Dec. 17, 1968 R. K. DORN 3,416,598

INLET DEVICE AND METHOD FOR PREVENTING COKE BUILD-UP

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Fig. 2.

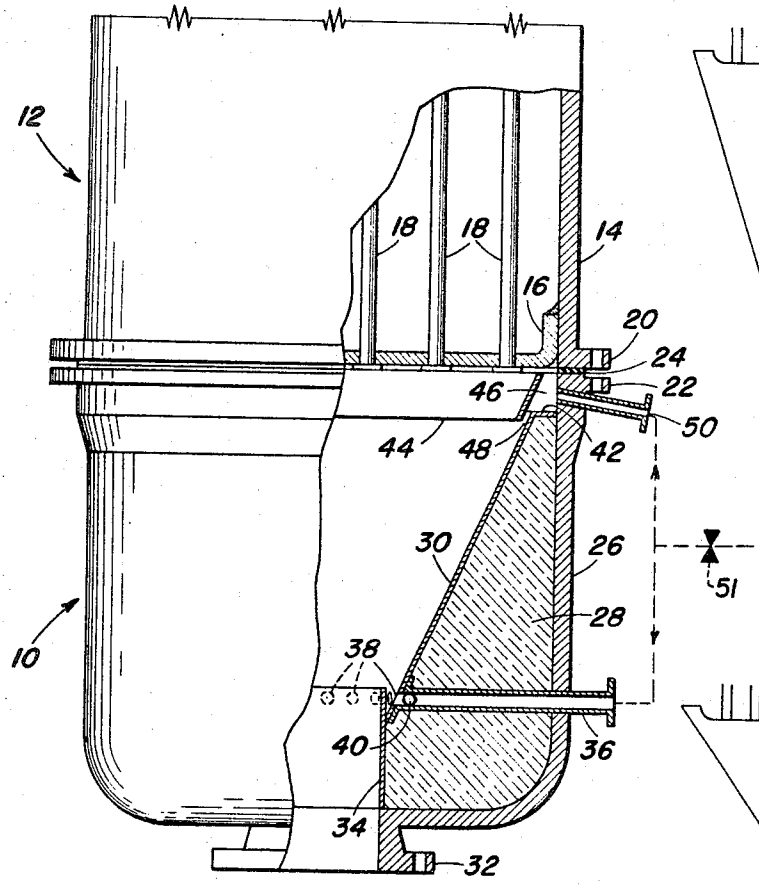


Fig. 1a.

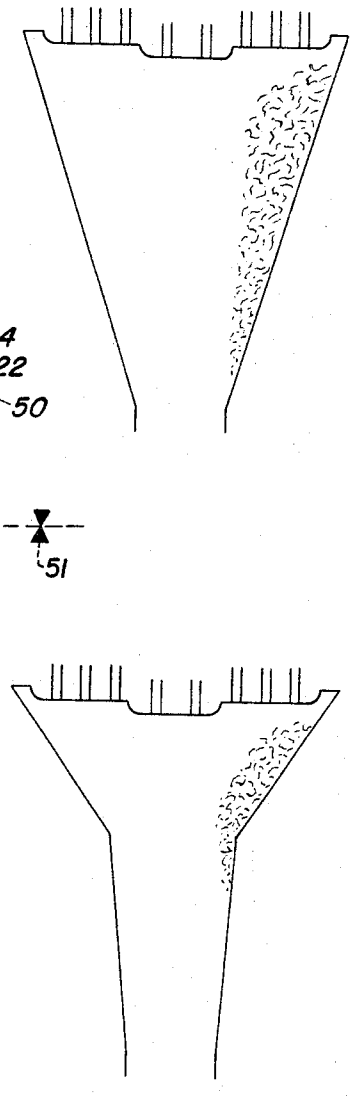


Fig. 1b.

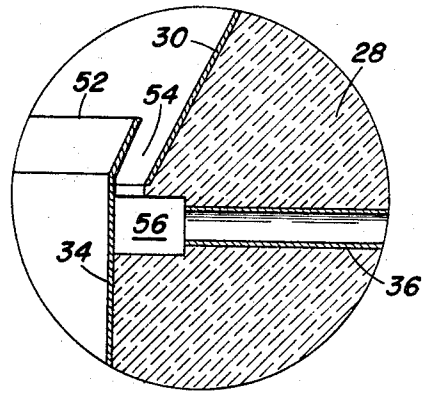


Fig. 2a.

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INLET DEVICE AND METHOD FOR PREVENTING COKE BUILD-UP

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ABSTRACT OF THE DISCLOSURE

This invention relates to a novel inlet device for connecting the output of a gas cracking heater with the inlet of a transfer line heat exchanger, whereby coke buildup in the inlet cone is prevented. The inlet device provides for the injection of steam into the circumference thereof concurrently and/or countercurrently with the cracked gas. The steam injection is controlled so as to fill completely the area of the cone where eddying and back flow occur, thus preventing the cracked gas from entering this area.

This invention relates to a novel inlet device for connecting the output of a cracking heater with the inlet of a transfer line heat exchanger.

In the production of olefins from normally gaseous hydrocarbons by thermal cracking or in the steam reforming of naphtha and the like, it is necessary that the reaction products be cooled very quickly from the cracking temperature to a temperature below the point where secondary reactions can proceed. Such secondary reactions decrease yield and cause coke formations which decrease the length of time a heater can be kept in service. In conventional practice, the heater effluent is passed in a conduit to an insulated inlet cone which is in direct communication with the tube side of a transfer line exchanger (also referred to as a cracked gas cooler or quench cooler), the cone shape being necessary because of the substantially larger diameter of the exchanger. The insulation, which may be internal or external, is provided in an attempt to keep the gas as hot as possible until it actually reaches the exchanger. It is also possible to cool the effluent directly by injection of a suitable cooling medium but while this effects the desired cooling very rapidly, it results in a significant loss of recovered high pressure steam. As a result, indirect cooling in a transfer line exchanger is generally preferred.

Operating experience has demonstrated that for certain feedstocks, particularly ethane and propane, and for high severity naphtha cracking, the inlet cone is the most critical zone for coke buildup in the entire heater-transfer line system. This is apparently due to the flow characteristics of the hot gases within the cone. A layer of gas apparently builds up along the cone walls, and with a substantial residence time caused by eddying and back flow, there is significant coking. Coke will build up on the walls of the cone and eventually break off, causing blockage of gas flow through a portion of the exchanger. Further, it is difficult to distribute the flow to all of the exchanger tubes equally; tubes with low gas flow tend to foul quickly. Ultimately, the resulting high pressure drop requires that the whole heater-exchanger system be shut down and the cone and tubes cleaned out, even though there may be essentially no coke buildup in the heater itself.

High severity pyrolysis requires extremely rapid cooling and very low pressure drop across the cooler. This is accomplished by providing many parallel tubes of small diameter, but such an arrangement demands that the inlet cone have a large volume. This turns the inlet cone into an adiabatic reactor, the same as a large or long transfer line. The adiabatic reaction is contrary to the principles of short residence time cracking, and reduces the temperature and causes coke formation, increasing pressure drop and shortening run length.

The area of the heater outlet is typically about one-half of the area of the exchanger tubes, and with a conventional inlet cone the volume thereof may be as much as 10–20% of the volume of the heater coil. Since discharge from the heater is at maximum temperature, the adiabatic reaction is rapid, with a significant effect on yield and coke formation.

Prior workers have addressed themselves to this problem, but a truly satisfactory solution has been elusive. It has been suggested, for example, to weld extensions onto the exchanger tubes and bring them close together near the narrow end of the cone, the object being to get the gas into the exchanger tubes without any opportunity for disturbed flow in the cone area, and to reduce adiabatic reaction by reducing cone volume. With such a design it is possible for gas to enter between the tubes and deposit coke, causing tube deformation and, ultimately, failure. A second disadvantage of this design is that it is often not desirable to weld the inlet cone tubes to the exchanger tubes, because this can impose restrictions on the free movement of the tube sheet and impose thermal stress. This is particularly true with ethane-propane feedstocks, where water-cooled fixed tube exchangers are preferred, and the tube sheet must remain flexible.

A further previous effort to prevent coke buildup in the inlet cone involved the injection of steam into the fluid stream. Introduction of the steam was accomplished in such a manner that it mixed with the heater effluent before the effluent reached the cone-shaped inlet device. This has the effect of reducing coking but not eliminating it, since eddying and back flow still occur, because the components of the mixture capable of coking are at a reduced concentration. Since reduction in coking tendency depends on the amount of steam injected, very substantial quantities of steam are required to reduce coking to an acceptably low level.

It has also been proposed to introduce the steam tangentially into the narrow end of the inlet cone, the object in view being to produce a spiraling film of steam on the inside surface of the cone, and thus avoid coke deposition on the surface without mixing of steam with the heater effluent to any great extent. In order to effect the tangential introduction and generally spiral motion of the steam against the inlet cone surface, however, the velocity of the steam had to be exceptionally high, and this resulted in a volume of steam introduction not materially different from the former case. Of course, large volumes of steam injected reduce the net yield of recoverable high pressure steam from the exchanger, which is the only advantage of indirect cooling over direct cooling.

It is thus a general object of the present invention to prevent coke buildup in the inlet cone between a heater and a transfer line exchange.

Another object of the invention is to provide an improved inlet cone for connecting a heater to a transfer line exchanger.

Yet another object of the invention is to provide means for passing cracked gas from a heater to a transfer line exchanger which effectively prevents coke buildup and which does not involve tube extensions on the exchanger tubes.

A still further object of the invention is to pass cracked gas from a heater to a transfer line exchanger without coke buildup, without reducing yield and without loss of heat recovery potential.

Yet another object of the invention is to provide a

device and method for passing cracked gas from a heater connection to a transfer line exchanger wherein steam is injected to prevent coke buildup, but wherein only a small volume of steam is required.

Various other objects and advantages of the invention will become clear from the following detailed description of two embodiments thereof, and the novel features will be particularly pointed out in connection with the appended claims.

In essence, the present invention comprises the injection of steam into the inlet cone around the circumference thereof and cocurrently with the cracked gas. The steam injection is controlled so as to fill completely the area of the cone where eddying and back flow occur, thus preventing the cracked gas from entering this area. In a preferred embodiment of the invention, steam is injected cocurrently with the cracked gas at the narrow end of the inlet cone and countercurrent to the cracked gas flow near the heat exchanger end. This assists in producing an area of turbulent steam around the inlet cone surface which the cracked gas does not penetrate to any material extent. The volume of steam required for this service is, broadly, within the range of 2–20 weight percent of the effluent gas and, preferably, about 5–10 weight percent.

Understanding of the invention will be facilitated by referring to the accompanying drawings, in which:

FIGURES 1*a*, and 1*b* are schematic profiles of a conventional inlet cone and a modified inlet cone, respectively;

FIGURE 2 is a partially cross-sectional elevation view of an inlet device in accordance with the invention, as attached to a heat exchanger; and

FIGURE 2*a* is an enlarged detail view of a portion of FIGURE 2, showing an alternative embodiment of the invention.

In evolving the inlet of the present invention, it was reasoned that since coke deposits were the result of a portion of the gases remaining in the cone for a substantial period, there must be areas of separation and reverse flow or eddys of the gas. To determine the location of these areas, a two-dimensional model was constructed on a flat table. This model had a 26 inch "tube sheet" and a 6.7 inch "heater outlet." The tube sheet simulated had individual projections of the tubes in a roughly conical arrangement, which is felt to be a beneficial arrangement. The sides and tube sheet were 3 inches high and a clear plastic cover was provided.

The sides were first arranged in the configuration of a conventional inlet cone, as illustrated diagrammatically in FIGURE 1*a*. With the cover in place, air was caused to flow through the device, and with the air flow established, smoke was introduced along the right side. A large area of eddying, separation and reverse flow became immediately apparent, as indicated in FIGURE 1*a*.

The sides of the cone were then modified as shown in FIGURE 1*b*, and another test with smoke was conducted. As can be seen in the drawing, there was still eddying and reverse flow, but on a much smaller scale.

It was then determined that if the area filled with eddying smoke was replaced with steam, the gas flow would be kept away from the inlet walls and coke buildup would be prevented. Such a design is illustrated in FIGURE 2, which is a very simple device for carrying out the invention.

In FIGURE 2, the inlet device is indicated generally at **10** and the heat exchanger at **12**.

Exchanger **12** comprises a shell **14**, a tube sheet **16** mounted essentially flush with the end of shell **14**, a number of tubes **18** and flange **20**. For ease of illustration, only a small number of tubes **18** are shown, but it will be understood that a large number of small diameter tubes are preferred.

Flange **20** matches a flange **22** on inlet **10**, and a gasket **24** provides a tight seal. Inlet **10** comprises a shell **26**, insulation **28**, a thin, cone-shaped skirt or cover **30** to protect insulation **28** and a flange **32** for attachment to the outlet of the cracking heater (not shown). It will be understood that flange **32** may be connected to intermediate piping, rather than directly to the heater outlet, as for example when one exchanger is connected to two heaters.

A sleeve **34** defines the gas passage at the heater side of the inlet. As can be seen in the drawing, sleeve **34** extends a short distance beyond the point of juncture with cone-shaped cover **30**. It is at this point that a pipe or pipes **36** open through a groove or a plurality of apertures **38**, allowing steam to be injected cocurrent with the gas flow along the wall of cover **30**. Two or more pipes **36** may be employed to provide the steam, with a conduit **40** connecting them with the various apertures **38**.

As noted hereinabove, it is preferred to inject steam also at a point near the tube sheet **16**, in this instance countercurrent to the fluid flow. This is readily accomplished by forming a shoulder **42** on cover **30** near the tube sheet, and providing element **44**, in the shape of a truncated cone, and having a small diameter slightly less than the diameter of cover **30** at the point where they meet. This provides an annular chamber **46** around the circumference of the device and an annular passage **48** communicating with the cone at its widest point. A pipe or pipes **50** are provided for injecting steam from an external source through control means **51** into chamber **46**, from which it passes through passage **48** into the inlet.

In operation, steam flows from apertures **38** up the wall of cover **30** around the entire circumference of the inlet, cocurrent with the fluid flow through the device. Steam also flows countercurrent to the gas flow from passage **48** and, when it meets the steam from apertures **38**, an area of high turbulence is created. There is little if any mixing of cracked gas with the steam in this area, and coke deposition is therefore substantially reduced or eliminated. Of course, steam is drawn off from this area and mixes with the cracked gas as it passes into tubes **18** of exchanger **12**, but the total volume of steam needed to keep the gas away from the cone walls is relatively small, compared to prior art devices. As noted hereinabove, the volume of steam required will be about 2–20 wt. percent and preferably should be 5–10 wt. percent of the cracked gas.

An alternative to the arrangement of apertures **38**, conduit **40** and pipes **36** is illustrated in FIGURE 2*a*, which is an enlarged detail drawing of that portion of FIGURE 2.

In the embodiment of FIGURE 2*a*, sleeve **34** is provided with a flared section **52**, which is flared at about the same angle as cone cover **30**, forming therebetween annular passage **54**. Passage **54** communicates at its lower end with annular chamber **56**, which is supplied with steam through pipe or pipes **36** around the circumference thereof. It will be realized that in both function and design, this steam inlet is quite similar to the countercurrent inlet described in connection with FIGURE 2. Further, it will be noted that annular passage **54**, like passage **48** in FIGURE 2, will be quite narrow, but has been enlarged for illustrative purposes.

When the embodiment of FIGURE 2*a* is used with the other features of FIGURE 2, it will be seen that what has been done, in effect, is to move the cone wall back slightly and substitute therefor a "wall" of steam.

Various other changes in the details, steps, materials and arrangements of parts, which have been herein described and illustrated, may be made by those skilled in the art within the principle and scope of the invention as defined in the appended claims. For example, it is clear that the invention can be readily adapted to avoid coking in the cone configuration illustrated in FIGURE 1*b* as well as the design of FIGURE 1*b* by merely moving the point of cocurrent steam injection.

I claim:

1. An inlet device for injecting steam into the inlet cone between a heater and a transfer line exchanger, said inlet cone having a heater end communicating with the outlet of said heater and an exchanger end communicating with the inlet of said transfer line exchanger, that comprises:

conduit means connecting with a source of steam;

aperture means integral with said conduit means comprising in part a generally ring shaped sleeve section positioned around the circumference of an end of said inlet cone, said ring section forming an annular chamber with said cone, so that steam injected therethrough fills the area of said inlet cone where eddying and back flow occur.

2. The steam inlet device as claimed in claim 1, wherein said aperture means are positioned in the heater end of said inlet cone, so that the steam is injected cocurrently to the bulk flow direction of the fluid along the surface of said cone.

3. The steam inlet device as claimed in claim 1, wherein said aperture means are positioned in the exchanger end of said inlet cone, so that the steam is injected countercurrent to the bulk flow direction of the fluid along the surface of said inlet cone.

4. The steam inlet device as claimed in claim 1, and additionally comprising aperture means positioned in both ends of said inlet cone, so that the steam is injected cocurrently to the bulk flow direction of the fluid in the heater end, and countercurrently to the bulk flow direction of the fluid in the exchanger end.

5. The sleeve section as claimed in claim 2, where said sleeve is flared at about the same angle as said inl cone.

6. The steam inlet device as claimed in claim 3, where said sleeve comprises a truncated cone section of slight less diameter than said inlet cone.

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U.S. Cl. X.R.

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