

Description

The invention relates to an apparatus for contacting particulate solids with a fluid, especially contacting catalyst particles with a hydrocarbon oil stream in the lower part of a riser reactor of a fluid catalytic cracking (FCC) unit.

It is known in FCC-technology to contact hydrocarbon oil with cracking catalyst particles by passing said hydrocarbon oil as an outer annular stream in a generally linear direction, imparting a centrifugal energy component to said stream and passing an inner gas stream concentrically with said outer stream through a restricted opening to bring said stream into contact with catalyst particles.

It would be advantageous, however, to reduce the relatively large pressure drop resulting from (i) the conversion of linear velocity of the hydrocarbon oil stream into a tangential velocity component corresponding to the afore-mentioned centrifugal energy component and (ii) the subsequent passage of said stream together with an at least partly unbroken inner gas stream through a restricted opening.

It has now been found that optimal mixing of a fluid with particulate solids can be attained with a relatively small pressure drop without requiring a separate inner fluid stream by introducing an annular fluid stream (preferably as a central, symmetrical, hollow-cone jet) directly into a solids stream, when use is made of an apparatus in accordance with the present invention.

The invention therefore relates to an apparatus for contacting particulate solids with a fluid which comprises a solids container at least partly surrounding fluid supply means which have an inlet opening in the upstream end part and an annular fluid outlet opening in the downstream end part thereof, which opening is surrounded by the solids container, and wherein an annular inlet opening for a first fluid is defined between the fluid supply means and tubular inlet means for a second fluid arranged at least partly inside the upstream end part of the fluid supply means. Such an apparatus may contain features of an apparatus for mixing fluids as described in British patent application No. 8607699.

It should be noted that from European patent application No. 0126191 a vibratory fluidized bed reactor is known for contacting an annulus of air with solid particles of fuel. The reactor comprises a device for injecting air in the form of a conic member having a bottom rim distributing the air into the solid particles of fuel below an upper surface thereof. This document is, however, totally silent about a second annular inlet opening and an improved fluid distribution which is obtained therewith.

Preferred embodiments of the apparatus according to the invention are described hereinafter using Figures 1-4 in which reference numerals relating to corresponding parts are the same.

In Figure 1 a longitudinal section of an apparatus for contacting particulate solids with a fluid is shown.

In Figure 2 a longitudinal section of the bottom part of a fluid catalytic cracking riser reactor is shown.

Figure 3 represents a cross section at AA' of the fluid supply means of the apparatus as depicted in Figure 1.

Figure 4 represents a cross section at BB' of the fluid supply means arranged in the riser reactor section shown in Figure 2.

The apparatus as schematically depicted in Figure 1 comprises fluid supply means (1) of which the major (downstream) part is surrounded by the bottom part of solids container (2). The upstream end part (3) of fluid supply means (1) preferably comprises separate inlet means (4) for a first fluid and most preferably tubular inlet means (5) for a second fluid arranged partly inside upstream end part (3). In the particularly preferred embodiment as shown in Figure 1 an annular inlet opening (6) for the first fluid is defined between the wall of fluid supply means (1) and tubular inlet means (5) in order to accelerate an upwardly directed stream of the first fluid and to provide an excellent distribution thereof over the cross section of fluid supply means (1). Further acceleration and mixing of the first and second fluid can be attained by employing tubular fluid supply means (1) of which the cross sectional surface area decreases in downstream direction. Preferably, the ratio of the diameters of the upstream (3) - and downstream (8) - end parts of the tubular fluid supply means is from 1-5, and most preferably from 1.2-3.

A major advantage of the apparatus according to the invention is that a single tubular fluid supply means (1) arranged substantially centrally in the bottom end part (7) of solids container (2) can be applied to attain rapid, intimate and uniform mixing of particulate solids with fluid.

The downstream end part (9) of tubular inlet means (5) may comprise positioning means, such as outwardly directed spacer fins (10). At least one opening (11) is present in said downstream end part (9); in some cases, however, it can be advantageous to provide downstream end part (9) with a plurality (e.g. 4-12) of openings through which the second fluid will flow with a relatively high velocity (of e.g. 30-300 m/s) and accordingly increase the velocity of the fluid mixture flowing through fluid supply means (1). In a preferred embodiment a deflection means is placed in opening (11), defining an annular fluid opening. The deflection means preferably comprise a rotation-symmetrical body having an increasing diameter in downstream direction.

The annular fluid outlet opening (12) is preferably defined between the wall of the downstream end part (8) of fluid supply means (1) and deflection means (13), which most preferably comprise a rotation-symmetrical body having an increasing diameter in downstream direction. In a particularly preferred embodiment of the apparatus according to the invention, deflection means (13) comprise a substantially conical body having a top angle of 30-180 degrees and preferably of 80-120 degrees. The ratio of the diameter of the base of said conical body

and of the downstream end part (8) of fluid supply means (1) is preferably from 0.8-6 and most preferably from 1-4. Deflection means (13) can be held in place by connecting means (14) which may be arranged either inside or outside (shown in Figure 1) the downstream end part (8) of fluid supply means (1); in the latter case connecting means (14) can also serve as vanes inside annular opening (17) defined between tubular shielding means (16) and the downstream end part (8) of fluid supply means (1). A rod (21) may be arranged substantially coaxially inside fluid supply means (1) and connected to deflection means (13) in order to attain a very stable annular fluid flow around said rod.

The apparatus according to the present invention furthermore preferably comprises fluidization means (23) (e.g. in the form of a perforated plate as depicted in Figure 1 or ring-shaped or annular fluidization means) provided with regularly spaced fluidization gas openings (e.g. nozzles (24)) through which a fluidization gas (e.g. steam or a sour fluid catalytic cracking off gas) introduced via fluidization gas inlet means (22) emanates into mixing zone (19). Moreover, a separate flow of gas introduced via inlet means (27) may be used to cool space (25) between shielding means (16) and tubular fluid inlet means (1). Solids container (2) may comprise a section having a restricted diameter (not shown in the Figures) near annular fluid outlet opening (17) in order to increase the velocity of the fluidized bed of particulate solids surrounding said opening, thus even further improving the contact between the fluid (mixture) emanating from fluid outlet opening (17) with the solids.

In Figure 2 another embodiment of the apparatus according to the invention is shown which is preferably employed as part of an apparatus for fluid catalytic cracking of hydrocarbonaceous material and which, in addition to the elements already described in connection with Figure 1, comprises solids inlet means (20) through which solid particles (e.g. originating from a catalyst regenerator) are introduced into the bottom section of solids container (2) (which can be the riser reactor of a fluid catalytic cracking apparatus). A cooling gas (e.g. low pressure steam) can be introduced through cooling gas inlet means (27) and annular cooling gas inlet space (26) into space (25) (enclosed by lower section (15) of shielding means (16)) and be removed through annular opening (17) provided with vanes (18). Preferably, a heavy hydrocarbon oil feed is introduced through inlet means (5) and accelerated through nozzle (11) in the downstream end part (9) thereof into fluid supply means (1) where mixing with steam introduced via inlet means (4) can take place.

The use of a single fluid/solid contacting apparatus which is centrally located in the bottom section of a riser reactor as depicted in Figure 2 leads to very uniform mixing of solid cracking catalyst and fluid (hydrocarbon/steam mixture) in mixing zone (19) in a relatively short period of time; consequently the length of the riser reactor section in which the solid catalyst particles are mixed with hydrocarbon feed is relatively short, resulting in optimal use of the remaining (upper) section of the riser

reactor for the actual catalytic cracking.

Moreover, by employing the apparatus and process according to the present invention only a relatively small amount of steam or another fluid is used for injecting a given quantity of liquid (hydrocarbons). In addition, coke formation on the catalyst particles and on the walls of the cracking apparatus is reduced as a result of optimal contacting of hydrocarbon feed with said catalyst particles.

The invention is illustrated by means of the following Example.

Example

A feed stream of heavy hydrocarbon oil enters inlet (5) of the apparatus as depicted in Figure 2 at a temperature of 250 °C and a pressure of 12 bar abs. and is mixed in tubular fluid supply means (1) having length of 3 m and a diameter of 0.2 m with steam introduced via inlet (4) at a temperature of 300 °C and a pressure of 15 bar abs. The resulting oil/steam mixture flows with a velocity of 50 m/s through annular outlet opening (12) into mixing zone (19), which is operated at a pressure of 3 bar abs. and a temperature of 520 °C. Regenerated silica-alumina based catalyst particles are introduced via inlet (20) at a temperature of 700 °C into mixing zone (19) wherein the catalyst particles are contacted with the oil/steam mixture.

Claims

1. Apparatus for contacting particulate solids with a fluid which comprises a solids container at least partly surrounding tubular fluid supply means having an inlet opening in the upstream end part and an annular fluid outlet opening in the downstream end part thereof, which opening is surrounded by the solids container, characterized in that an annular inlet opening for a first fluid is defined between the fluid supply means and tubular inlet means for a second fluid arranged at least partly inside the upstream end part of the fluid supply means.

2. Apparatus according to claim 1, characterized in that the cross sectional surface area of the fluid supply means decreases in downstream direction.

3. Apparatus according to claim 2, characterized in that the ratio of the diameters of the upstream- and downstream-end parts of the tubular fluid supply means is from 1-5 and most preferably from 1.2-3.

4. Apparatus according to any of claims 1-3, characterized in that the annular fluid outlet opening is defined between the downstream end part of the fluid supply means and deflection means.

5. Apparatus according to claim 4, characterized in that the deflection means comprise a rotation-symmetrical body having an increasing diameter in downstream direction.

Patentansprüche

1. Vorrichtung zum Kontaktieren von teilchenförmigen Feststoffen mit einem Fluid, die einen Feststoffbehälter aufweist, der eine rohrförmige Fluid-



and of the downstream end part (8) of fluid supply means (1) is preferably from 0.8-6 and most preferably from 1-4. Deflection means (13) can be held in place by connecting means (14) which may be arranged either inside or outside (shown in Figure 1) the downstream end part (8) of fluid supply means (1); in the latter case connecting means (14) can also serve as vanes inside annular opening (17) defined between tubular shielding means (16) and the downstream end part (8) of fluid supply means (1). A rod (21) may be arranged substantially coaxially inside fluid supply means (1) and connected to deflection means (13) in order to attain a very stable annular fluid flow around said rod.

The apparatus according to the present invention furthermore preferably comprises fluidization means (23) (e.g. in the form of a perforated plate as depicted in Figure 1 or ring-shaped or annular fluidization means) provided with regularly spaced fluidization gas openings (e.g. nozzles (24)) through which a fluidization gas (e.g. steam or a sour fluid catalytic cracking off gas) introduced via fluidization gas inlet means (22) emanates into mixing zone (19). Moreover, a separate flow of gas introduced via inlet means (27) may be used to cool space (25) between shielding means (16) and tubular fluid inlet means (1). Solids container (2) may comprise a section having a restricted diameter (not shown in the Figures) near annular fluid outlet opening (17) in order to increase the velocity of the fluidized bed of particulate solids surrounding said opening, thus even further improving the contact between the fluid (mixture) emanating from fluid outlet opening (17) with the solids.

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reactor for the actual catalytic cracking.

Moreover, by employing the apparatus and process according to the present invention only a relatively small amount of steam or another fluid is used for injecting a given quantity of liquid (hydrocarbons). In addition, coke formation on the catalyst particles and on the walls of the cracking apparatus is reduced as a result of optimal contacting of hydrocarbon feed with said catalyst particles.

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Patentansprüche

1. Vorrichtung zum Kontaktieren von teilchenförmigen Feststoffen mit einem Fluid, die einen Feststoffbehälter aufweist, der eine rohrförmige Fluid-

zufuhreinrichtung zumindest teilweise umgibt, welche in ihrem stromaufwärtigen Endteil eine Einlaßöffnung und in ihrem stromabwärtigen Endteil eine vom Feststoffbehälter umgebene ringförmige Fluidauslaßöffnung aufweist, dadurch gekennzeichnet, daß eine ringförmige Einlaßöffnung für ein erstes Fluid zwischen der Fluidzufuhreinrichtung und der rohrförmigen Einlaßeinrichtung für ein zweites Fluid gebildet ist, die zumindest teilweise innerhalb des stromaufwärtigen Endteiles der Fluidzufuhreinrichtung angeordnet ist.

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2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Querschnittsfläche der Fluidzufuhreinrichtung in stromabwärtiger Richtung abnimmt.

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3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß das Verhältnis der Durchmesser der stromaufwärtigen und stromabwärtigen Endteile der rohrförmigen Fluidzufuhreinrichtung von 1-5 und vorzugsweise von 1,2-3 beträgt.

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4. Vorrichtung nach einem der Ansprüche 1-3, dadurch gekennzeichnet, daß die ringförmige Fluidauslaßöffnung zwischen dem stromabwärtigen Endteil der Fluidzufuhreinrichtung und einer Ablenkeinrichtung gebildet ist.

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5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die Ablenkeinrichtung einen rotationssymmetrischen Körper aufweist, der in stromabwärtiger Richtung zunehmenden Durchmesser hat.

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Revendications

1. Appareil pour mettre en contact des particules solides avec un fluide, qui comprend un réservoir de matières solide entourant au moins partiellement un moyen tubulaire d'alimentation en fluide possédant un orifice d'admission dans l'extrémité d'amont et un orifice annulaire de sortie du fluide dans son extrémité d'aval, cet orifice étant entouré par le réservoir de matières solides, caractérisé en ce qu'un orifice annulaire d'admission pour un premier fluide est défini entre le moyen d'alimentation en fluide et un moyen tubulaire d'admission pour un second fluide disposé au moins partiellement à l'intérieur de l'extrémité d'amont du moyen d'alimentation en fluide.

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2. Appareil selon la revendication 1, caractérisé en ce que la superficie de la section droite du moyen d'alimentation en fluide diminue dans la direction aval.

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3. Appareil selon la revendication 2, caractérisé en ce que le rapport des diamètres des extrémités d'amont et d'aval du moyen tubulaire d'alimentation en fluide est de 1-5 et plus particulièrement de 1,2-3.

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4. Appareil selon l'une quelconque des revendications 1 à 3, caractérisé en ce que l'orifice annulaire de sortie du fluide est défini entre l'extrémité d'aval du moyen d'alimentation en fluide et un moyen défecteur.

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5. Appareil selon la revendication 4, caractérisé en ce que le moyen défecteur comprend un corps à symétrie de révolution ayant un diamètre croissant dans la direction d'aval.

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