exchanger. The quench tower has a large water circulation loop, and a water soluble solid could be an effective abrasive material for the reactor effluent heat exchanger. A particular water soluble solid is calcium hydroxide, or lime, and is a material that is readily available and inexpensive. Another possible material is potassium hydroxide, and various other salts can also serve as an abrasive material. However, selection should limit those salts without corrosive properties for downstream equipment and salts that are not poisons to the MTO catalyst.

[0015] The present invention is a process for online cleaning of a reactor effluent cooler in an MTO process. The process includes passing abrasive pellets to a blowpot. A blowpot is a system for transferring a dense phase material, often a solid, into a flowing system. The blowpot is pressurized, and then the abrasive pellets are passed through a transfer tube from the blowpot to upstream side of a heat exchanger. In particular, a tube and shell heat exchanger, wherein the abrasive pellets are transferred upstream of the tube side of the heat exchanger and pass through the tubes. The reactor effluent gas mixes with the abrasive pellets, and the mixtures comprising the pellets is passed through the tubes of the heat exchanger. This generates a cooled effluent stream comprising the cooled effluent gas, small particles removed from the cooler and abrasive pellets.

[0016] The cooled effluent stream is passed to a quench tower where the effluent stream is contacted with a circulating water stream. The water further cools the effluent and removes solids and water soluble materials in the effluent stream. The water removes the solid pellets and generates an effluent stream with the abrasive pellets removed. The abrasive pellets are made of a water soluble solid, or salt, and are dissolved in the quench stream to generate a liquid quench stream comprising water and the dissolved abrasive pellets.

[0017] The process can further include passing the liquid quench stream to a water recovery unit to generate a water stream and a waste water stream, and recycling the water stream to the quench tower. The abrasive pellets are comprised of a water soluble solid, such as salt. A preferred material for the abrasive pellets is calcium hydroxide. The pellets need to be large enough to perform the abrasion on the tube walls, but not too large so as to plug the tubes. A preferred pellet size range is from 1 to 4 mm along the longest dimension, with a more preferred range from 2 to 3 mm.

[0018] The process as can be seen in the Figure, includes charging a blowpot with an abrasive material. The blowpot is pressurized, and the abrasive material is passed through a transfer tube to the inlet of the tube side of a heat exchanger. A hot effluent gas from a reactor is passed to the heat exchanger. The blowpot is pressurized to a pressure above the pressure of the hot effluent gas leaving the reactor. In the inlet to the heat exchanger the hot effluent gas and the abrasive material generates a mixture to be passed through the heat exchanger. An exchanger effluent stream, comprising the cooled gas, abrasive material and particles abraded from the heat exchanger tubes is passed to a quench tower.

[0019] A water stream 32 entering the quench tower 30 contacts the exchanger effluent stream 22 to generate a quenched effluent gas stream 34 with the solid particles and abrasive material removed. The quench tower 30 also generates an aqueous stream 36 comprising the abrasive material and the solid particles that were abraded from the heat exchanger tubes.

5 **[0020]** The aqueous stream 36 can be processed to recover water for reuse. A concentrated waste stream can be treated to either recover or dispose of catalyst fines, and to recover or dispose of the dissolved abrasive material.

[0021] While the invention has been described with what are presently considered the preferred embodiments, it is to be understood that the invention is not limited to the disclosed
10 embodiments, but it is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

SPECIFIC EMBODIMENTS

While the following is described in conjunction with specific embodiments, it will be
15 understood that this description is intended to illustrate and not limit the scope of the preceding description and the appended claims.

A first embodiment of the invention is a process for cleaning effluent coolers comprising passing abrasive pellets to a blowpot; pressuring the blowpot; passing the pellets in the blowpot through a transfer tube to the tube side of a heat exchanger; mixing a reactor
20 effluent gas with the pellets; and passing the pellets through the tubes of the heat exchanger, thereby removing particle buildup in the tube side of the heat exchanger. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising generating a cooler effluent stream comprising cooled effluent gas and abrasive pellets. An embodiment of the invention is one,
25 any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising passing the cooler effluent stream to a quench tower to generate a cooled and quenched effluent stream with a reduced abrasive pellet concentration. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the quench tower generates a liquid
30 quench stream that comprises cooling water and dissolved abrasive pellets. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph further comprising passing the liquid quench stream to a water

recovery unit to generate a water stream and a waste water stream; and recycling the water stream to the quench tower. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets comprise calcium hydroxide. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets are soluble in water. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets are sized between 1 and 4 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph wherein the abrasive pellets are sized between 2 and 3 mm.

A second embodiment of the invention is a process for cleaning cooling tubes comprising passing a hot effluent gas to a heat exchanger; passing an abrasive material to the heat exchanger, thereby generating an abrasive-effluent gas mixture; and passing the abrasive-effluent gas mixture to a quench tower, thereby generating a quenched effluent gas, and an aqueous stream comprising the abrasive material. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive material is soluble in water. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive material comprises calcium hydroxide.

An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive material comprises pellets that are sized between 1 and 4 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph wherein the abrasive pellets are sized between 2 and 3 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph further comprising passing an abrasive material to a blowpot; pressuring the blowpot; and passing the abrasive material in the blowpot through a transfer tube to the tube side of a heat exchanger.

A third embodiment of the invention is a process for cleaning effluent coolers comprising passing an abrasive material to a blowpot; pressuring the blowpot; passing the abrasive material in the blowpot through a transfer tube to the tube side of a heat exchanger; passing a hot effluent gas to the heat exchanger; mixing the hot effluent gas with the abrasive

material to generate a mixture; and passing the mixture through the tubes of the heat exchanger, thereby removing particle buildup in the tube side of the heat exchanger, and generating a heat exchanger effluent. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph

5 wherein the abrasive material comprises pellets that are sized between 1 and 4 mm. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph further comprising passing the heat exchanger effluent to a quench tower, thereby generating a quenched effluent gas, and an aqueous stream comprising the abrasive material. An embodiment of the invention is one,

10 any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph wherein the abrasive material comprises a water soluble material. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the third embodiment in this paragraph wherein the abrasive material comprises calcium hydroxide.

Without further elaboration, it is believed that using the preceding description that

15 one skilled in the art can utilize the present invention to its fullest extent and easily ascertain the essential characteristics of this invention, without departing from the spirit and scope thereof, to make various changes and modifications of the invention and to adapt it to various usages and conditions. The preceding preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limiting the remainder of the disclosure in any way

20 whatsoever, and that it is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

In the foregoing, all temperatures are set forth in degrees Celsius and, all parts and percentages are by weight, unless otherwise indicated.

CLAIMS

What is claimed is:

1. A process for cleaning effluent coolers comprising:
passing abrasive pellets to a blowpot;
5 pressuring the blowpot;
passing the pellets in the blowpot through a transfer tube to the tube side of a heat
exchanger;
mixing a reactor effluent gas with the pellets; and
passing the pellets through the tubes of the heat exchanger, thereby removing particle
10 buildup in the tube side of the heat exchanger.
2. The process of claim 1 further comprising generating a cooler effluent stream
comprising cooled effluent gas and abrasive pellets.
- 15 3. The process of claim 2 further comprising passing the cooler effluent stream to a
quench tower to generate a cooled and quenched effluent stream with a reduced abrasive
pellet concentration.
4. The process of claim 3 wherein the quench tower generates a liquid quench stream
20 that comprises cooling water and dissolved abrasive pellets.
5. The process of claim 4 further comprising:
passing the liquid quench stream to a water recovery unit to generate a water stream
and a waste water stream; and
25 recycling the water stream to the quench tower.
6. The process of claim 1 wherein the abrasive pellets comprise calcium hydroxide.
7. The process of claim 1 wherein the abrasive pellets are soluble in water.
30
8. The process of claim 1 wherein the abrasive pellets are sized between 1 and 4 mm.

9. The process of claim 8 wherein the abrasive pellets are sized between 2 and 3 mm.

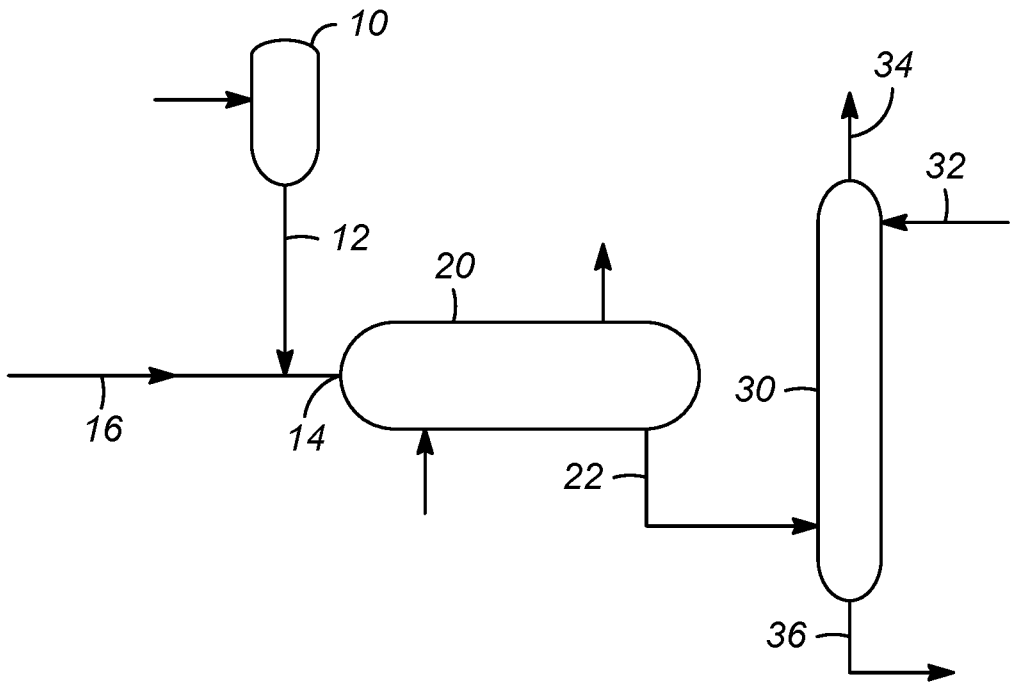


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2016/030555

A. CLASSIFICATION OF SUBJECT MATTER

F28G 9/00 (2006.01)
B08B 9/057 (2006.01)
F28F 19/00 (2006.01)

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)

F28F 19/00, F28G 9/00, B08B 9/00, 9/02, 9/027, 9/032, 9/04, 9/053, 9/057

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SU 588025 A1 (MAKAROV A.P. et al.) 15.01.1978	1-9
A	WO 2006/010771 A1 (TWISTER B.V. et al.) 02.02.2006	1-9
A	US 4615382 A (ESMIL B.V.) 07.10.1986	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

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22 July 2016 (22.07.2016)

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