

CLAIMS

1. An apparatus for carrying out a gas-phase olefin polymerization comprising:
 - a first polymerization zone adapted and arranged for growing polymer particles to flow upward under fast fluidization or transport conditions comprising a cylindrical segment (1) having a diameter D01;
 - a second polymerization zone adapted and arranged for the growing polymer particles to flow downward comprising a cylindrical upper part (5) having a diameter D05 and a cylindrical lower part (6) having a diameter D06;
 - a gas/solid separation zone (4) of a cylindrical shape having a diameter D04 adapted and arranged for separating growing polymer particles from a gas flow which is arranged on top of the upper part (5) of the second polymerization zone and is directly connected to the upper part (5) of the second polymerization zone;
 - a tubular first connecting element (3) having a diameter D03 adapted and arranged for connecting the cylindrical segment (1) of the first polymerization zone to the gas/solid separation zone (4);
 - a tubular gas recycle line (8) having a diameter D08 adapted and arranged for connecting the gas/solid separation zone (4) to the first polymerization zone;
 - a tubular transition segment (2) having a diameter D02 arranged between the gas recycle line (8) and the cylindrical segment (1) of the first polymerization zone; and
 - a tubular second connecting element (9) having a diameter D09 adapted and arranged for connecting the lower part (6) of the second polymerization zone to the transition segment (2);

wherein the gas recycle line (8) is equipped with a compressor (15) adapted and arranged for circulating gas in the gas recycle line (8) and a heat exchanger (14) adapted and arranged for removing heat from the gas flowing in the gas recycle line (8);

wherein the ratio of D04 to D05 is from 1.0 to 1.5 and the ratio of D05 to D06 is from 1.2 to 2;

wherein the first connecting element (3) is a bend having a radius R03 or is a tubular element comprising one or more bend parts having one or more radiuses R03 and one or more linear parts and the ratio of R03 to D03 is from 1 to 6 and the ratio of D03 to D01 is from 0.3 to 0.85;

wherein the first connecting element (3) comprises a connecting piece (16), the first connecting element (3) and the gas/solid separation zone (4) are connected by the connecting piece (16), and the connection of the connecting piece (16) to the gas/solid

separation zone (4) is tangential and has an inclination so that the central axis of the connecting piece (16) and the horizontal form an angle A16 and the angle A16 is in the range from 0° to 40°;

wherein the transition segment (2) is a bend or is a tubular element comprising one or more bend parts and one or more linear parts and the ratio of D02 to D08 is 1.0 to 2.2; and

wherein the second connecting element (9) is a bend or is a tubular element comprising one or more bend parts and one or more linear parts.

2. The apparatus of claim 1, wherein the central axis of the second connecting element (9) at the position where the second connecting element (9) is connected to the transition segment (2) and the horizontal form an angle A02 and the angle A02 is in the range from 0° to 40°.
3. The apparatus of claim 1 or 2, wherein the apparatus further comprises a line (13) for feeding a barrier gas and/or liquid into the upper part (5) of the second polymerization zone.
4. The apparatus of any of claims 1 to 3, wherein the apparatus further comprises a line (20) for feeding a transport gas into an upper part of the second connecting element (9).
5. The apparatus of claim 4, wherein the second connecting element (9) is provided with a gas distribution grid (23) extending from the upper end of the second connecting element (9) for an angle A09 of at least 50° along the bending of the second connecting element (9).
6. The apparatus of any of claims 1 to 5, wherein the second polymerization zone comprises a throttling valve (22) and the apparatus further comprises a line (21) for feeding a dosing gas into the lower part (6) of the second polymerization zone at one or more positions above the throttling valve (22).
7. The apparatus of any of claims 1 to 6, wherein the compressor (15) is a centrifugal compressor comprising variable guide vanes (17) and the gas recycle line (8) is further equipped with a butterfly valve (18).
8. The apparatus of claim 7, wherein the variable guide vanes (17) are arranged upstream of the centrifugal compressor and the butterfly valve (18) is arranged downstream of the centrifugal compressor.
9. The apparatus of any of claims 1 to 8, wherein the gas/solid separation zone (4) has a height H04 and the ratio of H04 to D04 is 2.5 to 4.5.

10. The apparatus of any of claims 1 to 9, wherein the upper part (5) of the second polymerization zone has a height H05 and the ratio of H05 to D05 is 2 to 4.
11. The apparatus of any of claims 1 to 10, wherein the apparatus is part of a series of polymerization reactors.
12. A process for carrying out a gas-phase olefin polymerization in the apparatus of any of claims 1 to 11 at temperatures of from 20°C to 200°C and pressures of from 0.5 MPa to 10 MPa in the presence of a polymerization catalyst, comprising feeding one or more olefins into the apparatus, contacting the olefins and the polymerization catalyst under reaction conditions and discharging the polymer product from the apparatus, wherein the growing polymer particles flow upward through the first polymerization zone under fast fluidization or transport conditions, leave the first polymerization zone, pass through the gas/solid separation zone and enter the second polymerization zone where the polymer particles flow downward under the action of gravity, leave the second polymerization zone and are at least partially reintroduced into the first polymerization zone, thus establishing a circulation of polymer between the first polymerization zone and the second polymerization zone, wherein the second polymerization zone comprises a bed of densified polymer particles.
13. The process of claim 12, wherein the gas mixture present in the first polymerization zone is completely or partially prevented from entering the upper part (5) of the second polymerization zone by introducing a gas or liquid into the second polymerization zone via a feeding line (13), and the gas mixture present in the second polymerization zone differs from the gas mixture present in the first polymerization zone.
14. The process of claim 13, wherein the surface of the bed of densified polymer particles is located in the upper part (5) of the second polymerization zone.
15. The process of any of claims 12 to 14, wherein the polymerization is a homopolymerization of ethylene or a copolymerization of ethylene and one or more other olefins selected from the group consisting of 1-butene, 1-hexene and 1-octene or the polymerization is a homopolymerization of propylene or a copolymerization of propylene and one or more other olefins selected from the group consisting of ethylene, 1-butene and 1-hexene.