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(54) TURBULENT FLUIDIZED-BED REACTOR, DEVICE, AND METHOD USING OXYGEN-CONTAINING COMPOUND FOR MANUFACTURING PROPENE AND C4 HYDROCARBON

TURBULENTER WIRBELBETTREAKTOR, VORRICHTUNG UND VERFAHREN MIT VERWENDUNG EINER SAUERSTOFFHALTIGEN VERBINDUNG ZUR HERSTELLUNG VON PROPEN UND C4-KOHLENWASSERSTOFF

RÉACTEUR À LIT FLUIDISÉ TURBULENT, DISPOSITIF ET PROCÉDÉ UTILISANT UN COMPOSÉ CONTENANT DE L’OXYGÈNE POUR LA FABRICATION DE PROPÈNE ET D’HYDROCARBURE EN C4

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Description

Technical Field

[0001] The present invention refers to the field of chemical catalysis, in particular to a method and device for preparing propylene and C4 hydrocarbons from oxygen-containing compounds.

Background

[0002] Propylene and butadiene are important chemical raw materials, which are usually obtained from naphtha cracking and steam cracking. The main sources of propylene are co-production of ethylene with propylene and by-product of refinery. The main source of butadiene is the further processing of C4 by-product produced in ethylene cracking process. In recent years, the technologies of methanol to olefin (MTO), methanol to propylene (MTP), ethane dehydrogenation to ethylene and propane dehydrogenation to propylene have been rapidly developed. There is an obvious tendency of raw material lightening in global olefin production, which will lead to the shortage of C4 resources. Therefore, it is necessary to develop a process that can produce propylene and C4 olefins with a high selectivity to meet market demand.

[0003] The fixed-bed methanol-to-olefin technology (WO2004/018089) was developed by LURGI AG in Germany. The technology utilized a ZSM-5 molecular sieve catalyst from Sud-Chemie AG to carry out methanol-to-olefin reaction in a fixed-bed reactor. The selectivity of propylene was close to 70%, and the by-products were ethylene, liquefied petroleum gas and gasoline.

[0004] The DMTO technology developed by Dalian Institute of Chemical Physics used a SAPO molecular sieve as catalyst, a dense-phase circulating fluidized-bed reactor and a methanol aqueous solution as raw material. The yield of ethylene and propylene in the product was about 80%, and more than 10% of C4 hydrocarbons were yielded as by-products.

[0005] Patent CN104098429A discloses a method of preparing propylene and C4 hydrocarbons from methanol in a circulating fluidized-bed using a ZSM-5 catalyst. The process features are that the raw material methanol and most of C1, C2 and C5 hydrocarbons in the product are entered into the circulating fluidized-bed reactor together, and propylene, C4 hydrocarbons, hydrocarbons of C6 and above and by-products are retrieved as final products.

[0006] Patent CN101177374B discloses a method for preparing olefins from methanol or dimethyl ether. The method includes the conversion of methanol or dimethyl ether, the alkylation of ethylene and methanol, and the catalytic cracking of components heavier than C4. Catalyst 1 is used for the methanol or dimethyl ether conversion and the ethylene and methanol alkylation in one reactor, and catalyst 2 is used for the catalytic cracking of components heavier than C4 in another reactor.

[0007] The methods disclosed in patents CN104098429A and CN101177374B share a common feature, that is, the selectivity of target products (propylene and C4) is increased through the recycling of light fractions (hydrocarbons with a carbon number of no more than 2). The alkylation of ethylene with methanol is the main reaction in the recycling reaction of the light fractions mentioned above.

[0008] The acidic molecular sieve catalysts can be used in both MTO reaction and alkylation of olefins. However, the rate of the MTO reaction is much higher than that of the alkylation of olefins. We have found that a fresh SAPO catalyst has a high activity, which is more beneficial to the alkylation of olefins. After a carbon deposition of catalyst, the reaction rate of alkylation of olefins will decrease rapidly.

[0009] Methanol is not only the raw material for the alkylation of olefins, but also the raw material for the MTO reaction. Therefore, the alkylation of olefins is necessarily accompanied by the MTO reaction. The MTO reaction will lead to a carbon deposition and lower activity of catalyst, which will hence inhibit the alkylation of olefins. An increase in the alkylation rate of olefins can reduce the content of light fractions in the product gas, and thus the unit volume production capacity of the reactor can be increased.

[0010] The methods disclosed in patents CN104098429A and CN101177374B do not refer to the reactor structure, nor do they clarify the flow modes of catalyst and raw material and the raw material distribution in the reactor. The method disclosed in patent CN101177374B uses a SAPO catalyst. The examples show that the mass ratio of methanol to light fractions is 1:10-20. Thus, it can be seen that the content of light fractions is very high and the unit volume production capacity of reactor is very low. A ZSM-5 catalyst is used in the method disclosed in patent CN104098429A. The content of hydrocarbons of C6 and above in the product is relatively high. The content of light fractions in the product gas is not disclosed in this method.

[0011] From the above analysis, it can be seen that the main reactions for the preparation of propylene and C4 hydrocarbons from methanol are the MTO reaction and the alkylation of olefins. Therefore, the key to improve the selectivity of propylene and C4 hydrocarbons lies in a catalyst design and a reactor design. Avoiding the inhibition of the MTO reaction to the alkylation of olefins through an optimization in the reactor design is one of the important methods to improve the economics of methanol to propylene and C4 hydrocarbons. CN104672045 discloses a fluidised-bed reactor for producing methanol.

Summary of The Invention

[0012] In view of the problem of low reaction rate of ethylene alkylation, the present invention provides a new method and device for increasing the reaction rate of ethylene alkylation in the process of preparing propylene and C4 hydrocarbons from methanol. Being used in the production of propylene and C4 hydrocarbons from oxygen-containing compounds, the method has the advantages of high yield of propylene and C4 hydrocarbons and good process economics.

[0013] To achieve the above purposes, one aspect of the present invention as indicated in claim 1 provides a turbulent fluidized-bed reactor - for preparing propylene and C4 hydrocarbons from oxygen-containing compounds. The turbulent fluidized-bed reactor comprises a reactor shell (2), n reactor feed distributors (3-1-3-n), a reactor gas-solid separator 1 (4), a reactor gas-solid separator 2 (5), a reactor heat extractor (6), a product gas outlet (7) and a reactor stripper (8), wherein the lower part of the turbulent fluidized-bed reactor (1) is a reaction zone, the upper part of the turbulent fluidized-bed reactor (1) is a settling zone, the n reactor feed distributors (3-1~3-n) are disposed in the reaction zone from bottom to top, the reactor heat extractor (6) is disposed in the reaction zone, the reactor gas-solid separator 1 (4) and the reactor gas-solid separator 2 (5) are placed in the settling zone or outside the reactor shell (2), the reactor gas-solid separator 1 (4) is equipped with a regenerated catalyst inlet, the catalyst outlet of the reactor gas-solid separator 1 (4) is located at the bottom of the reaction zone, the gas outlet of the reactor gas-solid separator 1 (4) is located in the settling zone, the inlet of the reactor gas-solid separator 2 (5) is located in the settling zone, the catalyst outlet of the reactor gas-solid separator 2 (5) is placed in the reaction zone, the gas outlet of the reactor gas-solid separator 2 (5) is connected to the product gas outlet (7), the reactor stripper (8) passes through the reactor shell from outside to inside at the bottom of the turbulent fluidized-bed reactor and is opened in the reaction zone of the turbulent fluidized-bed reactor (1), a reactor stripping gas inlet (9) is arranged at the bottom of the reactor stripper (8), and a spent catalyst outlet is arranged at the bottom of the reactor stripper.

[0014] The n reactor feed distributors (3-1~3-n) of the turbulent fluidized-bed reactor (1) are disposed in the reaction zone from bottom to top, and $0<n<10$.

[0015] In a preferred embodiment, the horizontal height of opening of the reactor stripper (8) in the reactor shell (2) is higher than 1/10 the height of the reaction zone, so as to avoid the direct entry of fresh catalyst into the reactor stripper.

[0016] In a preferred embodiment, the reactor gas-solid separator 1 (4) and the reactor gas-solid separator 2 (5) are cyclone separators.

[0017] The present invention further provides a device for preparing propylene and C4 hydrocarbons from oxygen-containing compounds, comprising the turbulent fluidized-bed reactor (1) described above and a fluidized-bed regenerator (14) for regenerating a catalyst.

[0018] In a preferred embodiment, the fluidized-bed regenerator (14) is a turbulent fluidized-bed regenerator.

[0019] In a preferred embodiment, the fluidized-bed regenerator (14) comprises a regenerator shell (15), a regenerator feed distributor (16), a regenerator gas-solid separator (17), a regenerator heat extractor (18), a flue gas outlet (19) and a regenerator stripper (20), wherein the lower part of the fluidized-bed regenerator (14) is a regeneration zone, the upper part of the fluidized-bed regenerator (14) is a settling zone, the regenerator feed distributor (16) is placed at the bottom of the regeneration zone, the regenerator heat extractor (18) is placed in the regeneration zone, the regenerator gas-solid separator (17) is placed in the settling zone or outside the regenerator shell (15), the inlet of the regenerator gas-solid separator (17) is disposed in the settling zone, the catalyst outlet of the regenerator gas-solid separator (17) is disposed in the regeneration zone, the gas outlet of the regenerator gas-solid separator (17) is connected to the flue gas outlet (19), and the inlet of the regenerator stripper (20) is connected to the bottom of the regenerator shell (15);

> the spent catalyst outlet of the reactor stripper (8) is connected to the inlet of a inclined spent catalyst pipe (10), a spent catalyst sliding valve (11) is arranged in the inclined spent catalyst pipe (10), the outlet of the inclined spent catalyst pipe (10) is connected to the inlet of a spent catalyst lift pipe (12), the bottom of the spent catalyst lift pipe (12) is provided with a spent catalyst lifting gas inlet (13), and the outlet of the spent catalyst lift pipe (12) is connected to the settling zone of the fluidized-bed regenerator (14);
>
> the bottom of the regenerator stripper (20) is provided with a regenerator stripping gas inlet (21), the bottom of the regenerator stripper (20) is connected to the inlet of a inclined regenerated catalyst pipe (22), a regenerated catalyst sliding valve (23) is arranged in the inclined regenerated catalyst pipe (22), the outlet of the inclined regenerated catalyst pipe (22) is connected to the inlet of a regenerated catalyst lift pipe (24), the bottom of the regenerated catalyst lift pipe (24) is provided with a regenerated catalyst lifting gas inlet (25), and the outlet of the regenerated catalyst lift pipe (24) is connected to the inlet of the reactor gas-solid separator 1 (4).

[0020] Another aspect of the present invention provides a method for preparing propylene and C4 hydrocarbons from oxygen-containing compounds, including:

> feeding a raw material containing an oxygen-containing compound from n reactor feed distributors (3-1~3-n) to a reaction zone of a turbulent fluidized-bed reactor (1), and contacting the raw material with a catalyst, to generate a stream containing propylene and C4 hydrocarbons product and a spent catalyst containing carbon;

sending the stream discharged from the turbulent fluidized-bed reactor (1) containing propylene and C4 hydrocarbons product into a product separation system, obtaining propylene, C4 hydrocarbons, light fractions,

propane and hydrocarbons with 5 or more carbons after separation, wherein the light fractions contain more than 90 wt% of ethylene and a small amount of methane, ethane, hydrogen, CO and CO_2, returning 70 wt.% or more of the light fractions to the reaction zone of the turbulent fluidized-bed reactor (1) from the reactor feed distributor (3-1) at the bottommost of the turbulent fluidized-bed reactor (1), and reacting ethylene and the oxygen-containing compounds to perform an alkylation reaction in presence of the catalyst, to produce a product containing propylene;

regenerating the spent catalyst by a fluidized-bed regenerator (14), and after being gas-solid separated by a reactor gas-solid separator 1 (4), the regenerated catalyst is fed to the bottom of the reaction zone of the turbulent fluidized-bed reactor (1).

[0021] In a preferred embodiment, the method described in the present invention is carried out using the above-mentioned device for preparing propylene and C4 hydrocarbons from oxygen-containing compounds.

[0022] In a preferred embodiment, the spent catalyst passes through the reactor stripper (8), the inclined spent catalyst pipe (10), the spent catalyst sliding valve (11) and the spent catalyst lift pipe (12) into the settling zone of the fluidized-bed regenerator (14);

a regeneration medium enters the regeneration zone of the fluidized-bed regenerator (14) from the regenerator feed distributor (16) and reacts with the spent catalyst to perform calcination to produce a flue gas containing CO and CO_2 and the regenerated catalyst, and the flue gas is discharged after dust removal by the regenerator gas-solid separator (17);

the regenerated catalyst passes through the regenerator stripper (20), the inclined regenerated catalyst pipe (22), the regenerated catalyst sliding valve (23) and the regenerated catalyst lift pipe (24) into the inlet of the reactor gas-solid separator 1 (4), and after gas-solid separation, the regenerated catalyst enters the bottom of the reaction zone of the turbulent fluidized-bed reactor (1);

a reactor stripping gas enters the reactor stripper (8) via the reactor stripping gas inlet (9) and contacts countercurrent with the spent catalyst, and then enters the turbulent fluidized-bed reactor (1); a spent catalyst lifting gas enters the spent catalyst lift pipe (12) via the spent catalyst lifting gas inlet (13) and contacts cocurrent with the spent catalyst, and then enters the settling zone of the fluidized-bed regenerator (14);

a regenerator stripping gas enters the regenerator stripper (20) via the regenerator stripping gas inlet (21) and contacts countercurrent with the regenerated catalyst, and then enters the fluidized-bed regenerator (14); a regenerated catalyst lifting gas enters the regenerated catalyst lift pipe (24) via the regenerated catalyst lifting gas inlet (25) and contacts cocurrent with the regenerated catalyst, and then enters the inlet of the reactor gas-solid separator 1 (4).

[0023] The main characteristics of the turbulent fluidized-bed reactor in the present invention are that the light fractions enter from the reactor feed distributor at the bottom-most, the oxygen-containing compound enters from n reactor feed distributors respectively, and the regenerated catalyst directly enters the bottom of the reaction zone. On one hand, in the lower part of the reaction zone, the catalyst has a high activity, which is advantageous to the alkylation of ethylene, propylene and methanol; on the other hand, because of the multi-stage feeding of the oxygen-containing compounds, the case where most of the conversion reactions of the oxygen-containing compounds are completed in a small region of the lower part of the reaction zone is avoided, so that the concentration of the oxygen-containing compounds is more uniform in most of the reaction zone, weakening the inhibition of MTO reaction to the alkylation of olefins. Therefore, the turbulent fluidized-bed reactor in the present invention can effectively improve the alkylation reaction rate of olefins, and the unit volume production capacity of the reactor is high.

[0024] In the method for preparing propylene and C4 hydrocarbons from oxygen-containing compounds of the present invention, the MTO reaction produces ethylene, propylene, and the like, and the alkylation of olefins consumes ethylene, propylene, and the like. Since the reaction rate of ethylene alkylation is high, the content of light fractions in the product gas is low, and the circulating amount of the light fractions is low. In the method of the present invention, the circulating amount of the light fractions is 5-40 wt.% of the feeding amount of the oxygen-containing compound.

[0025] In the method of the present invention, 70 wt.% or more of the light fractions are circulated in the system, and the release rate of the light fractions affects the composition of the product gas in the equilibrium state. In the equilibrium state, the product gas consists of 20-50 wt.% propylene, 15-40 wt.% C4 hydrocarbons, 10-45 wt.% light fractions, 0-5 wt.% propane and 5-20 wt.% hydrocarbons with 5 or more carbons. The light fractions contain more than 90 wt.%, e.g. >95 wt.% ethylene, and other components include methane, ethane, hydrogen, CO and CO_2.

[0026] In a preferred embodiment, the catalyst contains a SAPO molecular sieve, and the catalyst simultaneously has the functions of catalyzing methanol to olefins and alkylation of olefins.

[0027] In a preferred embodiment, the carbon content of the regenerated catalyst is less than 2 wt.%, and further preferably, the carbon content of the regenerated catalyst is less than 0.5 wt.%.

[0028] In a preferred embodiment, the carbon content of the spent catalyst is 5-12 wt.%, and further preferably, the carbon content of the spent catalyst is 5-10 wt.%.

[0029] In a preferred embodiment, the reaction conditions in the reaction zone of the turbulent fluidized-bed reactor (1) are as follows: the apparent linear velocity of gas is in a range from 0.1 m/s to 2 m/s, the reaction temperature is in a range from 300□ to 550□, the reaction pressure is in a range from 100 kPa to 500 kPa, and the bed density is in a range from 200 kg/m^3 to 1200 kg/m^3.

[0030] In a preferred embodiment, the reaction conditions in the regeneration zone of the fluidized-bed regenerator (14) are as follows: the apparent linear velocity of gas is in a range from 0.1 m/s to 2 m/s, the regeneration temperature is in a range from 5000 to 7500, the regeneration pressure is in a range from 100 kPa to 500 kPa, and the bed density is in a range from 200 kg/m^3 to 1200 kg/m^3.

[0031] In a preferred embodiment, the oxygen-containing compound is methanol and/or dimethyl ether; the regeneration medium is any one of air, oxygen-poor air or water vapor or a mixture thereof; the reactor stripping gas, the regenerator stripping gas, the spent catalyst lifting gas and the regenerated catalyst lifting gas are water vapor or nitrogen.

Description of The Figures

[0032] Figure 1 is a schematic diagram of a device for preparing propylene and C4 hydrocarbons from oxygen-containing compounds according to an embodiment of the present invention.

[0033] The reference numerals in the figure are listed as follows:

1- turbulent fluidized-bed reactor; 2- reactor shell; 3- reactor feed distributors (3-1~3-n); 4- reactor gas-solid separator 1; 5- reactor gas-solid separator 2; 6- reactor heat extractor; 7- product gas outlet; 8- reactor stripper; 9- reactor stripping gas inlet; 10- inclined spent catalyst pipe; 11- spent catalyst sliding valve; 12- spent catalyst lift pipe; 13- spent catalyst lifting gas inlet; 14- fluidized-bed regenerator; 15- regenerator shell; 16-regenerator feed distributor; 17- regenerator gas-solid separator; 18- regenerator heat extractor; 19- flue gas outlet; 20- regenerator stripper; 21- regenerator stripping gas inlet; 22- inclined regenerated catalyst pipe; 23-regenerated catalyst sliding valve; 24- regenerated catalyst lift pipe; 25- regenerated catalyst lifting gas inlet.

Detailed Description of the Embodiment

[0034] In a specific embodiment, the schematic diagram of the device according to the present invention for preparing propylene and C4 hydrocarbons from oxygen-containing compounds is shown in Fig. 1, which comprises:

a) a turbulent fluidized-bed reactor (1), which comprises a reactor shell (2), n reactor feed distributors (3-1~3-n), a reactor gas-solid separator 1 (4), a reactor gas-solid separator 2 (5), a reactor heat extractor (6), a product gas outlet (7) and a reactor stripper (8), wherein the lower part of the turbulent fluidized-bed reactor (1) is a reaction zone, the upper part of the turbulent fluidized-bed reactor (1) is a settling zone, the n reactor feed distributors (3-1~3-n) are arranged from bottom to top in the reaction zone and 0<n<10, the reactor heat extractor (6) is disposed in the reaction zone, the reactor gas-solid separator 1 (4) and the reactor gas-solid separator 2 (5) are placed in the settling zone or outside the reactor shell (2), the inlet of the reactor gas-solid separator 1 (4) is connected to a regenerated catalyst lift pipe (24), the catalyst outlet of the reactor gas-solid separator 1 (4) is located at the bottom of the reaction zone, the gas outlet of the reactor gas-solid separator 1 (4) is located in the settling zone, the inlet of the reactor gas-solid separator 2 (5) is located in the settling zone, the catalyst outlet of the reactor gas-solid separator 2 (5) is located in the reaction zone, the gas outlet of the reactor gas-solid separator 2 (5) is connected to the product gas outlet (7), and the inlet of the reactor stripper (8) is in the reaction zone of the turbulent fluidized-bed reactor (1), with the horizontal height higher than 1/10 that of the reaction zone;

b) a fluidized-bed regenerator (14), which comprises a regenerator shell (15), a regenerator feed distributor (16), a regenerator gas-solid separator (17), a regenerator heat extractor (18), a flue gas outlet (19) and a regenerator stripper (20), wherein the lower part of the fluidized-bed regenerator (14) is a regeneration zone, the upper part of the fluidized-bed regenerator (14) is a settling zone, the regenerator feed distributor (16) is placed at the bottom of the regeneration zone, the regenerator heat extractor (18) is placed in the regeneration zone, the regenerator gas-solid separator (17) is placed in the settling zone or outside the regenerator shell (15), the inlet of the regenerator gas-solid separator (17) is placed in the settling zone, the catalyst outlet of the regenerator gas-solid separator (17) is placed in the regeneration zone, the gas outlet of the regenerator gas-solid separator (17) is connected to the flue gas outlet (19), and the inlet of the regenerator stripper (20) is connected to the bottom of the regenerator shell (15);

c) the bottom of the reactor stripper (8) is provided with a reactor stripping gas inlet (9), the bottom of the reactor stripper (8) is connected to the inlet of a inclined spent catalyst pipe (10), a spent catalyst sliding valve (11) is arranged in the inclined spent catalyst pipe (10), the outlet of the inclined spent catalyst pipe (10) is connected to the inlet of a spent catalyst lift pipe (12), the bottom of the spent catalyst lift pipe (12) is provided with a spent catalyst lifting gas inlet (13), and the outlet of the spent catalyst lift pipe (12) is connected to the settling zone of the fluidized-bed regenerator (14);

d) the bottom of the regenerator stripper (20) is provided with a regenerator stripping gas inlet (21), the bottom of the regenerator stripper (20) is connected to the inlet of a inclined regenerated catalyst pipe (22), a regenerated catalyst sliding valve (23) is arranged in the inclined regenerated catalyst pipe (22), the outlet of the inclined regenerated catalyst pipe (22) is connected to the inlet of the regenerated catalyst lift pipe (24), the bottom of the regenerated catalyst lift pipe (24) is provided with a regenerated catalyst lifting gas inlet (25), and the outlet of the regenerated catalyst lift pipe (24) is connected to the inlet of the reactor gas-solid separator 1 (4).

[0035] In the above embodiment, the fluidized-bed regenerator (14) may be a turbulent fluidized-bed regenerator; the reactor gas-solid separator 1 (4), the reactor gas-solid separator 2 (5) and the regenerator gas-solid separator (17) may be cyclone separators.

[0036] In a specific embodiment, the method according to the present invention for preparing propylene and C4 hydrocarbons from oxygen-containing compounds includes the following steps:

a) feeding a raw material containing oxygen-containing compounds into the reaction zone of the turbulent fluidized-bed reactor (1) from the n reactor feed distributors (3-1~3-n), and contacting the raw material with a catalyst, to generate a stream containing propylene and C4 hydrocarbons product and a spent catalyst containing carbon;

b) sending the stream discharged from the turbulent fluidized-bed reactor (1) containing propylene and C4 hydrocarbons product into the product separation system, obtaining propylene, C4 hydrocarbons, light fractions, propane and hydrocarbons with 5 or more carbons after separation, wherein the light fractions are mainly ethylene with a small amount of methane, ethane, hydrogen, CO and CO_2, returning 70 wt.% or more of the light fractions to the reaction zone of the turbulent fluidized-bed reactor (1) from the reactor feed distributor (3-1) at the bottom-most of the turbulent fluidized-bed reactor (1), and reacting ethylene and the oxygen-containing compounds to perform an alkylation reaction in presence of the catalyst to produce a product containing propylene, with less than 30 wt.% of the light fractions being retrieved as a by-product;

c) the spent catalyst passes through the reactor stripper (8), the inclined spent catalyst pipe (10), the spent slide valve (11) and the spent catalyst lift pipe (12) into the settling zone of the fluidized-bed regenerator (14);

d) a regeneration medium enters the regeneration zone of the fluidized-bed regenerator (14) from the regenerator feed distributor (16), the regeneration medium reacts with the spent catalyst to perform calcination to produce a flue gas containing CO and CO_2 and a regenerated catalyst, and the flue gas is discharged after dust removal by the regenerator gas-solid separator (17);

e) the regenerated catalyst passes through the regenerator stripper (20), the inclined regenerated catalyst pipe (22), the regenerated catalyst sliding valve (23) and the regenerated catalyst lift pipe (24) into the inlet of the reactor gas-solid separator 1 (4), and after gas-solid separation, the regenerated catalyst enters the bottom of the reaction zone of the turbulent fluidized-bed reactor (1);

f) a reactor stripping gas enters the reactor stripper (8) via the reactor stripping gas inlet (9) and contacts countercurrent with the spent catalyst, and then enters the turbulent fluidized-bed reactor (1); a spent catalyst lifting gas enters the spent catalyst lift pipe (12) via the spent catalyst lifting gas inlet (13) and contacts cocurrent with the spent catalyst, and then enters the settling zone of the fluidized-bed regenerator (14);

g) a regenerator stripping gas enters the regenerator stripper (20) via the regenerator stripping gas inlet (21) and contacts countercurrent with the regenerated catalyst, and then enters the fluidized-bed regenerator (14); a regenerated catalyst lifting gas enters the regenerated catalyst lift pipe (24) via the regenerated catalyst lifting gas inlet (25) and contacts cocurrent with the regenerated catalyst, and then enters the inlet of the reactor gas-solid separator 1 (4).

[0037] In order to better illustrate the present invention and facilitate the understanding of the technical scheme of the present invention, comparative examples and representative but non-restrictive examples of the present invention are listed as follows:

Example 1

[0038] The present example is a comparative example. The device shown in Figure 1 is used, but the turbulent fluidized-bed reactor (1) does not contain the reactor gas-solid separator 1 (4), and the regenerated catalyst lift pipe (24) is directly connected to the settling zone of the turbulent fluidized-bed reactor (1).

[0039] The turbulent fluidized-bed reactor (1) contains three reactor feed distributors (3-1~3-3), the reactor gas-solid separator 1 (4) is placed outside the reactor shell (2), and the horizontal height of the inlet of the reactor stripper (8) is at 1/2 height of the reaction zone. The reaction conditions in the reaction zone of the turbulent fluidized-bed reactor (1) are as follows: the apparent linear velocity of gas is about 1.0 m/s, the reaction temperature is about 4500, the reaction pressure is about 150 kPa, and the bed density is about 350 kg/m^3.

[0040] The reaction conditions in the regeneration zone of the fluidized-bed regenerator (14) are as follows: the apparent linear velocity of gas is about 1.0 m/s, the regeneration temperature is about 650 □, the regeneration pressure is about 150 kPa, and the bed density is about 350 kg/m^3.

[0041] The catalyst contains a SAPO molecular sieve. The carbon content of the spent catalyst is about 7%, and the carbon content of the regenerated catalyst is about 0.2 wt.%.

[0042] The oxygen-containing compound is methanol, and the regeneration medium is air; the reactor stripping gas, the regenerator stripping gas, the spent catalyst lifting gas and the regenerated catalyst lifting gas are water vapor.

[0043] The circulating amount of the light fractions is 20 wt.% of the feeding amount of methanol, and 83 wt.% of the light fractions are circulated in the system.

[0044] The composition of the product gas discharged from the turbulent fluidized-bed reactor (1) is: 34 wt.% propylene, 20 wt.% C4 hydrocarbons, 35 wt.% light fractions, 1 wt.% propane and 10 wt.% hydrocarbons with 5 or more carbons. The light fractions contain 99 wt.% ethylene and 1 wt.% methane, ethane, hydrogen, CO, CO_2, and the like.

[0045] The composition of the product gas discharged from the separation system is: 48 wt.% propylene, 28 wt.% C4 hydrocarbons, 9 wt.% light fractions, 1 wt.% propane and 14 wt.% hydrocarbons with 5 or more carbons.

Example 2

[0046] The device shown in Fig. 1 is used. The turbulent fluidized-bed reactor (1) contains three reactor feed distributors (3-1~3-3), the reactor gas-solid separator 1 (4) is placed outside the reactor shell (2), and the horizontal height of the inlet of the reactor stripper (8) is at 1/2 height of the reaction zone. The reaction conditions in the reaction zone of the turbulent fluidized-bed reactor (1) are as follows: the apparent linear velocity of gas is about 1.0 m/s, the reaction temperature is about 450□, the reaction pressure is about 150 kPa, and the bed density is about 350 kg/m^3.

[0047] The reaction conditions in the regeneration zone of the fluidized-bed regenerator (14) are as follows: the apparent linear velocity of gas is about 1.0 m/s, the regeneration temperature is about 650 □, the regeneration pressure is about 150 kPa, and the bed density is about 350 kg/m^3.

[0048] The catalyst contains a SAPO molecular sieve. The carbon content of the spent catalyst is about 7%, and the carbon content of the regenerated catalyst is about 0.2 wt.%.

[0049] The oxygen-containing compound is methanol, and the regeneration medium is air; the reactor stripping gas, the regenerator stripping gas, the spent catalyst lifting gas and the regenerated catalyst lifting gas are water vapor.

[0050] The circulating amount of the light fractions is 20 wt.% of the feeding amount of methanol, and 98 wt.% of the light fractions are circulated in the system.

[0051] The composition of the product gas discharged from the turbulent fluidized-bed reactor (1) is: 32 wt.% propylene, 24 wt.% C4 hydrocarbons, 31 wt.% light fractions, 2 wt.% propane and 11 wt.% hydrocarbons with 5 or more carbons. The light fractions contain 97 wt.% ethylene and 3 wt.% methane, ethane, hydrogen, CO, CO_2, and the like.

[0052] The composition of the product gas discharged from the separation system is: 46 wt.% propylene, 34 wt.% C4 hydrocarbons, 1 wt.% light fractions, 3 wt.% propane and 16 wt.% hydrocarbons with 5 or more carbons.

[0053] The present example is different from Example 1 (comparative example) merely in that the regenerated catalyst enters the bottom of the turbulent fluidized-bed reactor and contacts firstly with the light fractions, while in Example 1, the regenerated catalyst enters the settling zone of the turbulent fluidized-bed reactor. Comparing the present example with Example 1, it can be seen that the conversion rate of light fractions can be greatly improved when the catalyst is contacted firstly with the light fractions. The light fractions discharged from the separation system in present example is only 11% of that in the comparative example. Therefore, the device of the present invention effectively improves the reaction rate of ethylene alkylation.

Example 3

[0054] The device shown in Fig. 1 is used. The turbulent fluidized-bed reactor (1) contains four reactor feed distributors (3-1~3-4), the reactor gas-solid separator 1 (4) is placed in the settling zone, and the horizontal height of the inlet of the reactor stripper (8) is at 3/4 height of the reaction zone. The reaction conditions in the reaction zone of the turbulent fluidized-bed reactor (1) are as follows: the apparent linear velocity of gas is about 1.2 m/s, the reaction temperature is about 360□, the reaction pressure is about 200 kPa, and the bed density is about 300 kg/m^3.

[0055] The reaction conditions in the regeneration zone of the fluidized-bed regenerator (14) are as follows: the apparent linear velocity of gas is about 1.2 m/s, the regeneration temperature is about 700 □, the regeneration pressure is about 200 kPa, and the bed density is about 300 kg/m^3.

[0056] The catalyst contains a SAPO molecular sieve. The carbon content of the spent catalyst is about 8%, and the carbon content of the regenerated catalyst is about 0.1 wt.%.

[0057] The oxygen-containing compound is methanol, and the regeneration medium is air; the reactor stripping gas, the regenerator stripping gas, the spent catalyst lifting gas and the regenerated catalyst lifting gas are water vapor.

[0058] The circulating amount of the light fractions is 16 wt.% of the feeding amount of methanol, and 90 wt.% of the light fractions are circulated in the system.

[0059] The composition of the product gas discharged from the turbulent fluidized-bed reactor (1) is: 34 wt.% propylene, 25 wt.% C4 hydrocarbons, 29 wt.% light fractions, 2 wt.% propane and 10 wt.% hydrocarbons with 5 or more carbons. The light fractions contain 98 wt.% ethylene and 2 wt.% methane, ethane, hydrogen, CO, CO_2, and the like.

[0060] The composition of the product gas discharged from the separation system is: 46 wt.% propylene, 34 wt.% C4 hydrocarbons, 4 wt.% light fractions, 3 wt.% propane and 13 wt.% hydrocarbons with 5 or more carbons.

Example 4

[0061] The device shown in Fig. 1 is used. The turbulent fluidized-bed reactor (1) contains six reactor feed distributors (3-1~3-6), the reactor gas-solid separator 1 (4) is placed in the settling zone, and the horizontal height of the inlet of the reactor stripper (8) is at 5/6 height of the reaction zone. The reaction conditions in the reaction zone of the turbulent fluidized-bed reactor (1) are as follows: the apparent linear velocity of gas is about 1.5 m/s, the reaction temperature is about 420 □, the reaction pressure is about 250 kPa, and the bed density is about 250 kg/m^3.

[0062] The reaction conditions in the regeneration zone of the fluidized-bed regenerator (14) are as follows: the apparent linear velocity of gas is about 1.5m/s, the regeneration temperature is about 700 □, the regeneration pressure is about 250 kPa, and the bed density is about 250 kg/m^3.

[0063] The catalyst contains a SAPO molecular sieve. The carbon content of the spent catalyst is about 9%, and the carbon content of the regenerated catalyst is about 0.05 wt.%.

[0064] The oxygen-containing compound is dimethyl ether, and the regeneration medium is oxygen-poor air; the reactor stripping gas, the regenerator stripping gas, the spent catalyst lifting gas and the regenerated catalyst lifting gas are nitrogen.

[0065] The circulating amount of the light fractions is 14 wt.% of the feeding amount of dimethyl ether, and 85 wt.% of the light fractions are circulated in the system.

[0066] The composition of the product gas discharged from the turbulent fluidized-bed reactor (1) is: 38 wt.% propylene, 30 wt.% C4 hydrocarbons, 21 wt.% light fractions, 2 wt.% propane and 9 wt.% hydrocarbons with 5 or more carbons. The light fractions contain 98 wt.% ethylene and 2 wt.% methane, ethane, hydrogen, CO, CO_2, and the like.

[0067] The composition of the product gas discharged from the separation system is: 46 wt.% propylene, 37 wt.% C4 hydrocarbons, 4 wt.% light fractions, 2 wt.% propane and 11 wt.% hydrocarbons with 5 or more carbons.

Claims

1. A turbulent fluidized-bed reactor for preparing propylene and C4 hydrocarbons from oxygen-containing compounds, comprising a reactor shell, n reactor feed distributors, a first reactor gas-solid separator, a second reactor gas-solid separator, a reactor heat extractor, a product gas outlet and a reactor stripper, wherein the lower part of the turbulent fluidized-bed reactor is a reaction zone, the upper part of the turbulent fluidized-bed reactor is a settling zone, the n reactor feed distributors are disposed in the reaction zone, the reactor heat extractor is disposed in the reaction zone, the first reactor gas-solid separator and the second reactor gas-solid separator are placed in the settling zone or outside the reactor shell, the first reactor gas-solid separator is equipped with a regenerated catalyst inlet, the catalyst outlet of the first reactor gas-solid separator is located at the bottom of the reaction zone, the gas outlet of the first reactor gas-solid separator is located in the settling zone, the inlet of the second reactor gas-solid separator is located in the settling zone, the catalyst outlet of the second reactor gas-solid separator is placed in the reaction zone, the gas outlet of the second reactor gas-solid separator is connected to the product gas outlet, the reactor stripper passes through the reactor shell from outside to inside at the bottom of the turbulent fluidized-bed reactor and is opened in the reaction zone of the turbulent fluidized-bed reactor, a reactor stripping gas inlet is arranged at the bottom of the reactor stripper, and a spent catalyst outlet is arranged at the bottom of the reactor stripper;

wherein the n reactor feed distributors are disposed in the reaction zone from bottom to top, and $0<n<10$.

2. The turbulent fluidized-bed reactor according to claim 1, wherein the horizontal height of opening of the reactor stripper in the reactor shell is higher than 1/10 the height of the reaction zone.

3. The turbulent fluidized-bed reactor according to claim 1, wherein the first reactor gas-solid separator and the second reactor gas-solid separator are cyclone separators.

4. A device for preparing propylene and C4 hydrocarbons from oxygen-containing compounds, comprising the turbulent fluidized-bed reactor according to any one of claims 1 to 3 and a fluidized-bed regenerator for regenerating a catalyst.

5. The device according to claim 4, wherein the fluidized-bed regenerator is a turbulent fluidized-bed regenerator.

6. The device according to claim 4, wherein the fluidized-bed regenerator comprises a regenerator shell, a regenerator feed distributor, a regenerator gas-solid separator, a regenerator heat extractor, a flue gas outlet and a regenerator stripper, in which the lower part of the fluidized-bed regenerator is a regeneration zone, the upper part of the fluidized-bed regenerator is a settling zone, the regenerator feed distributor is placed at the bottom of the regeneration zone, the regenerator heat extractor is placed in the regeneration zone, the regenerator gas-solid separator is placed in the settling zone or outside the regenerator shell, the inlet of the regenerator gas-solid separator is disposed in the settling zone, the catalyst outlet of the regenerator gas-solid separator is disposed in the regeneration zone, the gas outlet of the regenerator gas-solid separator is connected to the flue gas outlet, and the regenerator stripper is opened at the bottom of the regenerator shell;

    the spent catalyst outlet of the reactor stripper is connected to the inlet of a inclined spent catalyst pipe, a spent catalyst sliding valve is arranged in the inclined spent catalyst pipe, the outlet of the inclined spent catalyst pipe is connected to the inlet of a spent catalyst lift pipe, the bottom of the spent catalyst lift pipe is provided with a spent catalyst lifting gas inlet, and the outlet of the spent catalyst lift pipe is connected to the settling zone of the fluidized-bed regenerator;
    the bottom of the regenerator stripper is provided with a regenerator stripping gas inlet, the bottom of the regenerator stripper is connected to the inlet of a inclined regenerated catalyst pipe, a regenerated catalyst sliding valve is arranged in the inclined regenerated catalyst pipe, the outlet of the inclined regenerated catalyst pipe is connected to the inlet of a regenerated catalyst lift pipe, the bottom of the regenerated catalyst lift pipe is provided with a regenerated catalyst lifting gas inlet, and the outlet of the regenerated catalyst lift pipe is connected to the regenerated catalyst inlet of the first reactor gas-solid separator.

7. A method for preparing propylene and C4 hydrocarbons from oxygen-containing compounds, including:

    feeding a raw material containing an oxygen-containing compound from n reactor feed distributors to a reaction zone of a turbulent fluidized-bed reactor, and contacting the raw material with a catalyst, to generate a stream containing propylene and C4 hydrocarbons product and a spent catalyst containing carbon;
    sending the stream discharged from the turbulent fluidized-bed reactor containing propylene and C4 hydrocarbons product into a product separation system, obtaining propylene, C4 hydrocarbons, light fractions, propane and hydrocarbons with 5 or more carbons after separation, wherein the light fractions contain more than 90 wt% of ethylene and a small amount of methane, ethane, hydrogen, CO and CO_2, returning 70 wt.% or more of the light fractions to the reaction zone of the turbulent fluidized-bed reactor from the reactor feed distributor at the bottom-most of the turbulent fluidized-bed reactor, and reacting ethylene and the oxygen-containing compounds to perform an alkylation reaction in presence of the catalyst, to produce a product containing propylene;
    regenerating the spent catalyst by a fluidized-bed regenerator, and after being gas-solid separated by a first reactor gas-solid separator, the regenerated catalyst is fed to the bottom of the reaction zone of the turbulent fluidized-bed reactor;
    wherein the method is carried out by using the device according to any one of claims 5 to 6;
    wherein the spent catalyst passes through the reactor stripper, the inclined spent catalyst pipe, the spent catalyst sliding valve and the spent catalyst lift pipe into the settling zone of the fluidized-bed regenerator;
    a regeneration medium enters the regeneration zone of the fluidized-bed regenerator and
    reacts with the spent catalyst to perform calcination to produce a flue gas containing CO and CO_2 and the regenerated catalyst, and the flue gas is discharged after dust removal by the regenerator gas-solid separator;
    the regenerated catalyst passes through the regenerator stripper, the inclined regenerated catalyst pipe, the regenerated catalyst sliding valve

and the regenerated catalyst lift pipe into the inlet of the first reactor gas-solid separator, and after gas-solid separation, the regenerated catalyst enters the bottom of the reaction zone of the turbulent fluidized-bed reactor;
a reactor stripping gas enters the reactor stripper via the reactor stripping gas inlet and contacts countercurrent with the spent catalyst, and then enters the turbulent fluidized-bed reactor; a spent catalyst lifting gas enters the spent catalyst lift pipe via the spent catalyst lifting gas inlet and contacts cocurrent with the spent catalyst, and then enters the settling zone of the fluidized-bed regenerator;
a regenerator stripping gas enters the regenerator stripper via the regenerator stripping gas inlet and contacts countercurrent with the regenerated catalyst, and then enters the fluidized-bed regenerator; a regenerated catalyst lifting gas enters the regenerated catalyst lift pipe via the regenerated catalyst lifting gas inlet and contacts cocurrent with the regenerated catalyst, and then enters the inlet of the first reactor gas-solid separator; wherein the reaction conditions in the reaction zone of the turbulent fluidized-bed reactor are: the apparent linear velocity of gas is in a range from 0.1 m/s to 2 m/s, the reaction temperature is in a range from 300°C to 550°C, the reaction pressure is in a range from 100 kPa to 500 kPa, and the bed density is in a range from 200 kg/m^3 to 1200 kg/m^3;
wherein the reaction conditions in the regeneration zone of the fluidized-bed regenerator are: the apparent linear velocity of gas is in a range from 0.1 m/s to 2 m/s, the regeneration temperature is in a range from 500°C to 750°C, the regeneration pressure is in a range from 100 kPa to 500 kPa, and the bed density is in a range from 200 kg/m^3 to 1200 kg/m^3.

8. The method according to claim 8, wherein the circulating amount of the light fractions is 5-40 wt.% of the feeding amount of the oxygen-containing compound.

9. The method according to claim 8, wherein the carbon content of the spent catalyst is 5-12 wt.%, and the carbon content of the regenerated catalyst is less than 2 wt.%.

10. The method according to claim 7, wherein the oxygen-containing compound is methanol and/or dimethyl ether; and/or the regeneration medium is any one of air, oxygen-poor air or water vapor or a mixture thereof; and/or the reactor stripping gas, the regenerator stripping gas, the spent catalyst lifting gas and the regenerated catalyst lifting gas are water vapor or nitrogen.

Patentansprüche

1. Turbulenter Wirbelschichtreaktor zur Herstellung von Propylen und C4-Kohlenwasserstoffen aus sauerstoffhaltigen Verbindungen, der Folgendes aufweist, nämlich eine Reaktorschale, n Reaktorzuführverteiler, einen ersten Reaktor Gas-Feststoff-Abscheider, einen zweiten Reaktor Gas-Feststoff-Abscheider, einen Reaktorwärmetauscher, einen Produktgasauslass und einen Reaktorstripper, wobei der untere Teil des turbulenten Wirbelschichtreaktors eine Reaktionszone ist, der obere Teil des turbulenten Wirbelschichtreaktors eine Absetzzone ist, die n Reaktorzuführverteiler in der Reaktionszone angeordnet sind, der Reaktorwärmetauscher in der Reaktionszone angeordnet ist, der erste Reaktor Gas-Feststoff-Abscheider und der zweite Reaktor Gas-Feststoff-Abscheider in der Absetzzone oder außerhalb der Reaktorschale platziert sind, der erste Reaktor Gas-Feststoff-Abscheider mit einem regenerierten Katalysatorzulauf ausgestattet ist, der Katalysatorauslass des ersten Reaktor Gas-Feststoff-Abscheiders sich am Boden der Reaktionszone befindet, der Gasauslass des ersten Reaktor Gas-Feststoff-Abscheiders sich in der Absetzzone befindet, der Einlass des zweiten Reaktor Gas-Feststoff-Abscheiders sich in der Absetzzone befindet, der Katalysatorauslass des zweiten Reaktor Gas-Feststoff-Abscheiders in der Reaktionszone platziert ist, der Gasauslass des zweiten Reaktor Gas-Feststoff-Abscheiders mit dem Produktgasauslass verbunden ist, der Reaktorstripper durch die Reaktorschale von außen nach innen am Boden des turbulenten Wirbelschichtreaktors führt und in der Reaktionszone des turbulenten Wirbelschichtreaktors geöffnet ist, ein Reaktorstrippinggas-Einlass am Boden des Reaktorstrippers angeordnet ist und ein verbrauchter Katalysatorauslass am Boden des Reaktorstrippers angeordnet ist; wobei die n Reaktorzuführverteiler in der Reaktionszone von unten nach oben angeordnet sind und 0 < n < 10.

2. Turbulenter Wirbelschichtreaktor gemäß Anspruch 1, wobei die horizontale Höhe der Öffnung des Reaktorstrippers in der Reaktorschale höher als 1/10 der Höhe der Reaktionszone ist.

3. Turbulente Wirbelschichtreaktor gemäß Anspruch 1, wobei der erste Reaktor Gas-Feststoff-Abscheider und der zweite Reaktor Gas-Feststoff-Abscheider Zyklonabscheider sind.

4. Vorrichtung zur Herstellung von Propylen und C4-Kohlenwasserstoffen aus sauerstoffhaltigen Verbindungen, die den turbulenten Wirbelschichtreaktor gemäß einem der Ansprüche 1 bis 3 und einen Wirbelschichtregenerator zur Regeneration eines Katalysators aufweist.

5. Vorrichtung gemäß Anspruch 4, wobei der Wirbelschichtregenerator ein turbulenter Wirbelschichtregenerator ist.

6. Vorrichtung gemäß Anspruch 4, wobei der Wirbelschichtregenerator Folgendes aufweist, nämlich eine Regeneratorschale, einen Regeneratorzuführverteiler, einen Regenerator Gas-Feststoff-Abscheider, einen Regeneratorwärmetauscher, einen Abgas-Auslass und einen Regeneratorstripper, in dem der untere Teil des Wirbelschichtregenerators eine Regenerationszone ist, der obere Teil des Wirbelschichtregenerators eine Absetzzone ist, der Regeneratorzuführverteiler am Boden der Regenerationszone platziert ist, der Regeneratorwärmetauscher in der Regenerationszone platziert ist, der Regenerator Gas-Feststoff-Abscheider in der Absetzzone oder außerhalb der Regeneratorschale platziert ist, der Einlass des Regenerator Gas-Feststoff-Abscheiders in der Absetzzone angeordnet ist, der Katalysatorauslass des Regenerator Gas-Feststoff-Abscheiders in der Regenerationszone angeordnet ist, der Gasauslass des Regenerator Gas-Feststoff-Abscheiders mit dem Abgasauslass verbunden ist und der Regeneratorstripper am Boden der Regeneratorschale geöffnet ist;

der verbrauchte Katalysatorauslass des Reaktorstrippers ist mit dem Einlass eines geneigten verbrauchten Katalysatorrohrs verbunden, ein verbrauchtes Katalysator-Schiebeventil ist im geneigten verbrauchten Katalysatorrohr angeordnet, der Auslass des geneigten verbrauchten Katalysatorrohrs ist mit dem Einlass eines verbrauchten Katalysatorförderrohrs verbunden, der Boden des verbrauchten Katalysatorförderrohrs ist mit einem verbrauchten Katalysator-Fördergaseinlass ausgestattet und der Auslass des verbrauchten Katalysatorförderrohrs ist mit der Absetzzone des Wirbelschichtregenerators verbunden;

der Boden des Regeneratorstrippers ist mit einem Regeneratorstrippinggas-Einlass ausgestattet, der Boden des Regeneratorstrippers ist mit dem Einlass eines geneigten regenerierten Katalysatorrohrs verbunden, ein regeneriertes Katalysator-Schiebeventil ist im geneigten regenerierten Katalysatorrohr angeordnet, der Auslass des geneigten regenerierten Katalysatorrohrs ist mit dem Einlass eines regenerierten Katalysatorförderrohrs verbunden, der Boden des regenerierten Katalysatorförderrohrs ist mit einem regenerierten Katalysator-Fördergaseinlass ausgestattet und der Auslass des regenerierten Katalysatorförderrohrs ist mit dem Einlass des ersten Reaktor Gas-Feststoff-Abscheiders verbunden.

7. Verfahren zur Herstellung von Propylen und C4-Kohlenwasserstoffen aus sauerstoffhaltigen Verbindungen, das folgende Schritte aufweist:

Zuführen eines Rohmaterials, das eine sauerstoffhaltige Verbindung enthält, aus n Reaktorzuführverteilern zu einer Reaktionszone eines turbulenten Wirbelschichtreaktors und Kontaktieren des Rohmaterials mit einem Katalysator, um einen Strom zu erzeugen, der Propylen und C4-Kohlenwasserstoffprodukte sowie einen verbrauchten Katalysator mit Kohlenstoff enthält;

Zuführen des aus dem turbulenten Wirbelschichtreaktor austretenden Stroms, der Propylen und C4-Kohlenwasserstoffprodukte enthält, in ein Produkttennsystem, wobei Propylen, C4-Kohlenwasserstoffe, leichte Fraktionen, Propan und Kohlenwasserstoffe mit 5 oder mehr Kohlenstoffatomen nach der Trennung gewonnen werden, wobei die leichten Fraktionen mehr als 90 Gew.-% Ethylen und eine kleine Menge Methan, Ethan, Wasserstoff, CO und CO_2 enthalten, und wobei 70 Gew.-% oder mehr der leichten Fraktionen in die Reaktionszone des turbulenten Wirbelschichtreaktors aus dem Reaktorzuführverteiler am unteren Ende des turbulenten Wirbelschichtreaktors zurückgeführt werden und Ethylen und die sauerstoffhaltigen Verbindungen in Gegenwart des Katalysators eine Alkylierungsreaktion durchlaufen, um ein Produkt, das Propylen enthält, zu erzeugen;

Regenerieren des verbrauchten Katalysators durch einen Wirbelschichtregenerator, und nach Gas-Feststoff-Trennung durch einen ersten Reaktor Gas-Feststoff-Abscheider wird der regenerierte Katalysator in den Boden der Reaktionszone des turbulenten Wirbelschichtreaktors geführt;

wobei das Verfahren unter Verwendung der Vorrichtung gemäß einem der Ansprüche 5 bis 6 durchgeführt wird;

wobei der verbrauchte Katalysator durch den Reaktorstripper, das geneigte verbrauchte Katalysatorrohr, das verbrauchte Katalysator-Schiebeventil und das verbrauchte Katalysatorförderrohr in die Absetzzone des Wirbelschichtregenerators gelangt;

ein Regenerationsmedium tritt in die Regenerationszone des Wirbelschichtregenerators ein und reagiert mit dem verbrauchten Katalysator zur Durchführung einer Kalzinierung zur Erzeugung eines Abgases, das CO und CO_2 enthält, und der regenerierte Katalysator sowie das Abgas werden nach Staubabscheidung durch den Regenerator Gas-Feststoff-Abscheider abgeleitet;

der regenerierte Katalysator passiert den Regeneratorstripper, das geneigte regenerierte Katalysatorrohr, das regenerierte Katalysator-Schiebeventil und das regenerierte Katalysatorförderrohr in den Einlass des ersten Reaktor Gas-Feststoff-Abscheiders und nach Gas-Feststoff-Trennung gelangt der regenerierte Katalysator in den Boden der Reaktionszone des turbulenten Wirbelschichtreaktors;

ein Reaktorstrippinggas tritt über den Reaktorstrippinggas-Einlass in den Reaktorstripper ein und tritt gegenläufig mit dem verbrauchten Katalysator in Kontakt und gelangt dann in den turbulenten Wirbelschichtreaktor; ein verbrauchtes Katalysator-Fördergas tritt über den verbrauchten Katalysator-Fördergaseinlass in das verbrauchte Katalysatorförderrohr ein und tritt gleichläufig mit dem verbrauchten Katalysator in Kontakt und gelangt dann in die Absetzzone des Wirbelschichtregenerators;

ein Regeneratorstrippinggas tritt über den Regeneratorstrippinggas-Einlass in den Regeneratorstripper ein und tritt gegenläufig mit dem regenerierten Katalysator in Kontakt und gelangt dann in den Wirbelschichtregenerator; ein regeneriertes Katalysator-Fördergas tritt über den regenerierten Katalysator-Fördergaseinlass in das regenerierte Katalysatorförderrohr ein und tritt gleichläufig mit dem regenerierten Katalysator in Kontakt und gelangt dann in den Einlass des ersten Reaktor Gas-Feststoff-Abscheiders;

wobei die Reaktionsbedingungen in der Reaktionszone des turbulenten Wirbelschichtreaktors folgende sind: die scheinbare lineare Geschwindigkeit des Gases liegt im Bereich von 0,1 m/s bis 2 m/s, die Reaktionstemperatur liegt im Bereich von 300 °C bis 550 °C, der Reaktionsdruck liegt im Bereich von 100 kPa bis 500 kPa und die Bettendichte liegt im Bereich von 200 kg/m^3 bis 1200 kg/m^3;

wobei die Reaktionsbedingungen in der Regenerationszone des Wirbelschichtregenerators folgende sind: die scheinbare lineare Geschwindigkeit des Gases liegt im Bereich von 0,1 m/s bis 2 m/s, die Regenerationstemperatur liegt im Bereich von 500 °C bis 750 °C, der Regenerationsdruck liegt im Bereich von 100 kPa bis 500 kPa und die Bettendichte liegt im Bereich von 200 kg/m^3 bis 1200 kg/m^3.

8. Verfahren gemäß Anspruch 7, wobei die Umlaufmenge der leichten Fraktionen 5-40 Gew.-% der Zuführmenge der sauerstoffhaltigen Verbindung beträgt.

9. Verfahren gemäß Anspruch 7, wobei der Kohlenstoffgehalt des verbrauchten Katalysators 5-12 Gew.-% beträgt und der Kohlenstoffgehalt des regenerierten Katalysators weniger als 2 Gew.-% beträgt.

10. Verfahren gemäß Anspruch 7, wobei die sauerstoffhaltige Verbindung Methanol und/oder Dimethylether ist; und/oder das Regenerationsmedium ist eines von Luft, sauerstoffarme Luft oder Wasserdampf oder ein Gemisch davon; und/oder das Reaktorstrippinggas, das Regeneratorstrippinggas, das verbrauchte Katalysator-Fördergas und das regenerierte Katalysator-Fördergas sind Wasserdampf oder Stickstoff.

Revendications

1. Réacteur à lit fluidisé turbulent pour préparer du propylène et des hydrocarbures en C4 à partir de composés contenant de l'oxygène, comprenant une enveloppe du réacteur, n distributeurs d'alimentation du réacteur, un premier séparateur gaz-solide du réacteur, un second séparateur gaz-solide du réacteur, un extracteur de chaleur du réacteur, une sortie de gaz produit et un stripeur du réacteur, dans lequel la partie inférieure du réacteur à lit fluidisé turbulent est une zone de réaction, la partie supérieure du réacteur à lit fluidisé turbulent est une zone de décantation, les n distributeurs d'alimentation du réacteur sont disposés dans la zone de réaction, l'extracteur de chaleur du réacteur est disposé dans la zone de réaction, le premier séparateur gaz-solide du réacteur et le second séparateur gaz-solide du réacteur sont placés dans la zone de décantation ou à l'extérieur de l'enveloppe du réacteur, le premier séparateur gaz-solide du réacteur est équipé d'une entrée de catalyseur régénéré, la sortie de catalyseur du premier séparateur gaz-solide du réacteur est située au fond de la zone de réaction, la sortie de gaz du premier séparateur gaz-solide du réacteur est située dans la zone de décantation, l'entrée du second séparateur gaz-solide du réacteur est située dans la zone de décantation, la sortie de catalyseur du second séparateur gaz-solide du réacteur est placée dans la zone de réaction, la sortie de gaz du second séparateur gaz-solide du réacteur est reliée à la sortie de gaz produit, le stripeur du réacteur traverse l'enveloppe du réacteur de l'extérieur vers l'intérieur au fond du réacteur à lit fluidisé turbulent et est ouvert dans la zone de réaction du réacteur à lit fluidisé turbulent, une entrée de gaz de stripage du réacteur est agencée au fond du stripeur du réacteur, et une sortie de catalyseur épuisé est agencée au fond du stripeur du réacteur ;

dans lequel les n distributeurs d'alimentation du réacteur sont disposés dans la zone de réaction, de bas en haut, et 0<n<10.

2. Réacteur à lit fluidisé turbulent selon la revendication

1, dans lequel la hauteur horizontale d'ouverture du stripeur du réacteur dans l'enveloppe du réacteur est supérieure à 1/1o^{e} de la hauteur de la zone de réaction.

3. Réacteur à lit fluidisé turbulent selon la revendication 1, dans lequel le premier séparateur gaz-solide du réacteur et le second séparateur gaz-solide du réacteur sont des séparateurs cycloniques.

4. Dispositif pour préparer du propylène et des hydrocarbures en C4 à partir de composés contenant de l'oxygène, comprenant le réacteur à lit fluidisé turbulent selon l'une quelconque des revendications 1 à 3 et un régénérateur à lit fluidisé pour régénérer un catalyseur.

5. Dispositif selon la revendication 4, dans lequel le régénérateur à lit fluidisé est un régénérateur à lit fluidisé turbulent.

6. Dispositif selon la revendication 4, dans lequel le régénérateur à lit fluidisé comprend une enveloppe du régénérateur, un distributeur d'alimentation du régénérateur, un séparateur gaz-solide du régénérateur, un extracteur de chaleur du régénérateur, une sortie de gaz de combustion et un stripeur du régénérateur, dans lequel la partie inférieure du régénérateur à lit fluidisé est une zone de régénération, la partie supérieure du régénérateur à lit fluidisé est une zone de décantation, le distributeur d'alimentation du régénérateur est placé au fond de la zone de régénération, l'extracteur de chaleur du régénérateur est placé dans la zone de régénération, le séparateur gaz-solide du régénérateur est placé dans la zone de décantation ou à l'extérieur de l'enveloppe du régénérateur, l'entrée du séparateur gaz-solide du régénérateur est disposée dans la zone de décantation, la sortie de catalyseur du séparateur gaz-solide du régénérateur est disposée dans la zone de régénération, la sortie de gaz du séparateur gaz-solide du régénérateur est reliée à la sortie de gaz de combustion, et le stripeur du régénérateur est ouvert au fond de l'enveloppe du régénérateur ;

la sortie du catalyseur épuisé du stripeur du réacteur est reliée à l'entrée d'une conduite inclinée du catalyseur épuisé, une vanne à tiroir du catalyseur épuisé est agencée dans la conduite inclinée du catalyseur épuisé, la sortie de la conduite inclinée du catalyseur épuisé est reliée à l'entrée d'une conduite de levage du catalyseur épuisé, le fond de la conduite de levage du catalyseur épuisé est pourvu d'une entrée de gaz de levage du catalyseur épuisé, et la sortie de la conduite de levage du catalyseur épuisé est reliée à la zone de décantation du régénérateur à lit fluidisé ;

le fond du stripeur du régénérateur est pourvu d'une entrée de gaz de stripage du régénérateur, le fond du stripeur du régénérateur est relié à l'entrée d'une conduite inclinée du catalyseur régénéré, une vanne à tiroir du catalyseur régénéré est agencée dans la conduite inclinée du catalyseur régénéré, la sortie de la conduite inclinée du catalyseur régénéré est reliée à l'entrée d'une conduite de levage du catalyseur régénéré, le fond de la conduite de levage du catalyseur régénéré est pourvu d'une entrée de gaz de levage du catalyseur régénéré, et la sortie de la conduite de levage du catalyseur régénéré est reliée à l'entrée du catalyseur régénéré du premier séparateur gaz-solide du réacteur.

7. Procédé pour préparer du propylène et des hydrocarbures en C4 à partir de composés contenant de l'oxygène, comprenant :

l'alimentation d'une matière première contenant un composé contenant de l'oxygène à partir de n distributeurs d'alimentation du réacteur vers une zone de réaction d'un réacteur à lit fluidisé turbulent, et la mise en contact de la matière première avec un catalyseur, afin de générer un flux contenant du propylène et des hydrocarbures en C4 et un catalyseur épuisé contenant du carbone ;
l'envoi du flux évacué du réacteur à lit fluidisé turbulent contenant un produit de propylène et d'hydrocarbures en C4 dans un système de séparation de produits, l'obtention de propylène, d'hydrocarbures en C4, de fractions légères, de propane et d'hydrocarbures contenant 5 carbones ou plus après séparation, dans lesquelles les fractions légères contiennent plus de 90% en poids d'éthylène et une petite quantité de méthane, d'éthane, d'hydrogène, de CO et de CO_2, le renvoi de 70% en poids ou plus des fractions légères vers la zone de réaction du réacteur à lit fluidisé turbulent à partir du distributeur d'alimentation du réacteur situé à l'extrémité inférieure du réacteur à lit fluidisé turbulent, et la mise en réaction de l'éthylène et des composés contenant de l'oxygène pour réaliser une réaction d'alkylation en présence du catalyseur, afin de produire un produit contenant du propylène ;
la régénération du catalyseur épuisé par un régénérateur à lit fluidisé et, après séparation gaz-solide par un premier séparateur gaz-solide du réacteur, le catalyseur régénéré est alimenté vers le fond de la zone de réaction du réacteur à lit fluidisé turbulent ;
dans lequel le procédé est effectué en utilisant le dispositif selon l'une quelconque des revendications 5 à 6 ;
dans lequel le catalyseur épuisé traverse le stri-

peur du réacteur, la conduite inclinée du catalyseur épuisé, la vanne à tiroir du catalyseur épuisé et la conduite de levage du catalyseur épuisé dans la zone de décantation du régénérateur à lit fluidisé ;
un milieu de régénération pénètre dans la zone de régénération du régénérateur à lit fluidisé et réagit avec le catalyseur épuisé pour réaliser une calcination afin de produire un gaz de combustion contenant du CO et du CO_2 et le catalyseur régénéré, et le gaz de combustion est évacué après dépoussiérage par le séparateur gaz-solide du régénérateur ;
le catalyseur régénéré traverse le stripeur du régénérateur, la conduite inclinée du catalyseur régénéré, la vanne à tiroir du catalyseur régénéré et la conduite de levage du catalyseur régénéré dans l'entrée du premier séparateur gaz-solide du réacteur et, après une séparation gaz-solide, le catalyseur régénéré pénètre dans le fond de la zone de réaction du réacteur à lit fluidisé turbulent ;
un gaz de stripage du réacteur pénètre dans le stripeur du réacteur via l'entrée de gaz de stripage du réacteur et entre en contact à contre-courant avec le catalyseur épuisé, puis pénètre dans le réacteur à lit fluidisé turbulent ;
un gaz de levage du catalyseur épuisé pénètre dans la conduite de levage du catalyseur épuisé via l'entrée de gaz de levage du catalyseur épuisé et entre en contact à co-courant avec le catalyseur épuisé, puis pénètre dans la zone de décantation du régénérateur à lit fluidisé ;
un gaz de stripage du régénérateur pénètre dans le stripeur du régénérateur via l'entrée de gaz de stripage du régénérateur et entre en contact à contre-courant avec le catalyseur régénéré, puis pénètre dans le régénérateur à lit fluidisé ;
un gaz de levage du catalyseur régénéré pénètre dans la conduite de levage du catalyseur régénéré via l'entrée de gaz de levage du catalyseur régénéré et entre en contact à co-courant avec le catalyseur régénéré, puis pénètre dans l'entrée du premier séparateur gaz-solide du réacteur ;
dans lequel les conditions de réaction dans la zone de réaction du réacteur à lit fluidisé turbulent sont : la vitesse linéaire apparente du gaz est comprise entre 0,1 m/s et 2 m/s, la température de réaction est comprise entre 300°C et 550°C, la pression de réaction est comprise entre 100 kPa et 500 kPa, et la densité du lit est comprise entre 200 kg/m^3 et 1200 kg/m^3;
dans lequel les conditions de réaction dans la zone de régénération du régénérateur à lit fluidisé sont : la vitesse linéaire apparente du gaz est comprise entre 0,1 m/s et 2 m/s, la température de régénération est comprise entre 500°C et 750°C, la pression de régénération est comprise entre 100 kPa et 500 kPa, et la densité du lit est comprise entre 200 kg/m^3 et 1200 kg/m^3.

8. Procédé selon la revendication 8, dans lequel la quantité circulante des fractions légères est de 5 à 40% en poids de la quantité d'alimentation du composé contenant de l'oxygène.

9. Procédé selon la revendication 8, dans lequel la teneur en carbone du catalyseur épuisé est de 5 à 12% en poids, et la teneur en carbone du catalyseur régénéré est inférieure à 2% en poids.

10. Procédé selon la revendication 7, dans lequel le composé contenant de l'oxygène est le méthanol et/ou le diméthyléther ; et/ou le milieu de régénération est l'un quelconque parmi l'air, l'air appauvri en oxygène ou la vapeur d'eau ou un de leurs mélanges ; et/ou le gaz de stripage du réacteur, le gaz de stripage du régénérateur, le gaz de levage du catalyseur épuisé et le gaz de levage du catalyseur régénéré sont de la vapeur d'eau ou de l'azote.

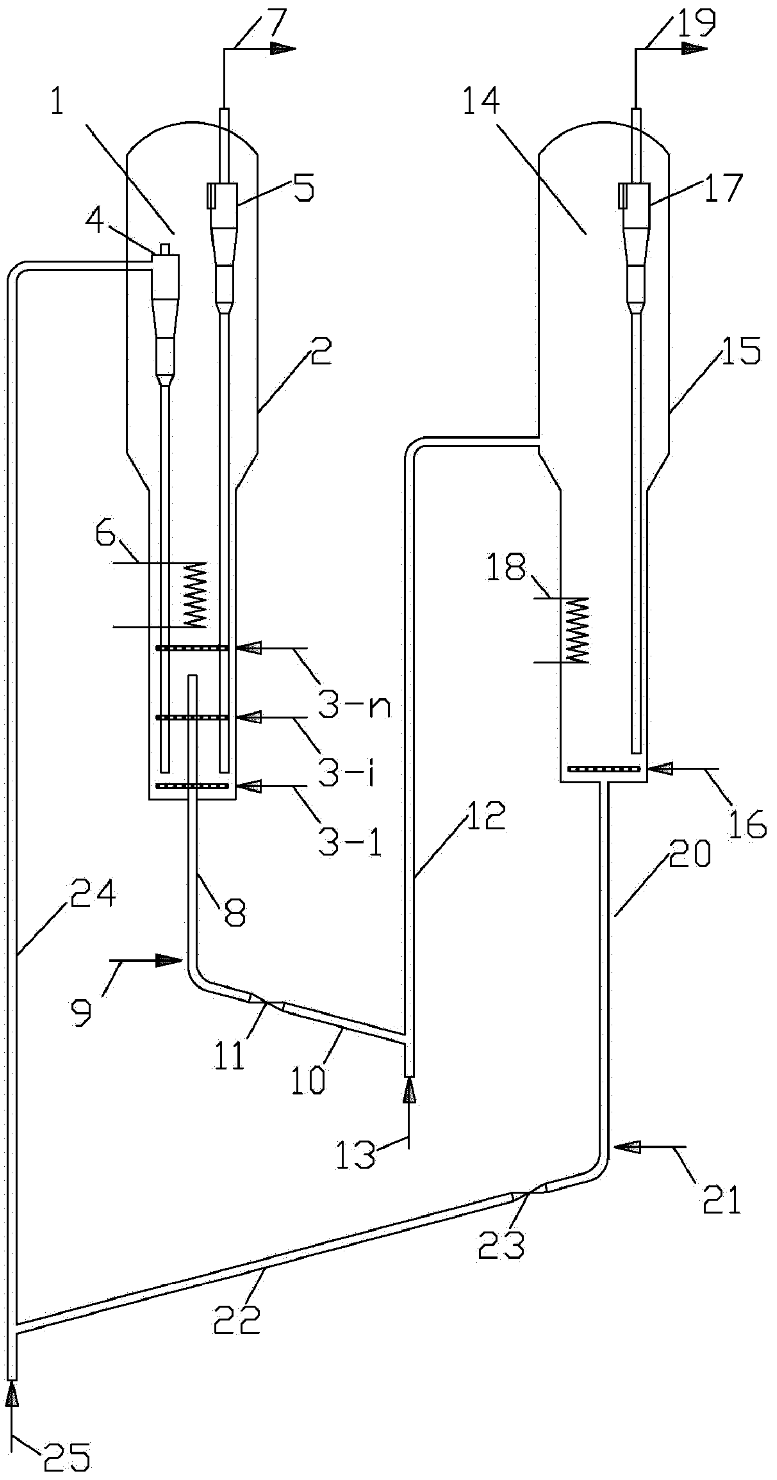

Figure 1

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 2004018089 A **[0003]**
- CN 104098429 A **[0005] [0007] [0010]**
- CN 101177374 B **[0006] [0007] [0010]**
- CN 104672045 **[0011]**