Claims

1. A fluidized bed reactor, comprising a shell, a gas distributor, and an inner chamber defined by an inner wall of said shell and an upper surface of said gas distributor, said inner chamber has a bottom, corresponding to the upper surface of said gas distributor, and a top, wherein along the central axis direction of said fluidized bed reactor, assuming the vertical distance between the bottom and the top is H, the unit is m, the region of inner chamber from the bottom and upwards to 0.1H, 0.2H, 0.3H, 0.4H, 0.5H, 0.6H, 0.7H or 0.8H is the lower region, the region of inner chamber from the top and downward to 0.1H, 0.2H, 0.3H, 0.4H, 0.5H, 0.6H, 0.7H or 0.8H is the upper region, and the region of inner chamber between the lower region and the upper region is the middle region, the height of the middle region along the central axis direction of said fluidized bed reactor is 0.005H-0.2H, 0.005H-0.05H or 0.005H-0.02H, in the middle region is disposed a perforated plate ; the perforated plate includes an outer edge region and a center region, wherein straight-line distance between any point on the peripheric edge of the perforated plate and the center point of the perforated plate is R , the region surrounded by all points that are on the perforated plate and away from the center point by the straight-line distance of r is referred to as the center region, the region between the center region and the peripheric edge is referred to as the outer edge region, then r/R=0.5-0.9, or R/r=2/1-9/1, (1) assuming the opening rate of the outer edge region is A1, the unit is %, assuming the opening rate of the center region is A2, the unit is %, then A1/A2=0.1-0.5, or (2) the ratio of the total opening area of the outer edge region, the unit is m^2, to the total opening area of the center region, the unit is m^2, is 1/10-1/2 or 1/5-1/2.

2. The fluidized bed reactor according to claim 1, wherein said perforated plate is selected from at least one of punched-plate, screen mesh and grid, and/or R is radius, and/or r/R= 0.7-0.85 or R/r= 2/1-5/1.

3. The fluidized bed reactor according to claim 1, wherein the axial direction height of the perforated plate from the upper surface of said gas distributor, the unit is m, is 1.05-1.5 times or 1.05-1.2 times the axial direction height of the lower region, the unit is m.

4. The fluidized bed reactor according to claim 1, wherein the number of the perforated plate is one or more, and in case of more than one, the vertical distance between any two adjacent perforated plates along the central axis direction of said fluidized bed reactor, the unit is m, is 0.001H-0.05H.

5. The fluidized bed reactor according to claim 4, wherein the number of the perforated plate is 1-5.

6. The fluidized bed reactor according to claim 1, wherein the number of opening(s) in the center region, referred to as center opening(s), is 1-650/square meter of the center region, and/or, the number of opening(s) in the outer edge region, referred to as outer edge opening(s), is 0-4000/square meter of the outer edge region, and/or, in case of more than one, the equivalent diameters for a plurality of the center openings are, identical to or different from each other, each independently 0.04-1m, and/or, in case of more than one, the equivalent diameters for a plurality of the outer edge openings are, identical to or different from each other, each independently 0.005-0.2m, and/or, the opening rate of the outer edge region is 2-40%, the opening rate of the center region is 30-100%, and/or, the perforated plate has a basically circle shape, the diameter of the circle is 1-10m, and/or, the thickness of the perforated plate is 5-40mm.

7. The fluidized bed reactor according to claim 6, wherein the number of opening(s) in the center region, is 15-150/square meter of the center region, and/or, the number of opening(s) in the outer edge region is 200-500/square meter of the outer edge region, and/or, in case of more than one, the equivalent diameters for a plurality of the center openings are, identical to or different from each other, each independently 0.04-0.1m, and/or, in case of more than one, the equivalent diameters for a plurality of the outer edge openings are, identical to or different from each other, each independently 0.005-0.03m, and/or, the opening rate of the outer edge region is 8-20%, and/or, the opening rate of the center region is 40-80%, and/or, the diameter of the circle is 2-5m, and/or, the thickness of the perforated plate is 10-35mm.

8. The fluidized bed reactor according to claim 1, wherein when the

perforated plate is placed horizontally, the shape of the cross-section formed by cutting along the vertical direction a support body separating any two adjacent openings is selected from square, triangle, rhombus, rectangle, circle, ellipse, ring and any combination of these shapes, or the shape of the cross-section formed by cutting along the vertical direction a support body separating any two adjacent openings is such that substantially no solid particles accumulate on the surface facing towards the upper region of the support body and/or is such that solid particles in contact with the surface facing towards the lower region of the support body are substantially intercepted, or the support body is curved plate-shaped or flat plate-shaped.

9. The fluidized bed reactor according to claim 8, wherein the support body is arranged vertically or arranged inclined 10-20° from the vertical direction towards the lower region.

10. The fluidized bed reactor according to claim 1, wherein the outer edge region and the center region are coaxial with the central axis of the fluidized bed reactor, and/or, the peripheric edge of the perforated plate conforms to the shape of the inner wall of the shell of the middle region, and is fixed or connected to the inner wall of said shell, and/or, the peripheric edge of the perforated plate is airtightly combined with the inner wall of the shell of the middle region.

11. The fluidized bed reactor according to claim 1, wherein the H is 5-60m, and/or, the diameter of the lower region is 0.5-12m, and/or, the diameter of the middle region is 0.5-16m.

12. The fluidized bed reactor according to claim 11, wherein the H is 10-30m, and/or, the diameter of the lower region is 1-8m, and/or, the diameter of the middle region is 1-10m.

13. The fluidized bed reactor according to claim 1, which further comprises a gas-solid separation device disposed in the upper region and a heat-exchanging device disposed in the lower region, and optionally comprises a double-trapezoid structural member disposed in the lower region.

14. The fluidized bed reactor according to claim 13, wherein the gas-solid separation device is a cyclone separator, and/or the heat-exchanging device is a heat-exchanging pipe.

15. The fluidized bed reactor according to claim 13, wherein the double-trapezoid structural member comprises an upper baffle plate, a lower baffle plate and a connecting piece for relatively fixing the upper baffle plate and the lower baffle plate, the longitudinal section of the upper baffle plate along its central axis is a trapezoid, referred to as first trapezoid, the upper base, referred to as relatively long base, and the lower base, referred to as relatively short base, of the first trapezoid are mouth-opened, two side edges, referred to as legs, mutually form an included angle to each other, the longitudinal section of the lower baffle plate along its central axis is a trapezoid, referred to as second trapezoid, the upper base, referred to as relatively short base, and the lower base, referred to as relatively long base, of the second trapezoid are mouth-opened, two side edges, referred to as legs, mutually form an included angle to each other, the opened mouth of the lower base of the first trapezoid and the opened mouth of the upper base of the second trapezoid are nested with each other.

16. The fluidized bed reactor according to claim 15, wherein the opened mouth of the upper base of the second trapezoid is nested in the opened mouth of the lower base of the first trapezoid.

17. The fluidized bed reactor according to claim 15, wherein the central axis of the upper baffle plate is coaxial with the central axis of the lower baffle plate, and/or, the included angle (α) of the two side edges of the upper baffle plate is in the range of 0-120° , the included angle (β) of the two side edges of the lower baffle plate is in the range of 0-120°, and/or, the ratio of the length of the relatively short base of the upper baffle plate to the length of the relatively short base of the lower baffle plate is greater than 1, and/or, the vertical distance between the relatively short base of the lower baffle plate and the relatively short base of the upper baffle plate, the unit is mm, is 0 to less than H1, wherein H1 is the height of the first trapezoid, the unit is mm, and/or, the height of the first trapezoid H1 is 20-150mm, the height of the second trapezoid H2 is 20-150mm.

18. The fluidized bed reactor according to claim 17, wherein the included angle (α) of the two side edges of the upper baffle plate is in the range of 0-60°, and/or the included angle (β) of the two side edges of the lower baffle plate is in the range of 45-90°, and/or, the ratio of the length of the relatively short base of the upper baffle plate to the length of the relatively short base of the lower baffle plate is 1.1-3, and/or, the vertical distance between the relatively short base of the lower baffle plate and the relatively short base of the upper baffle plate, is 0.01H1 to 0.5H1.

19. The fluidized bed reactor according to claim 15, wherein the two side edges of the upper baffle plate form a confined or unconfined curved surface around its central axis, the two side edges of the lower baffle plate form a confined or unconfined curved surface around its central axis, and/or, the opening rate of the curved surface of the upper baffle plate is 10-50%, the opening rate of the curved surface of the lower baffle plate is 3-30%,

or,

the two side edges of the upper baffle plate extend along its length direction to form two side faces, the two side edges of the lower baffle plate extend along its length direction to form two side faces, and/or, the opening rate of at least one of the two side faces of the upper baffle plate is 10-50%, the opening rate of at least one of the two side faces of the lower baffle plate is 3-30%, and/or, the size of the upper baffle plate along its length direction is 30-250mm, the size of the lower baffle plate along its length direction is 30-250mm.

20. The fluidized bed reactor according to claim 19, wherein the opening rate of the two side faces of the upper baffle plate is 10-50%, and/or the opening rate of the two side faces of the lower baffle plate is 3-30%.

21. The fluidized bed reactor according to claim 13, wherein when the number of the double-trapezoid structural member(s) is 4-240, a plurality of the double-trapezoid structural member can be all positioned in the same horizontal plane, each and every positioned in different horizontal planes or any combination thereof, and/or, the included angle in the length

direction between any two of the double-trapezoid structural members positioned in different horizontal planes and adjacent to each other in the vertical direction (γ) is 30-90°, and/or, the vertical distance between any two of the double-trapezoid structural members positioned in different horizontal planes and adjacent to each other in the vertical direction H3 is not less than 100mm, and/or, the horizontal distance between any two adjacent double-trapezoid structural members positioned in the same horizontal plane H4 is not less than 80mm.

22. The fluidized bed reactor according to claim 21, wherein the number of the double-trapezoid structural member(s) is 10-120.

23. A double-trapezoid structural member, comprising an upper baffle plate, a lower baffle plate and a connecting piece for relatively fixing the upper baffle plate and the lower baffle plate, the longitudinal section of the upper baffle plate along its central axis is a trapezoid, referred to as first trapezoid, the upper base, referred to as relatively long base, and lower base, referred to as relatively short base, of the first trapezoid are mouth-opened, two side edges, referred to as legs, mutually form an included angle to each other, the longitudinal section of the lower baffle plate along its central axis is a trapezoid, referred to as second trapezoid, the upper base, referred to as relatively short base, and the lower base, referred to as relatively long base, of the second trapezoid are mouth-opened, two side edges, referred to as legs, mutually form an included angle to each other, the opened-mouth of the lower base of the first trapezoid and the opened mouth of the upper base of the second trapezoid are nested with each other.

24. The double-trapezoid structural member according to claim 23, wherein the opened mouth of the upper base of the second trapezoid is nested in the opened-mouth of the lower base of the first trapezoid.

25. The double-trapezoid structural member according to claim 23, wherein the central axis of the upper baffle plate is coaxial with the central axis of the lower baffle plate, and/or, the included angle (α) of the two side edges of the upper baffle plate is in the range of 0-120° , the included angle (β) of the two side edges of the lower baffle plate is in the range of 0-120°, and/or, the ratio of the length of the relatively short base of the upper baffle

plate to the length of the relatively short base of the lower baffle plate is greater than 1, and/or, the vertical distance between the relatively short base of the lower baffle plate and the relatively short base of the upper baffle plate, the unit is mm, is 0 to less than H1, wherein H1 is the height of the first trapezoid, the unit is mm, and/or, the height of the first trapezoid H1 is 20-150mm, the height of the second trapezoid H2 is 20-150mm.

26. The double-trapezoid structural member according to claim 25, wherein the included angle (α) of the two side edges of the upper baffle plate is in the range of 0-60°, and/or, the included angle (β) of the two side edges of the lower baffle plate is in the range of 45-90°, and/or, the ratio of the length of the relatively short base of the upper baffle plate to the length of the relatively short base of the lower baffle plate is 1.1-3, and/or, the vertical distance between the relatively short base of the lower baffle plate and the relatively short base of the upper baffle plate is 0.01H1 to 0.5H1.

27. The double-trapezoid structural member according to claim 23, wherein the two side edges of the upper baffle plate form a confined or unconfined curved surface around its central axis, the two side edges of the lower baffle plate form a confined or unconfined curved surface around its central axis, and/or, the opening rate of the curved surface of the upper baffle plate is 10-50%, the opening rate of the curved surface of the lower baffle plate is 3-30%,

or,

the two side edges of the upper baffle plate extend along its length direction to form two side faces, the two side edges of the lower baffle plate extend along its length direction to form two side faces, and/or, the opening rate of at least one of the two side faces of the upper baffle plate is 10-50%, the opening rate of at least one of the two side faces of the lower baffle plate is 3-30%, and/or, the size of the upper baffle plate along its length direction is 30-250mm, the size of the lower baffle plate along its length direction is 30-250mm.

28. The double-trapezoid structural member according to claim 27, wherein the opening rate of the two side faces of the upper baffle plate is 10-50%, and/or, the opening rate of the two side faces of the lower baffle plate is 3-30%.

29. A fluidized bed reactor, comprising a shell, a gas distributor, and an inner chamber defined by an inner wall of said shell and an upper surface of said gas distributor, wherein in said inner chamber is disposed the double-trapezoid structural member according to claim 23.

30. A nitro compound hydrogenation reaction process, comprising a step of contacting a nitro compound as the reaction raw material and hydrogen gas with a hydrogenation catalyst to obtain a reaction product, referred to as a hydrogenation reaction step, wherein the hydrogenation reaction step is carried out in the fluidized bed reactor according to claim 1 or 29.

31. The hydrogenation reaction process according to claim 30, wherein the nitro compound is nitrobenzene, the reaction product is aniline.

32. The hydrogenation reaction process according to claim 30, wherein the reaction conditions of the hydrogenation reaction step comprise: the superficial gas velocity is 0.2-0.8 m/s, the molar ratio of hydrogen gas to the reaction raw material is 6-21, the reaction temperature is 220-280°C, the reaction pressure is 0.05-1 MPa, gauge pressure, the hydrogenation catalyst is selected from at least one of a copper-based loaded catalyst, a nickel-based loaded catalyst and a noble metal-based loaded catalyst, and/or, the bulk density of the hydrogenation catalyst is 300-1200kg/m3, and/or, the average particle diameter of the hydrogenation catalyst is 30-800 μm, and catalyst particles having a particle diameter of less than 80 μm comprise not less than 2wt% by mass percent of all catalyst particles, and/or, the nitro compound is selected from at least one of the compounds represented by the following formula (1),

$R\text{-}NO_2$ (1)

in the structural formula (1), R is an optionally substituted C2-20 straight, branched or cyclic hydrocarbyl.

33. The hydrogenation reaction process according to claim 32, wherein the reaction raw material is nitrobenzene, and/or, the average particle diameter of the hydrogenation catalyst is 50-600 μm, and/or the catalyst particles having a particle diameter of less than 80 μm comprise 5-15 wt%

by mass percent of all catalyst particles, and/or,
in the structural formula (1), R is an optionally substituted phenyl.