Impact-Reducing Uniform-Flowing Disc and Reactor

Field of the Invention

The present invention relates to the chemical processing equipment field, in particular to an impact-reducing uniform-flowing disc and a reactor.

Background of the Invention

Hydrogenation technology becomes more and more important and takes an increasingly important role in the petroleum refining industry. Whether the hydrogenation reaction can operate stably, whether the hydrogenation catalyst can fully play its role, and whether the product quality is high are largely depend on the uniformity of distribution of the gas-liquid material in the catalyst bed layer in the hydrogenation reactor. A hydrogenation reactor has an inlet diffuser, a gas-liquid distributor, a scale trap basket, catalyst bed layer supporting members, a cold hydrogen box, an outlet collector, and inert ceramic balls, etc., in it, wherein, the components that have direct influence on the efficiency of the catalyst and are the most important are the gas-liquid distributor and cold hydrogen box. The function of the gas-liquid distributor is to distribute and mix the gas-phase raw material and the liquid-phase raw material, and to uniformly spray them to the surface of the catalyst bed layer, so as to improve the flow condition of the liquid phase in the catalyst bed layer. The distribution of the reaction material via the gas-liquid distributor involves macroscopic uniformity and microscopic uniformity.

The macroscopic uniformity of the gas-liquid distributor is defined as that the quantity of the liquid phase flowing through each distributor is equal to the quantity volume of the gas phase flowing through the distributor, to ensure "uniform" covering of the material on the catalyst bed layer. It is difficult to achieve high macroscopic uniformity of distribution of the liquid, because the diameter of hydrogenation reactor becomes greater and greater nowadays and the distribution tower tray is assembled from blocks, and it is unable to accurately ensure the levelness of the distribution plate surface. Usually, the distribution plate surface may be inclined from the horizontal direction by 1/8°~1/2°, and the inclination may be as high as 3/2°, owing to the installation error. Even if the tower tray is installed to be level initially, the tray plate surface may lose its levelness under a combined action of thermal expansion and material impact load

during operation. Therefore, the macroscopic uniformity of distribution of the liquid phase should be ensured by virtue of the structure of the distributor.

In addition, since an inlet diffuser is arranged, the residual kinetic energy of material flow transport may generate strong impact force; moreover, since the material is fed through the inlet diffuser at the central position, the kinematic trajectory of the material flow formed in the space in the reactor closure is a slope line, and the liquid phase with kinetic energy creates a "wave pushing" phenomenon to the liquid layer on the tower tray below the top distributor, bringing an adverse entry condition to the distributor that depends on the levelness of the tower tray. Even a distributor that has the best performance can't provide uniform material distribution under a condition of liquid layers in different depths, and the increase of temperature difference in the radial direction is inevitable.

Summary of the Invention

To solve the problem of non-uniformity of material distribution via a distributor in the prior art, the present invention provides an impact-reducing uniform-flowing disc, which can distribute the material flow uniformly.

To attain that object, according to an aspect of the present invention, the present invention provides an impact-reducing uniform-flowing disc, comprising a tower tray, a material falling pipe penetrating through the tower tray, and an impact-reducing device configured to buffer the kinetic energy of an obliquely falling material flow, wherein, the impact-reducing device has a guide surface configured to guide the obliquely falling material flow to flow along the guide surface and fall vertically to the tower tray, and overflow holes are provided at a portion of the material falling pipe above the tower tray, and wherein, the impact-reducing uniform-flowing disc comprises a plurality of the material falling pipes and a plurality of impact-reducing devices configured to provide buffering falling material function for the plurality of material falling pipes.

According to another aspect of the present invention, the present invention provides a reactor, which comprises an inlet diffuser and the impact-reducing uniform-flowing disc provided in the present invention, wherein, the impact-reducing uniform-flowing disc is arranged in a top closure of the reactor or at the top end of a reactor shell of the reactor, and the inlet diffuser is configured to feed the material to the impact-reducing uniform-flowing disc.

With the above-mentioned technical scheme, the impact-reducing device can buffer the kinetic energy of the material flow and/or prevent the falling material flow from directly entering into

the material falling pipe; instead, the material flow falls onto the tower tray and forms a liquid layer with certain depth before it is distributed via the overflow holes; thus, material distribution non-uniformity incurred by error in levelness of the tower tray can be avoided. Moreover, since the material flow forms a liquid layer first and then is distributed via the overflow holes, the impact force generated by the residual kinetic energy is eliminated, and a "wave pushing" phenomenon is avoided. Therefore, the impact-reducing uniform-flowing disc provided in the present invention can distribute the material flow uniformly.

Brief Description of Drawings

Fig. 1 is a schematic structural diagram of a first embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 2 is a partially enlarged view of the impact-reducing device shown in Fig. 1;

Fig. 3 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 2;

Fig. 4 is a schematic structural diagram of a second embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 5 is a partially enlarged view of the impact-reducing device shown in Fig. 4;

Fig. 6 is a partially enlarged view of another example of the impact-reducing device shown in Fig. 4;

Fig. 7 is a top view of the device shown in Fig. 5;

Fig. 8 is a sectional view of the material falling pipe shown in Fig. 4;

Fig. 9 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 4;

Fig. 10 is a schematic structural diagram of a third embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 11 is a partially enlarged view of the impact-reducing device shown in Fig. 10;

Fig. 12 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 10;

Fig. 13 is a schematic structural diagram of a fourth embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 14 is a partially enlarged view of the impact-reducing device shown in Fig. 13;

Fig. 15 is a top view of the device shown in Fig. 14;

Fig. 16 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 13;

Fig. 17 is a schematic structural diagram of a fifth embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 18 is an appearance view of the device shown in Fig. 17;

Fig. 19 is a structural diagram of a cylindrical member shown in Fig. 18;

Fig. 20 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 17;

Fig. 21 is a schematic structural diagram of a sixth embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 22 is a top view of the impact-reducing plate and material falling pipe shown in Fig. 21;

Fig. 23 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 21;

Fig. 24 is a schematic structural diagram of a seventh embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 25 is a partially enlarged view of the impact-reducing device shown in Fig. 24;

Fig. 26 is a top view of the device shown in Fig. 25;

Fig. 27 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 24;

Fig. 28 is a top view of the device shown in Fig. 27;

Fig. 29 is a schematic structural diagram of an eighth embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 30 is a partially enlarged view of the impact-reducing device shown in Fig. 29;

Fig. 31 is a top sectional view of the device shown in Fig. 30;

Fig. 32 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 29;

Fig. 33 is a top view of the device shown in Fig. 32;

Fig. 34 is a schematic structural diagram of a ninth embodiment of the impact-reducing uniform-flowing disc according to the present invention;

Fig. 35 is a partially enlarged view of the impact-reducing device shown in Fig. 34;

Fig. 36 is a top view of the device shown in Fig. 35;

Fig. 37 is a functional diagram of impact reduction achieved by the impact-reducing device shown in Fig. 34;

Fig. 38 is a schematic diagram illustrating the temperature measurement positions in radial direction on the bed layer in the reference examples and embodiments.

Brief Description of the Reference numbers

100 - tower tray; 110 - tower tray part; 120 - fitting member; 130 - supporting member; 140 - bent edge; 200 - material falling pipe; 201 - overflow hole; 210 - top surface; 220 - notch surface; 230 – pipe body; 240 - filter screen; 300 - impact-reducing device; 310 - plate; 311 - first connecting member; 320 - side wall; 321 - first tooth slot; 330 - baffle portion; 331 - communicating hole; 340 - barrier grating; 341 - grating plate; 342 - connecting rod; 343 - second connecting member; 350 - cylindrical member; 351 - through-hole; 360 - impact-reducing plate; 361 - flat plate; 362 - first bent plate; 363 - second bent plate; 363a - direct surface; 370 - impact-reducing sleeve; 371 - third connecting member

Detailed Description of the Embodiments

Hereunder some embodiments of the present invention will be described with reference to the accompanying drawings. It should be understood that the embodiments described here are only provided to describe and explain the present invention, but shall not be deemed as constituting any limitation to the present invention.

According to an aspect of the present invention, the present invention provides an impact-reducing uniform-flowing disc, comprising a tower tray 100, a material falling pipe 200 penetrating through the tower tray 100, and an impact-reducing device 300 configured to buffer the kinetic energy of an obliquely falling material flow, wherein, the impact-reducing device 300 has a guide surface configured to guide the obliquely falling material flow to flow along the guide surface and fall vertically to the tower tray 100, and overflow holes 200 are provided at a portion of the material falling pipe 201 above the tower tray 100, and wherein, the impact-reducing uniform-flowing disc comprises a plurality of material the falling pipes 200 and a plurality of impact-reducing devices 300 configured to provide buffering falling material function for the plurality of material falling pipes 200.

The impact-reducing uniform-flowing disc provided in the present invention utilizes the impact-reducing device 300 to buffer the kinetic energy of the material flow, so that the material flow can flow along the guide surface and fall onto the tower tray 100 and forms a liquid layer with certain depth before it is distributed via the overflow holes 201; thus, material distribution non-

uniformity incurred by error in levelness of the tower tray can be avoided. Moreover, since the material flow forms a liquid layer first and then is distributed via the overflow holes 201, the impact force generated by the residual kinetic energy is eliminated, and a "wave pushing" phenomenon is avoided. Therefore, the impact-reducing uniform-flowing disc provided in the present invention can distribute the material flow uniformly.

In use, after the material flow enters into the material falling pipe 200 via the overflow holes 201, it can be guided through the material falling pipe 200 and fall vertically, so that the original slope flow state is changed to a vertical flow state and the material falls naturally; thus, a "wave pushing" phenomenon of the material flow to the liquid layer on the distribution tray below the impact-reducing uniform-flowing disc is eliminated. In addition, the material flow buffered by the impact-reducing device 300 falls to the tower tray 100 and forms a liquid layer with uniform depth before it falls via the overflow holes 201 to the distribution tray; thus, a smooth, steady, and uniform entry condition is provided for the distribution tray, the fluid flow condition is refined, and preliminary material distribution is realized.

Wherein, there are a plurality of impact-reducing devices, which can provide a buffer function for the falling material for each of the plurality of the material falling pipes 200. According to different embodiments of the present invention, each material falling pipe 200 may be provided with a corresponding impact-reducing device 300 (e.g., the embodiment shown in Fig. 1), or the plurality of material falling pipes 200 may be provided with the same impact-reducing device 300 (e.g., the embodiment shown in Fig. 17). Hereunder different embodiments of the impact-reducing device 300 provided in the present invention will be described with reference to the accompanying drawings.

To provide a buffer function for the material flow falling obliquely from the material falling pipe 200, the impact-reducing device 300 may comprise a plate 310 that is arranged above the material falling pipe 200 and configured to cover the top end of the material falling pipe 200. Thus, the material flow may fall to the plate 310 first, and then flow along the plate 310 and fall from the edge of the plate 310 along the side of the plate 310 to the tower tray 100 (in that case, the side is the guide surface, and the material flow is guide by the guide surface to flow vertically and fall to the tower tray 100); thus, the plate 310 blocks the material flow and buffers the kinetic energy of the material flow, and prevents the material flow from directly entering into the material falling pipe 200 at the same time.

Preferably, as shown in Figs. 1-3, the impact-reducing device 300 comprises a side wall 320 that extend upward from the edge of the plate 310; in that case, the vertical side wall 320 is the guide surface, and material flow is guide to flow along the guide surface vertically. Thus, after

the material flow falls to the plate 310 and a liquid layer is accumulated to predetermined height by means of the side wall 320, the material flow can flow over the side wall 320 and then fall to the tower tray 100. With such an arrangement, the kinetic energy of the material flow in other directions except the vertical direction can also be eliminated, so that the material flow only has kinetic energy generated by natural falling when the material flow falls to the tower tray 100.

Furthermore, a first tooth slot 321 may be provided on at least a portion of the top edge of the side wall 320. Thus, the material flow that has fallen to the plate 310 can overflow and fall down when the material is accumulated to the height of tooth root of the first tooth slot 321. With the first tooth slot 321, the material flow can be controlled better to overflow uniformly along the impact-reducing device 300 via the first tooth slot 321. As shown in Fig. 2, several first tooth slots 321 can be arranged on the top edge of the side wall 320 at an even interval, so that the material can fall uniformly along the top edge of the side wall 320.

According to another embodiment of the present invention, as shown in Figs. 4-7, 9, and 10-12, the impact-reducing device 300 may comprise a plurality of baffle portions 330 that extend upward from the plate 310 and face the falling material flow, wherein, the baffle portions 330 extend from one side of the plate 310 to the other side, and a material discharge channel is formed between adjacent baffle portions 330. Thus, the material can fall at predetermined positions through the material discharge channels. In such a case, the side faces of the plate 310 are guide surfaces, and the material flow is guided to flow along the guide surfaces vertically. Wherein, the plurality of baffle portions 330 may be arranged parallel to each other, and their plate surfaces may be spaced from each other at an interval, to form regular material discharge channels. In addition, the baffle portions 330 extend upward vertically from the plate 310, to avoid any additional interference to the falling material that may cause degraded material falling efficiency.

Furthermore, preferably, as shown in Figs. 6 and 11, the baffle portion 330 is provided with a communicating hole 331 that penetrates through the baffle portion 330, so that the material can fall through adjacent material discharge channels communicating with each other via the communicating hole 331 to the tower tray 100 at essentially the same material flow rate.

Wherein, the impact-reducing device 300 may be mounted and fixed in any proper way. For example, in the embodiment shown in Fig. 10-12, the top end of the material falling pipe 200 has a notch, so that the top end has a top surface 210 and a notch surface 220 below the top surface 210, and the plate 310 is connected to the top surface 210. Thus, on one hand, the material falling pipe 200 may be used as an installation base for the impact-reducing device 300; on the other hand, a gas-phase channel for the material flow can be formed via the notch, so

that a part of the gas-phase material in the material flow can quickly enter into the material falling pipe 200 via the notch rather than enter via the overflow holes 201 along with the rest of the material flow.

Optionally, in the embodiment shown in Figs. 1 and 4, the plate 310 is connected via a first connecting member 311 to the material falling pipe 200. In addition, clearance exists between the plate 310 and the top end of the material falling pipe 200 to form a gas phase channel, so that a part of the gas-phase material in the material flow can enter into the material falling pipe 200 quickly via the clearance rather than enter via the overflow holes 201 along with the rest of the material flow.

According to another embodiment of the present invention, as shown in Figs. 13-16, the impact-reducing device 300 comprises a barrier grating 340 above the material falling pipe 200. The barrier grating 340 provides an effect similar to the effect of the plate 310, which can buffer the kinetic energy of material flow, and can prevent the material flow from directly entering into the material falling pipe 200 at the same time.

Wherein, the barrier grating 340 may comprise a plurality of grating plates 341 that are arranged obliquely in relation to the extending direction of the material falling pipe 200 and face the falling material flow, and the plurality of grating plates 341 are parallel to each other and their plate surfaces are spaced from each other at an internal. Thus, on one hand, the grating plate 341 buffers the kinetic energy of the material flow and prevents the material flow from directly entering into the material falling pipe 200; on the other hand, the material flow that falls to the grating plates 341 can flow along the grating plates 341 and fall naturally from the edges of the grating plates 341 to the tower tray 100. In such a case, the plate surfaces of the grating plates 341 are guide surfaces, and the material flow is guided to flow along the guide surfaces to the edges of the grating plates 314 and then falls vertically naturally.

For the convenience of installation, as shown in Fig. 15, the barrier grating 340 comprises a connecting rod 342 that connects the plurality of grating plates 341; thus, by mounting and adjusting the connecting rod 342, the grating plates 341 can be mounted and their positions can be adjusted integrally.

Wherein, since the material flow that has fallen to the grille grating plates 341 flow obliquely along the grating plates 341 over certain distance, the material flow has speed and kinetic energy in other directions in addition to the vertical direction when it falls from the edges of the grating plates 341. By arranging the dimensions and inclination angles of the grating plates 341 properly, such undesired kinetic energy can be minimized while the falling material is buffered. Specifically, the connecting rod 342 may be arranged horizontally, parallel to the tower tray

100, and the angle α between the grating plates 341 and the connecting rod 342 may be 10°~170°, preferably 20°~45°. The width B of the grating plates 341 may be 10~200mm, preferably 50~120mm. The spacing L between adjacent grating plates 341 may be 10~300mm, preferably 50~150mm.

Likewise, the material falling pipe 200 may be used as an installation base for the impact-reducing device 300, and the barrier grating 340 is connected via a second connecting member 343 to the material falling pipe 200. In the embodiment shown in Fig. 14, the connecting rod 342 is connected via a second connecting member 343 to the material falling pipe 200; alternatively, some of the grating plates 341 may be connected via the second connecting member 343 to the material falling pipe 200. In addition, clearance exists between the barrier grating 340 and the top end of the material falling pipe 200 to form a gas phase channel, so that a part of the gas-phase material in the material flow can enter into the material falling pipe 200 quickly via the clearance rather than enter via the overflow holes 201 along with the rest of the material flow.

According to another embodiment of the present invention, the impact-reducing device 300 is mainly used to buffer the kinetic energy of the material flow, especially the kinetic energy of the material flow in other directions except the vertical direction. As shown in Fig. 17-20, the impact-reducing device 300 comprises a plurality of cylindrical members 350 that are sleeved each other in sequence, the bottoms of the cylindrical members 350 are connection to the tray surface of the tower tray 100, the plurality of material falling pipes 200 are arranged between adjacent cylindrical members 350, and the tops of the cylindrical members 350 are higher than the top ends of the material falling pipes 200. Thus, when the material flow falls, it hits the cylindrical member 350 first and the kinetic energy is eliminated; then the material slides along the side wall (guide surface) of the cylindrical member 350 to the tower tray 100; after a liquid layer is accumulated to predetermined height, the material flows via the overflow holes 201 into the material falling pipe 200. It is understood that the cylindrical member 350 provides a shielding function for the material falling pipe and can essentially prevent the material flow from directly entering into the material falling pipe 200, because the top of the cylindrical piece 350 is higher than the top end of the material falling pipe 200.

Wherein, to avoid increasing kinetic energy in any other direction except the vertical direction when the material flow is guided to slide along the side wall of the cylindrical member 350, the cylindrical member 350 is arranged perpendicular to the tray surface.

In addition, preferably, the cylindrical wall of the cylindrical member 350 is arranged with a through-hole 351 penetrating through the cylindrical wall so that the cylindrical members 350

that are sleeved each other are in fluid connection with each other and thereby the material flows between different cylindrical members 350 can enter into corresponding material falling pipes 200 essentially at the same material flow rate.

To form a uniform liquid layer on the tower tray 100, a plurality of through-holes 351 are provided and arranged in the circumferential direction of the cylindrical member 350. In addition, the height of the through-holes 351 may be correspond to the height of the overflow holes 201, to ensure that the liquid layers at the positions of different material falling pipes 200 are the same in real time.

To provide a good material buffering function, the dimensions of the cylindrical members 350 may be designed properly. For example, the spacing between adjacent two cylindrical members 350 may be 0.5~1.5 times of the height of the cylindrical member 350, preferably 0.8~1.1 times of the height of the cylindrical member 350.

According to another embodiment of the present invention, the impact-reducing device 300 may comprise an impact-reducing plate 360 arranged at a side of the material falling pipe 200 that faces the falling material, and the top of the impact-reducing plate 360 is higher than the top end of the material falling pipe 200. The falling material flow hits the impact-reducing plate 360 first (the plate surface of the impact-reducing plate 360 is the guide surface) and slides along the impact-reducing plate 360 to the tower tray 100, and then enters into the material falling pipe 200 via the overflow holes 201.

Since the impact-reducing plate 360 is arranged at the side of the material falling pipe 200 that faces the falling material, on one hand, the impact-reducing plate 360 provides an effect of buffering the kinetic energy of the obliquely falling material flow; on the other hand, the impact-reducing plate 360 can shield the material falling pipe 200 to prevent the material flow from directly falling into the material falling pipe 200.

Wherein, to avoid increasing kinetic energy in any other direction except the vertical direction when the material flow is guided to slide down along the impact-reducing plate 360, preferably, the impact-reducing plate 360 is arranged perpendicular to the tray surface of the tower tray.

To provide a shielding effect for the material falling pipe 200, the impact-reducing plate 360 may be fixed to the top of the material falling pipe 200.

According to an embodiment of the present invention, as shown in Figs. 21-23, the impact-reducing plate 360 is a flat plate 361. According to another embodiment of the present invention, as shown in Figs. 24-28, the impact-reducing plate 360 is a first bent plate 362 that embraces the material falling pipe 200. In the embodiment shown in Figs. 21-28, the overflow holes 201 may be arranged at any position of the material falling pipe 200; the material flow will flow

downward along the flat plate 361 or the first bent plate 362 after it hits the flat plate 361 or the first bent plate 362, so that a liquid layer is accumulated, and then the material flows via the overflow holes 201 into the material falling pipe 200.

According to another embodiment of the present invention, as shown in Figs. 29-33, the impact-reducing plate 360 is a second bent plate 363 that embraces the material falling pipe 200, the end of the bent edge of the second bent plate 363 is formed with a direct surface 363a that guides the material flow inward, the overflow holes 201 are arranged at the portion of the material falling pipe 200 away from the second bent plate 363, and the top end of the second bent plate 363 is not lower than the top end of the material falling pipe 200. Thus, the falling material flow hits the second bent plate 363 first and flow downward along the second bent plate 363 to the tower tray 100, and then the material flow is guided by the direct surface 363a to flow towards the space embraced by the second bent plate 363, and flows via the overflow holes 201 in the material falling pipe 200 into the material falling pipe 200.

Wherein, the top end of the second bent plate 363 is not lower than the top end of the material falling pipe 200, i.e., the top end of the second bent plate 363 may be flush with or higher than the top end of the material falling pipe 200. In the case that the top end of the second bent plate 363 is higher than the top end of the material falling pipe 200, the second bent plate 363 not only can provide a kinetic energy buffering function, but also can shield the top end of the material falling pipe 200 to prevent the material flow from directly falling into the material falling pipe 200.

According to another embodiment of the present invention, as shown in Figs. 34-37, the impact-reducing device 300 comprises an impact-reducing sleeve 370 that is sleeved over the upper part of the material falling pipe 200, the top of the impact-reducing sleeve 370 is higher than the top of the material falling pipe 200, and side clearance exists between the impact-reducing sleeve 370 and the material falling pipe 200. Thus, the falling material flow will hit the impact-reducing sleeve 370 and slide down along the side wall (guide surface) of the impact-reducing sleeve 370 to the tower tray 100, and then enters into the material falling pipe 200 via the overflow holes 201.

Particularly, since the impact-reducing sleeve 370 is fitted over the upper part of the material falling pipe 200 and as an extension of the material falling pipe 200, the material flow will be blocked essentially by the impact-reducing sleeve 370 and thereby slide down along the impact-reducing sleeve 370, even the material flow that has entered into to the impact-reducing sleeve 370 will be blocked and slide along the inner wall of the impact-reducing sleeve 370, and then flow through the side clearance between the impact-reducing sleeve 370 and the material falling

pipe 200, and fall to the tower tray 100. Thus, a situation that the material flow directly enters into the material falling pipe 200 is avoided essentially. In addition, by arranging side clearance between the impact-reducing sleeve 370 and the material falling pipe 200, a gas phase channel can be formed, and a part of the gas-phase material in the material flow can enter into the material falling pipe 200 quickly from the top end of the material falling pipe 200 via the clearance rather than enter via the overflow holes 201 along with the rest of the material flow. Wherein, the impact-reducing sleeve 370 may be fixed via a third connecting member 371 to the material falling pipe 200. The third connecting member 371 may be in any appropriate shape, such as a rod shape, as long as it can connect the impact-reducing sleeve 370 and the material falling pipe 200 and reserve the side clearance between them.

In addition, preferably, the edge of the top end of the impact-reducing sleeve 370 may be arranged with a second tooth slot. By arranging the second tooth slot, when the material flow falling obliquely is buffered, one part of the material flow can hit the outer wall at one side of the impact-reducing sleeve 370 and fall along the outer wall, while the other part of the material flow can pass through the clearance between the teeth of the second tooth slot, hit the inner wall at the opposite side of the impact-reducing sleeve 370 and fall along the inner wall; thus, the material flow part that can be buffered is separated alternately into two parts, i.e., a part blocked by the outer wall, and a part blocked by the inner wall by the radial direction of the above-mentioned separating the impact-reducing sleeve 370 into one side and opposite side ; in addition, in the two parts that are blocked by the outer wall and inner wall, the material flow will fall at a horizontal interval, and thereby the impact to the liquid layer on the tower tray 100 is reduced.

In this embodiment, the impact-reducing sleeve 370 may be connected to the top end of the material falling pipe 200, or may be partially overlapped with the upper part of the material falling pipe 200 in the axial direction. The above-mentioned material flow buffering effect can be ensured by arranging the radial dimension of the impact-reducing sleeve 370 and the dimensions of the part that is higher than the material falling pipe 200.

Furthermore, preferably, the material falling pipe 200 described in the present invention may be a structure that has a filter function, so as to provide a pre-filtering effect for the material flow that enters into the material falling pipe 200 via the overflow holes 201. According to an embodiment of the present invention, the material falling pipe 200 may be formed by a mesh filter member, and the meshes of the mesh filter member may serve as the overflow holes 201. Optionally, for the convenience of maintenance work, the material falling pipe 200 may comprise a pipe body 230 and a filter screen 240 wrapped on the circumference of the pipe body

230. Wherein, the overflow holes 201 are arranged in the pipe body 230, and the filter screen 240 can cover the overflow holes 201. Thus, if the filter screen 240 is clogged, it can be replaced or removed for cleaning. For the convenience of installation and maintenance, the filter screen 240 may an annular piece that is made of an elastic material and attached to the pipe 230. Thus, the filter screen 240 can be mounted or removed by means of elastic deformation of the annular piece in the radial direction.

Furthermore, for the convenience of installation, the tower tray 100 may be designed as an assembly. Specifically, as shown in Figs. 1, 4, 10, 13, 17, 21, 24, 29 and 34, the tower tray 100 comprises a plurality of tower tray parts 110 that are assembled via a fitting member 120 to form the tray surface of the tower tray, and the tower tray 100 further comprises supporting member s 130 that support the tray surface.

In addition, in the embodiment shown in Figs. 1, 4, 10, 13, 21, 24, 29 and 34, there may be a plurality of impact-reducing devices, the material falling pipe 200 corresponding to each of the material falling pipes respectively, so as to provide a material buffer function for all material falling pipes 200. Wherein, the material falling pipes 200 and the corresponding impact-reducing devices 300 may be distributed on the tower tray 100 under an appropriate rule. For example, the material falling pipes 200 and the corresponding impact-reducing devices 300 may be arranged in a triangular, quadrangular, or circular layout. Wherein, preferably, to cover the region above the tower tray 100 as far as possible with the least number of impact-reducing devices 300, the material falling pipes 200 and the corresponding impact-reducing devices 300 may be arranged in a equilateral triangular layout.

To enable the material flow that has fallen to the tower tray 100 to enter into the material falling pipe 200 via the overflow holes 201 successfully, the positions of the overflow holes 201 may be arranged appropriately, and the edges of the tower tray may be arranged with bent edges 140 that are bent upward, so as to form a required liquid layer. The distance from the center line of the overflow holes 201 to the top surface of the tower tray 100 may be 5~100mm, preferably 30~50mm, and the height of the bent edge 140 may be 5~100mm, preferably 30~50mm.

In addition, the dimensions of the overflow holes 201 may be arranged appropriately to ensure a material flow can be provided through the material falling pipe 200 at required flow rate and speed. For example, the total cross sectional area of the overflow holes 201 of each material falling pipe 200 may be 10%~100% of the cross sectional area of the material falling pipe 200, preferably 30%~50% of the cross sectional area of the material falling pipe 200. In addition, the diameter of the material falling pipe 200 may be 10~ 200mm, preferably 20~ 110mm. The height of the material falling pipe 200 may be 20~300mm, preferably 50~120mm.

The specific structures and parameters may be designed as required for different embodiments. Specifically:

In the embodiment shown in Fig. 1, the cross sectional area of the plate 310 may be 1~10 times of the cross sectional area of the material falling pipe 200, preferably is 2~5 times of the cross sectional area of the material falling pipe 200. The plate 310 is maybe a circular disc structure or a polygonal structure; specifically, the plate 310 may be a circular disc structure, rhombic disc structure, triangular disc structure, square structure or trapezoid disc structure, preferably is a circular disc structure in diameter of 40~300mm, preferably 60~120mm. Clearance exists between the bottommost edge of the plate 310 and the topmost edge of the material falling pipe 200 to form the gas-phase channel described above. The clearance may be 5~200mm, preferably is 10~50mm. The height of the side walls 320 of the plate 310 may be 5~80mm, preferably is 30~50mm. The first tooth socket slot 321 may be in a triangular, quadrangular or arc shape, preferably is in a triangular shape. The height of the first tooth slot 321 may be 5%~100% of the height of the side walls 320, preferably 30%~60% of the height of the side walls 320.

In the embodiment shown in Fig. 4, the height of the baffle portion 330 may be 5-200mm, preferably is 30-80mm, and the spacing between adjacent baffle portions 330 may be 5-100mm, preferably is 20-80mm. The bottom edge of the baffle part 330 is connected to the top surface of the plate 310 without clearance, or a communicating hole 331 is arranged at the bottom edge of the baffle portion 330, and the distance from the center line of the communicating hole 331 to the top surface of the plate 310 is not greater than 30% of the height of the baffle portion 330, the communicating holes 331 in adjacent two baffle portions 330 are staggered misaligned from each other in the horizontal direction, to avoid material flow along a straight line and a non-uniform distribution as a result of a linear arrangement of all communicating holes 331 in a straight line. Wherein, the communicating hole 331 may be in a polygonal shape (specifically, a triangular or quadrangular shape), a semi-circular shape or circular shape, preferably is in a semi-circular shape. The normal line passing through the center point of the baffle portion 330 in the length direction is perpendicular to and intersects with the center line of the material falling pipe 200. Clearance exists between the bottom surface of the plate 310 and the topmost edge of the material falling pipe 200, and the clearance may be 10~200mm, preferably 30~80mm. The center line of the impact-reducing device 300 may extend along or not along the axial line of the material falling pipe 200, preferably extend along the axial line of the material falling pipe 200. The material falling pipe 200 may be made from a Johnson screen or made from a metal pipe body 230 wrapped with a filter screen 240 outside, and one or more layers of filter screens 240 may be provided. In the case that the material falling pipe 200 is

made from a Johnson screen, the spacing between the slits may be 0.01~0.1mm, preferably 0.05~0.8mm; in the case that the material falling pipe 200 is made from a pipe body 230 wrapped with a filter screen 240 outside, overflow holes 201 are arranged in the pipe body 230 at 1~25% porosity, preferably 15~20%; the mesh number of the filter screen 240 may be 20~300 meshes, preferably 50~120 meshes.

In the embodiment shown in Fig. 10, the structure and parameters of the impact-reducing device 300 are similar to those in the embodiment shown in Fig. 4, an obliquely cut notch is arranged at the top end of the material falling pipe 200 and an oval cross section is formed there, and the angle between the cross section of the notch at the top end and the horizontal plane may be 5°~70°, preferably 20°~45°.

In the embodiment shown in Fig. 13, the overall horizontal projection shape of the barrier grille grating 340 is a quadrangular or circular shape (e.g., formed by quadrangular cutting). In the case of a circular shape, the horizontal projection shape of the grating plate 341 may be in diameter of 40~300mm, preferably 60~120mm. The barrier grating 340 comprises a plurality of grating plates 341 and a connecting rod 342, the plurality of grating plates 341 are connected together via the connecting rod 342, the connecting rod 342 extends horizontally, and the angle α between the grating plates 341 and the connecting rod 342 may be 10°~170°, preferably 20°~45°. The width of the grating plates 341 may be 10~200mm, preferably 50~120mm; the spacing between adjacent grating plates 341 may be 10~300mm, preferably 50~150mm.

In the embodiment shown in Fig. 17, the cylindrical members 350 may be arranged in a concentric form on the tower tray 100, and the cylindrical members 350 may be arranged in 2~30 layers, preferably 8~20 layers; the height of the cylindrical members 350 may be 10~400mm, preferably 80~200mm; several through-holes 351 are arranged at the bottom edge of the cylindrical member 350, and the through-holes 351 may be in a semi-circular, circular, quadrangular, or inverted triangular structure, preferably is in a semi-circular structure; the total cross sectional area of the through-holes 351 arranged in each cylindrical member 350 may be 0.5~1.8 times of the cross sectional area of the inlet pipe of the reactor, preferably 0.8~1.2 times of the cross sectional area of the inlet pipe of the reactor; the spacing in the circumferential direction between adjacent two through-holes 351 arranged in each cylindrical member 350 may be 30mm~200mm, preferably 50mm~120mm; the spacing in the radial direction between adjacent two through-holes 351 may be 0.5~1.5 times of the height of the through-holes 351, preferably 0.8~ 1.1 times of the height of the through-holes 351.

In the embodiment shown in Fig. 21, the impact-reducing plate 360 is a strip shaped plate, the width of the strip shaped plate may be 20~300mm, preferably 80~200mm; the length of the strip shaped plate may be 50~300mm, preferably 80~220mm.

In the embodiment shown in Fig. 24, the impact-reducing plate 360 is a plate bent symmetrically, and the bending angle of the impact-reducing plate 360 usually is 15°~180°, preferably 90°~120°; the total side length of the impact-reducing plate 360 may be 20mm~200mm, preferably 60mm~120mm; the height of the impact-reducing plate 360 usually is 30mm~200mm, preferably 60mm~120mm. The bottom edge of the impact-reducing plate 360 is connected to the top edge of the material falling pipe 200, or the impact-reducing plate 360 may be partially overlapped with the material falling pipe 200. In the case that the bottom edge of the impact-reducing plate 360 is overlapped with the material falling pipe 200, the height of the overlapped portion may be 10%~100% of the height of the material falling pipe 200, preferably 5%~20% of the height of the material falling pipe 200. The central plane of the bending angle of the impact-reducing plate 360 extends through the center line of the material falling pipe 200.

In the embodiment shown in Fig. 29, the impact-reducing plate 360 is a plate bent symmetrically, the bending angle of the impact-reducing plate 360 usually is 15°~180°, preferably 90°~120°, and the total side length of the impact-reducing plate 360 usually is 20mm~200mm, preferably 60mm~120mm. The top edge of the impact-reducing plate 360 is flush with or slightly higher than the top edge of the material falling pipe 200, and the height of the portion higher than the top edge of the material falling pipe 200 usually doesn't exceed 30% of the height of the material falling pipe 200 (the portion above the tower tray). In the present invention, the top edge of the impact-reducing plate 360 usually is not higher than the top end surface of the material falling pipe 200 by 60mm. In the case that the top edge of the impact-reducing plate 360 is higher than the top edge of the material falling pipe 200, the bottom edge of the impact-reducing plate 360 usually is attached to the top surface of the tower tray 100. Wherein, the central plane of the bending angle of the impact-reducing plate 360 extends through the center line of the material falling pipe 200.

In the embodiment shown in Fig. 34, the height of the impact-reducing sleeve 370 usually is 30~400mm, preferably 100~300mm; the diameter of the impact-reducing sleeve 370 usually is 30~260mm, preferably 80~150mm. Preferably a second tooth slot is arranged at the opening at the top edge of the impact-reducing sleeve 370, and the second tooth slot is in a triangular, rectangular or arc shape, preferably is in a triangular shape. The height of the second tooth slot may be 1%~20% of the height of the impact-reducing sleeve 370, preferably 2%~10% of the

height of the impact-reducing sleeve 370. Clearance exists in the horizontal direction between the impact-reducing sleeve 370 and the material falling pipe 200 (e.g., arranged concentrically) to serve as a gas-phase channel, and the width of the clearance usually is 5~200mm, preferably 10~50mm. The cross sectional area of the impact-reducing sleeve 370 may be 1~8 times of the cross sectional area of the material falling pipe 200, preferably 2~6 times of the cross sectional area of the material falling pipe 200. The bottom edge of the impact-reducing sleeve 370 is connected to the top edge of the material falling pipe 200, or the impact-reducing sleeve 370 is overlapped with the material falling pipe 200 to increase the installation strength of the impact-reducing sleeve 370 and decrease the total height of the impact-reducing device 300 and the material falling pipe 200. In the case that the impact-reducing sleeve 370 is overlapped partially with the material falling pipe 200, the height of the overlapped portion usually is 5%~30% of the height of the material falling pipe 200, preferably 10%~25% of the height of the material falling pipe 200.

According to another aspect of the present invention, the present invention provides a reactor, which comprises an inlet diffuser and the impact-reducing uniform-flowing disc provided in the present invention, wherein, the impact-reducing uniform-flowing disc is arranged in a top closure of the reactor or at the top end of a reactor shell of the reactor, and the inlet diffuser is configured to feed the material to the impact-reducing uniform-flowing disc.

The obliquely falling material flow provided by the inlet diffuser falls to the tower tray 100 and form a liquid layer in certain height first, and then is distributed via the overflow holes 201; thus, non-uniform material distribution incurred by error in levelness of the tower tray can be avoided. Moreover, since the material flow forms a liquid layer first and then is distributed via the overflow holes 201, the impact force generated by the residual kinetic energy is eliminated, and a "wave pushing" phenomenon is avoided. Therefore, the reactor provided in the present invention can distribute the material flow uniformly via the impact-reducing uniform-flowing disc and thereby improve the efficiency of the follow-up reaction.

In addition, to distribute the material flow uniformly at an upstream position of the reactor, the impact-reducing uniform-flowing disc is disposed at the upper end of a reactor shell of the reactor above the topmost distribution tray of the reactor.

The reactor provided in the present invention may be of an proper type, as long as it has an inlet diffuser or an obliquely falling material flow. For example, the reactor may be a hydrogenation reactor.

Hereunder the advantages of the reactor provided in the present invention will be described with reference to embodiments and reference examples.

Reference example 1

A hydrogenation reactor is used, the diameter of the reactor is 3.2m, the space in the top closure is free, a top distribution tray is arranged at the entry to the topmost catalyst bed layer, a conventional ERI bubble cap gas-liquid distributor in the art is used in the top distribution tray, the hydrogenation raw material is coker naphtha, the catalyst is FGH-21 hydrofining catalyst from Fushun Petrochemical Research Institute, the processing conditions of the reactor are: partial pressure of hydrogen: 2.0MPa, volumetric space velocity: 2.0h-1, volume ratio of hydrogen to oil: 300:1, and inlet temperature of the reactor: 280°C.

Example 1

Compared with the reference example 1, in the example 1 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 1 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes 201 are arranged in the material falling pipes 200. The parameters of the impact-reducing device 300 are: the plate 310 is a circular disc structure in diameter of 120mm; the height of the side walls 320 is 30mm; a first tooth slot 321 in a triangular shape is arranged on the side wall 320, and the height of the first tooth slot 321 is 30% of the height of the side wall 320. The clearance between the bottom edge of the plate 310 and the top edge of the material falling pipe 200 is 40mm; the impact-reducing devices 300 are in the same quantity as the material falling pipes 200, and the center line of the plate 310 coincide with the center line of the material falling pipes 200, the cross sectional area of the plate 310 is 2 times of the cross sectional area of the material falling pipe 200.

Example 2

This example is essentially the same as the embodiment 1, but the conventional ERI gas-liquid distributor in the art in the hydrogenation reactor is canceled; instead, the impact-reducing uniform-flowing disc in the embodiment shown in Fig. 1 is used. The height of the material falling pipe 200 is 120mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 50mm, and the height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the

corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 1 and 2 and the reference example 1 are shown in Table 1, wherein, the positions of points a-e are shown in Fig. 38.

Table 1

Position of temperature measurement point	Reference example 1	Example 1	Example 2
a, °C	280.2	280.6	281.5
b, °C	285.4	281.4	282.2
c, °C	293.0	281.0	283.4
d, °C	284.8	282.1	281.8
e, °C	286.8	281.8	282.8
Maximum temperature difference in radial direction in the bed layer, °C	12.8	1.5	1.9

Reference example 2

Compared with the reference example 1, the differences are: the reactor is in diameter of 4.6m, the catalyst is FH-5A hydrofining catalyst from Fushun Petrochemical Research Institute, and the processing conditions of the reactor are: partial pressure of hydrogen: 6.5MPa, volumetric space velocity: 1.5h-1, volume ratio of hydrogen to oil: 400:1, and inlet temperature of the reactor: 320°C.

Example 3

Compared with the reference example 2, in the example 3 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 4 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: the plate 310 is a circular disc structure in diameter of 120mm; height of the baffle portions 330: 50mm; spacing between adjacent baffle portions 330: 80mm; the communicating holes 331 are semi-circular, the diameter of the opening of the semi-circular

shape is in the vertical direction, the distance from the center of the opening to the plate 310 is 20% of the height of the baffle portions 330, the communicating holes 331 in adjacent two baffle parts 330 are misaligned from each other in the horizontal direction. The clearance between the bottom edge of the plate 310 and the top edge of the material falling pipe 200 is 30mm; the impact-reducing devices 300 are in the same quantity as the material falling pipes 200, and the center line of the plate 310 coincide with the center line of the material falling pipes 200.

Example 4

This example is essentially the same as the example 3, but the conventional ERI gas-liquid distributor in the art in the hydrogenation reactor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 4 is used. The height of the material falling pipe 200 is 300mm; the material falling pipe 200 is made from a Johnson screen in diameter of 80mm, and the spacing between the slits is 0.2mm; the height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

Example 5

This example is essentially the same as the example 3, but the material falling pipe is made from a metal pipe body 230 wrapped with filter screens 240 outside, overflow holes 201 are arranged in the pipe 230 at 15% porosity, the pipe 230 is wrapped with two layers of filter screens 240, and the mesh number of the filter screens 240 is 100 meshes.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 3-5 and the reference example 2 are shown in Table 2, wherein, the positions of points a-e are shown in Fig. 38.

Table 2

Position of temperature measurement point	Reference example 2	Example 3	Example 4	Example 5
a, °C	320.5	319.8	320.3	320.2
b, °C	318.5	319.5	319.7	319.4
c, °C	312.3	320.8	321.2	319.6
d, °C	321.0	320.6	321.0	320.8
e, °C	322.3	319.3	321.6	320.8

Maximum temperature difference in radial direction in the bed layer, °C	13.3	1.5	1.9	1.4

Reference example 3

Compared with the reference example 1, the differences are: the reactor is in diameter of 4.6m, the hydrogenation raw material is diesel oil, the density of the diesel oil is 860kg/m3, and the sulfur content in the diesel oil is 1.7wt%; the catalyst is RS-2000 hydrofining catalyst; the processing conditions of the reactor are: partial pressure of hydrogen: 6.8MPa (G), volumetric space velocity: 1.9h-1, volume ratio of hydrogen to oil: 400:1, and inlet temperature of the reactor: 365°C.

Example 6

Compared with the reference example 3, in the example 6 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 10 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: the plate 310 is a circular disc structure in diameter of 120mm; height of the baffle portions 330: 50mm; the spacing between adjacent baffle portions 330 is 80mm, communicating holes 331 in a slot form are arranged between the bottom of the baffle portion 330 and the top of the plate 310, and the height of the slot is 20mm. A notch with an oval cross section is formed by obliquely cutting at the top end of the material falling pipe 200, and the cross section of the notch is at 45° from the horizontal plane; the impact-reducing devices 300 are in the same quantity as the material falling pipes 200, and the center line of the plate 310 coincide with the center line of the material falling pipes 200.

Example 7

This example is essentially the same as the example 6, but the conventional ERI gas-liquid distributor in the art in the hydrogenation reactor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 10 is used. The height of the material falling pipe 200 is 100mm, and the diameter is 50mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 30mm; the height of the bent edge 140 is 50mm. The tower tray 100 is

assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 6 and 7 and the reference example 3 are shown in Table 3, wherein, the positions of points a-e are shown in Fig. 38.

Table 3

Position of temperature measurement point	Reference example 3	Example 7	Example 8
a, °C	370.5	366.8	365.9
b, °C	367.3	365.5	365.7
c, °C	363.6	365.8	366.8
d, °C	361.0	365.7	366.6
e, °C	369.8	366.4	365.1
Maximum temperature difference in radial direction in the bed layer, °C	9.5	1.3	1.7

Reference example 4

Compared with the reference example 1, the differences are: the reactor is in diameter of 3.0m, hydrogenation raw material is naphtha fraction, the catalyst is FGH-21 hydrofining catalyst from Fushun Petrochemical Research Institute, and the processing conditions of the reactor are: operating pressure: 1.85MPa, volumetric space velocity: 2.5h-1, volume ratio of hydrogen to oil: 355:1, and inlet temperature of the reactor: 285°C.

Example 9

Compared with the reference example 4, in the example 9 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 13 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: a space exists between the bottom surface of the barrier grating and the topmost edge of the material falling pipe, and the height of the space is 50mm. Each barrier grating 340 comprises 6 grating plates 341 and 1 connecting rod 342, the grating plates 341 are

arranged parallel to each other in the horizontal direction, and are arranged obliquely at 30° inclination angle in relation to the horizontal plane. The cross section of the grating plate 341 is rectangular, and the width of the grating plate 341 is 100mm; the spacing between adjacent barrier gratings 340 is 100mm.

E xample 10

This embodiment is essentially the same as the e xample 9, but the ERI gas-liquid distributor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 13 is used. The height of the material falling pipe 200 is 120mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 50mm. The height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction in the bed layers in the e xample s 9 and 10 and the reference example 4 are shown in Table 4, wherein, the positions of points a-e are shown in Fig. 38.

Table 4

Position of temperature measurement point	Reference example 4	Example 9	Example 10
a, °C	285.3	285.8	285.3
b, °C	289.6	286.2	287.5
c, °C	278.6	286.0	286.5
d, °C	278.3	285.8	286.8
e, °C	284.3	287.2	285.9
Maximum temperature difference in radial direction in the bed layer, °C	11.3	1.4	2.2

Reference example 5

Compared with the reference example 1, the differences are: the reactor is in diameter of 4.6m, the hydrogenation raw material is diesel oil, the catalyst is FH-5A hydrofining catalyst from

Fushun Petrochemical Research Institute, and the processing conditions of the reactor are: partial pressure of hydrogen: 6.5MPa, volumetric space velocity: 1.5h-1, volume ratio of hydrogen to oil: 400:1, and inlet temperature of the reactor: 320°C.

E xample 11

Compared with the reference example 5, in the e xample 11 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 17 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: the cylindrical members 350 are arranged concentrically and fixed to the tower tray by welding, and the height of the cylindrical members 350 is 80mm; semi-circular holes are arranged at the bottom edge of the cylindrical member 350 as through-holes 351, and the total cross sectional area of the through-holes 351 in each cylindrical piece 350 is 0.8 times of the cross sectional area of the inlet pipe of the reactor; the spacing in the circumferential direction between two adjacent through-holes 351 in each cylindrical member 350 is 50mm; the spacing in the radial direction between adjacent cylindrical members 350 is 0.8 times of the height of the cylindrical members 350.

Example 12

This embodiment is essentially the same as the example 11, but the ERI gas-liquid distributor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 17 is used. The height of the material falling pipe 200 is 120mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 50mm. The height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 11 and 12 and the reference example 5 are shown in Table 5, wherein, the positions of points a-e are shown in Fig. 38.

Table 5

Position of temperature measurement point	Reference example 5	Example 11	Example 12
a, °C	320.5	320.6	320.4
b, °C	318.5	319.4	319.8
c, °C	312.3	319.6	320.3
d, °C	321.0	320.0	321.0
e, °C	322.3	320.3	321.4
Maximum temperature difference in radial direction in the bed layer, °C	13.3	1.2	1.9

Reference example 6

Compared with the reference example 1, the differences are: the reactor is in diameter of 4.6m, the hydrogenation raw material is diesel oil, the density of the diesel oil is 860kg/m3, and the sulfur content in the diesel oil is 1.7wt%; the catalyst is RS-2000 hydrofining catalyst; the processing conditions are: partial pressure of hydrogen: 6.8MPa (G), volumetric space velocity: 1.9h-1, volume ratio of hydrogen to oil: 400:1, and inlet temperature of the reactor: 365°C.

Example 13

Compared with the reference example 6, in the example 13 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 21 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: the height of the impact-reducing plate 360 is 40% of the total height of the impact-reducing plate 360 and the material falling pipe 200, the width of the impact-reducing plate 360 is 50mm, and the length of the impact-reducing plate 360 is 80mm.

Example 14

This embodiment is essentially the same as the example 13, but the ERI gas-liquid distributor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 21 is used. The height of the material falling pipe 200 is 50mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 40mm. The height of the bent edge 140 is 50mm. The tower

tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 13 and 14 and the reference example 6 are shown in Table 6, wherein, the positions of points a-e are shown in Fig. 38.

Table 6

Position of temperature measurement point	Reference example 6	Example 13	Example 14
a, °C	370.5	365.5	364.4
b, °C	367.3	366.2	365.0
c, °C	363.6	365.8	365.3
d, °C	361.0	365.7	365.9
e, °C	369.8	366.9	364.8
Maximum temperature difference in radial direction in the bed layer, °C	9.5	1.2	1.5

Reference example 7

Compared with the reference example 1, the differences are: the reactor is in diameter of 4.6m, the hydrogenation raw material is diesel oil, the density of the diesel oil is 860kg/m3, and the sulfur content in the diesel oil is 1. 7wt%; the catalyst is RS-2000 hydrofining catalyst; the processing conditions are: partial pressure of hydrogen: 6.8MPa (G), volumetric space velocity: 1.9h-1, volume ratio of hydrogen to oil: 400:1, and inlet temperature of the reactor: 365°C.

Example 15

Compared with the reference example 7, in the example 15 of the present invention, the impact-reducing device 300 in the embodiment shown in Fig. 24 in the present invention is arranged in the space in the top closure of the hydrogenation reactor, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: the bending angle of the impact-reducing plate 360 is 120°; the impact-reducing plate 360 is bent symmetrically, and the total side length is 120mm; the height of the impact-reducing plate 360 is 60mm. The impact-reducing plate 360 is partially overlapped with the material falling pipe 200, and the height of the overlapped portion is 20% of the height of the material falling pipe 200.

Example 16

This embodiment is essentially the same as the example 15, but the ERI gas-liquid distributor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 24 is used. The height of the material falling pipe 200 is 120mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and

the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 50mm. The height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 15 and 16 and the reference example 7 are shown in Table 7, wherein, the positions of points a-e are shown in Fig. 38.

Table 7

Position of temperature measurement point	Reference example 7	Example 15	Example 16
a, °C	370.5	365.5	365.8
b, °C	367.3	366.5	366.2
c, °C	363.6	365.4	365.6
d, °C	361.0	365.2	365.1
e, °C	369.8	365.1	366.8
Maximum temperature difference in radial direction in the bed layer, °C	9.5	1.4	1.7

Reference example 8

Compared with the reference example 1, the differences are: the reactor is in diameter of 4.6m, and includes three catalyst bed layers. Between the first catalyst bed layer and the second catalyst bed layer, a uniformly perforated spraying tower tray (i.e., a flat perforated tower tray structure) in the prior art is used between the cold hydrogen box and the redistribution plate; likewise, between the second catalyst bed layer and the third catalyst bed layer, a flat perforated tower tray structure is also used between the cold hydrogen box and the redistribution plate , the tower tray has evenly distributed circular holes in diameter of 3mm, and the porosity of the tower tray is 8%. The hydrogenation raw material is wax oil (with 2.0wt% sulfur content), the catalyst is hydrotreating catalyst 3936, and the processing conditions are: partial pressure of hydrogen: 9.0MPa (G), volumetric space velocity: 1.5h-1, volume ratio of hydrogen to oil: 700:1, and inlet temperature of the reactor: 260°C.

Example 17

Compared with the reference example 8, in the example 17 of the present invention, the flat perforated tower tray structure is replaced with the impact-reducing flow-equalizing disc shown in Fig. 29, and the parameters of the impact-reducing flow-equalizing disc are: the bending angle of the impact-reducing plate 360 is 90°, the impact-reducing plate 360 is bent symmetrically, and the total side length is 60mm. The height of the impact-reducing plate 360 is equal to the height of the part of the material falling pipe 200 protruding above the tower tray 100, the central plane of the bending angle of the impact-reducing plate 360 extends through the axial line of the material falling pipe 200, and the height of the material falling pipe 200 is 60mm. Two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 20mm. The height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

The temperature values and temperature difference values in the radial direction at the entries to the second bed layer and the third bed layer in the example 17 and the reference example 8 are shown in Table 8, wherein, the positions of points a-e are shown in Fig. 38.

Position of temperature measurement point	Reference example 8	Example 17
Entry to the second catalyst bed layer		
Temperature in radial direction a, °C	276.6	275.2
Temperature difference in radial direction b, °C	279.5	274.5
Temperature in radial direction c, °C	280.3	274.9
Temperature in radial direction d, °C	286.0	275.0
Temperature difference in radial direction e, °C	288.4	275.8
Maximum temperature difference in radial direction in the bed layer, °C	11.8	1.3
Entry to the third catalyst bed layer		
Temperature in radial direction a, °C	281.3	282.9

Temperature difference in radial direction b, °C	283.6	283.5
Temperature in radial direction c, °C	292.5	284.5
Temperature in radial direction d, °C	286.7	284.3
Temperature difference in radial direction e, °C	289.6	283.7
Maximum temperature difference in radial direction in the bed layer, °C	11.2	1.6

Reference example 9

Compared with the reference example 1, the differences are: the reactor is in diameter of 3.0m, a top distribution tray is arranged at the entry to the topmost catalyst bed layer, the hydrogenation raw material is naphtha fraction, the catalyst is FGH-21 hydrofining catalyst from Fushun Petrochemical Research Institute, and the processing conditions of the reactor are: operating pressure: 1.85MPa, volumetric space velocity: 2.5h-1, volume ratio of hydrogen to oil: 355:1, and inlet temperature of the reactor: 285°C.

Example 18

Compared with the reference example 9, in the example 18 of the present invention, the impact-reducing device 300 shown in Fig. 34 is utilized, and is used in combination with the tower trays and material falling pipes of the conventional ERI bubble cap gas-liquid distributor, wherein, overflow holes are arranged in the material falling pipes. The parameters of the impact-reducing device 300 are: the height of the impact-reducing sleeve 370 is 300mm; the diameter of the impact-reducing sleeve 370 is 150mm; a triangular tooth slot is arranged at the top edge of the impact-reducing sleeve 370, and the height of the tooth slot is 10% of the height of the impact-reducing sleeve 370. The impact-reducing sleeve 370 is sleeved over the material falling pipe 200 concentrically, and the clearance therebetween in the horizontal direction is 30mm; the cross sectional area of the impact-reducing sleeve 370 is 5 times of the cross sectional area of the material falling pipe 200; the lower part of the impact-reducing sleeve 370 is partially overlapped with the material falling pipe 200 in the axial direction, and the height of the overlapped portion is 20% of the height of the material falling pipe 200; the height of the material falling pipe 200 is 120mm; two circular overflow holes 201 are arranged in the pipe wall of the material falling pipe 200 in the horizontal direction, and the total cross sectional area of the overflow holes 201 is 30% of the cross sectional area of the material falling pipe 200; the

distance from the center line of the overflow hole 201 to the top surface of the tower tray 100 is 50mm. The height of the bent edge 140 is 50mm. The tower tray 100 is assembled by 9 tower tray parts 110, each of which is arranged with two material falling pipes 200 and corresponding impact-reducing devices 300. The material falling pipes 200 and the corresponding impact-reducing devices 300 are arranged in a triangular layout on the tower tray 100.

Example 19

This example is essentially the same as the example 18, but the ERI gas-liquid distributor is canceled; instead, the impact-reducing flow-equalizing disc in the embodiment shown in Fig. 34 is used.

The temperature values and temperature difference values in the radial direction in the bed layers in the examples 18 and 19 and the reference example 9 are shown in Table 9, wherein, the positions of points a-e are shown in Fig. 38.

Table 9

Position of temperature measurement point	Reference example 9	Example 18	Example 19
a, °C	285.3	285.8	286.0
b, °C	289.6	286.3	286.2
c, °C	278.6	286.7	286.1
d, °C	278.3	285.5	284.6
e, °C	284.3	285.4	285.6
Maximum temperature difference in radial direction in the bed layer, °C	11.3	1.3	1.6

Claims

1. An impact-reducing uniform-flowing disc, characterized in that, comprising a tower tray (100), a material falling pipe (200) penetrating through the tower tray (100), and an impact-reducing device (300) configured to buffer the kinetic energy of an obliquely falling material flow, wherein, the impact-reducing device (300) has a guide surface configured to guide the obliquely falling material flow to flow along the guide surface and fall to the tower tray (100), and overflow holes (201) are provided at a portion of the material falling pipe (200) above the tower tray (100), and wherein, the impact-reducing uniform -flowing disc comprises a plurality of the material falling pipes (200) and a plurality of the impact-reducing devices (300) configured to provide buffering falling material function for the plurality of material falling pipes (200).

2. The impact-reducing uniform-flowing disc according to claim 1, wherein, the impact-reducing device (300) comprises a plate (310) provided above the material falling pipe (200) and configured to cover the top end of the material falling pipe (200).

3. The impact-reducing uniform-flowing disc according to claim 2, wherein, the impact-reducing device (300) comprises a side wall (320) extending upward from the edge of the plate (310).

4. The impact-reducing uniform-flowing disc according to claim 3, wherein, a first tooth slot (321) is provided on at least a part of the top edge of the side wall (320).

5. The impact-reducing uniform-flowing disc according to claim 2, wherein, the impact-reducing device (300) comprises a plurality of baffle portions (330) that extend upward from the plate (310) and face the falling material flow, the baffle portion (330) extend from one side of the plate (310) to the other side of the plate (310), and a material discharge channel is formed between adjacent baffle portions (330).

6. The impact-reducing uniform-flowing disc according to claim 5, wherein, the plurality of baffle portions (330) are parallel to each other and their plate surfaces are spaced from each other at an interval, and/or the baffle portions (330) extend upward vertically from the plate (310).

7. The impact-reducing uniform-flowing disc according to claim 5, wherein, the baffle portion (330) is provided with a communicating hole (331) penetrating through the baffle portion (330).

8. The impact-reducing uniform-flowing disc according to claim 7, wherein, the top end

of the material falling pipe (200) has a notch so that the top end has a top surface (210) and a notch surface (220) below the top surface (210), and the plate (310) is connected to the top surface (210).

9. The impact-reducing uniform-flowing disc according to claim 2, wherein, the plate (310) is connected to the material falling pipe (200) via a first connecting member (311), and/or there is a clearance between the plate (310) and the top end of the material falling pipe (200).

10. The impact-reducing uniform-flowing disc according to claim 1, wherein, the impact-reducing device (300) comprises a barrier grating (340) located above the material falling pipe (200).

11. The impact-reducing uniform-flowing disc according to claim 10, wherein, the barrier grating (340) comprises a plurality of grating plates (341) that are arranged obliquely in relation to the extending direction of the material falling pipe (200) and face the falling material flow, and the plurality of grating plates (341) are parallel to each other and their plate surfaces are spaced from each other at an interval.

12. The impact-reducing uniform-flowing disc according to claim 11, wherein, the barrier grating (340) comprises a connecting rod (342) that connects the plurality of the grating plates (341).

13. The impact-reducing uniform-flowing disc according to claim 10, wherein, the barrier grille (340) is connected to the material falling pipe (200) via a second connecting member (343), and/or there is a clearance between the barrier grating (340) and the top end of the material falling pipe (200).

14. The impact-reducing uniform-flowing disc according to claim 1, wherein, the impact-reducing device (300) comprises a plurality of cylindrical members (350) that are sleeved over each other in sequence, the bottoms of the cylindrical members (350) are connected to the tray surface of the tower tray (100), the plurality of the material falling pipes (200) are provided between adjacent cylindrical members (350), and the top of the cylindrical member (350) is higher than the top end of the material falling pipe (200).

15. The impact-reducing uniform-flowing disc according to claim 14, wherein, the cylindrical members (350) are arranged perpendicular to the tray surface.

16. The impact-reducing uniform-flowing disc according to claim 14, wherein, the cylindrical wall of the cylindrical member (350) is provided with a through-hole (351) penetrating through the cylindrical wall.

17. The impact-reducing uniform-flowing disc according to claim 16, wherein, t a plurality

of the through-holes (351) are provided circumferentially around the cylindrical member (350), and/or the height of the through-holes (351) corresponds to the height of the overflow holes (201).

18. The impact-reducing uniform-flowing disc according to claim 1, wherein, the impact-reducing device (300) comprises an impact-reducing plate (360) provided at a side of the material falling pipe (200) that faces the falling material, and the top of the impact-reducing plate (360) is higher than the top end of the material falling pipe (200).

19. The impact-reducing uniform-flowing disc according to claim 18, wherein, the impact-reducing plate (360) is arranged perpendicular to the tray surface of the tower tray.

20. The impact-reducing uniform-flowing disc according to claim 19, wherein, the impact-reducing plate (360) is fixed to the top of the material falling pipe (200), and wherein: the impact-reducing plate (360) is a flat plate (361); or the impact-reducing plate (360) is a first bent plate (362) that embraces the material falling pipe (200).

21. The impact-reducing uniform-flowing disc according to claim 19, wherein, the impact-reducing plate (360) is a second bent plate (363) that embraces the material falling pipe (200), the end of the bent edge of the second bent plate (363) is formed with a direct surface (363a) that guides the material flowing inwardly, the overflow holes (201) are provided at a part of the material falling pipe (200) away from the second bent plate (363), and the top end of the second bent plate (363) is not lower than the top end of the material falling pipe (200).

22. The impact-reducing uniform-flowing disc according to claim 1, wherein, the impact-reducing device (300) comprises an impact-reducing sleeve sleevedover the upper part of the material falling pipe (200), the top of the impact-reducing sleeve (370) is higher than the top of the material falling pipe, and there is a side clearance between the impact-reducing sleeve (370) and the material falling pipe (200).

23. The impact-reducing uniform-flowing disc according to claim 22, wherein, the impact-reducing sleeve (370) is fixed to the material falling pipe (200) via a third connecting member (371), and/or the edge of the top end of the impact-reducing sleeve (370) is provided with a second tooth slot.

24. The impact-reducing uniform-flowing disc according to any of claims 1-23, wherein, the material falling pipe (200) is a structure that has a filter function.

25. The impact-reducing uniform-flowing disc according to claim 24, wherein, the material falling pipe (200) is formed by a mesh filter member; or the material falling pipe (200) comprises a pipe body (230) and a filter screen (240) wrapped on the circumference

of the pipe body (230).

26. The impact-reducing uniform-flowing disc according to any of claims 1-23, wherein, the tower tray (100) comprises a plurality of tower tray parts (110) that form the tray surface of the tower tray (100) via a fitting member (120), and the tower tray (100) further comprises a supporting member (130) that support the tray surface.

27. The impact-reducing uniform-flowing disc according to any of claim 1-13 and 18-23, wherein, there are a plurality of the impact-reducing devices (300) corresponding to each of the material falling pipes (200) respectively.

28. The impact-reducing uniform-flowing disc according to any of claims 1-23, wherein, the edges of the tower tray are formed with bent edges (140) that are bent upward.

29. A reactor, characterized in that, comprising an inlet diffuser and the impact-reducing uniform-flowing disc according to any of claims 1-28, wherein, the impact-reducing uniform-flowing disc is arranged in a top closure of the reactor or at the top end of a reactor shell of the reactor, and the inlet diffuser is configured to feed the material to the impact-reducing uniform-flowing disc.

30. The reactor according to claim 29, wherein, the impact-reducing uniform-flowing disc is provided at the top end of the reactor shell of the reactor, and is above the topmost distribution tray of the reactor.

31. The reactor according to claim 29 or 30, wherein, the reactor is a hydrogenation reactor.