CLAIMS

1. A process for producing poly-α-olefins (PAO), the process comprising the following steps

a) providing a reactor system (20) comprising at least one reactor (80) having a reactor vessel (60) and a system for recycling and cooling part of reactor vessel outlet stream (67, 70, 72),

b) introducing to at least one reactor vessel (60) of the reactor system (20) at least α-olefin monomers (10, 50), recycled reactor outlet stream (72), catalyst and co-catalyst (10, 50, 32), which co-catalyst together with the catalyst forms a catalyst complex,

c) reacting in the reactor vessel (60) the α-olefin monomers to form a mixture of poly-α-olefins (PAO) product,

d) withdrawing from the reactor vessel an outlet stream (66) comprising unreacted monomers, mixture of PAO product and catalyst complex,

e) splitting the outlet stream (66) to a first stream (67), which is cooled and introduced back to the reactor vessel (60) as a recycled reactor outlet stream (72), and a product stream (25), wherein

at least one reactor (60) in the reactor system (20) is a cone reactor, in which cone reactor the reactor vessel has a first cross sectional area (61) in an upper part of the vessel and the cross sectional area decreases downwards to a second cross sectional area (62), which is smaller than the first cross sectional area, and wherein the splitting of the outlet stream (66) to a first stream (67) and a product stream (25) is performed such that 50 – 99 % of the outlet stream (66) forms the first stream (67) and the rest forms the product stream (25).

2. The process of claim 1, wherein the cone reactor has a reaction zone and a rounded outlet zone from which the reactor outlet stream is withdrawn, and wherein the reaction zone has a first cross sectional area in an upper part of the vessel and the cross sectional area decreases downwards to a second cross sectional area, which is smaller than the first cross sectional area.

3. The process of claim 1, wherein the cone reactor has a reaction zone and the reactor outlet stream is withdrawn directly from the reaction zone, and the cone reactor does not have a rounded outlet zone.

4. The process of claim 1 or 2, wherein the reaction zone of the cone reactor is divided to at least two sections, of which one section is a cone section, with a first cross sectional area in an upper part of the vessel and the cross sectional area decreases downwards to a second cross sectional area, which is smaller than the first cross sectional area.

5. The process of any of the claims 1 – 4, wherein the reaction zone of the cone reactor has a length of between 0.2 – 5, preferably 0.3 – 3, more preferably 0.5 – 1.5, times

the maximum diameter of the cone reactor at the site of the first cross sectional area.

6. The process of claim 4, wherein the reaction zone of the cone reactor has a tubular section, with a third cross sectional area (63) in an upper part of the tubular section and a fourth cross sectional area (64) at a lower part of the tubular section, which fourth cross sectional area is essentially equal to the third cross sectional area; and a cone section with a first cross sectional area (61) in an upper part of the cone section and the cross sectional area decreases downwards to a second cross sectional area (62), which is smaller than the first cross sectional area.

7. The process of claim 6, wherein the length of the tubular section is between 0.1 – 8, preferably 0.5 – 4, more preferably 1 – 3, times the diameter of cross sectional area of the tubular section, and the length of the cone section is between 0.2 – 5, preferably 0.3 – 3, more preferably 0.5 – 1.5, times the maximum diameter of the cone section at the site of the first cross sectional area.

8. The process of any of the claims 1 to 7, wherein introduction of the recycled reactor outlet stream to the reactor vessel is performed with an ejector.

9. The process of claim 8, wherein at least part of the catalyst is introduced to the reactor vessel using the ejector with which the recycled reactor outlet stream is introduced to the reactor vessel.

10. The process of any of the claims 1 – 9, wherein the α-olefin monomer comprises C_4 – C_{20} α-olefins, preferably C_8 – C_{12} α-olefins and more preferably C_{10} α-olefin.

11. The process of any of the claims 1 – 10, wherein the catalyst is an aluminium halide or a boron halide, preferably the catalyst is BF_3 and the co-catalyst is selected from C_1-C_{10} alcohols, preferably the co-catalyst is n-butanol.

12. The process of any of the claims 1 – 11, wherein the splitting of the outlet stream to a first stream and a product stream is performed such that 80 – 97 % and preferably 90 – 95 %, of the outlet stream forms the first stream and the rest forms the product stream.

13. The process of any of the claims 1 – 12, wherein the process further comprises a step f) wherein the product stream is subjected to a separation step for separating a PAO product stream from unreacted monomers and catalyst complex.

14. The process of claim 13, wherein the step f) is performed by distillation in a temperature of 10 °C to 300 °C in reduced pressure, and the separation also separates the catalyst complex, as catalyst and co-catalyst, from the unreacted monomers.

15. The process according to claim 13 or 14, wherein the PAO product is further processed by separating the PAO product in further PAO fractions followed by hydrogenation of the PAO fractions in presence of a noble metal catalyst or nickel catalyst, or hydrogenation of the PAO product in presence of a noble metal catalyst or nickel catalyst followed by separation of the hydrogenated PAO product in further hydrogenated

PAO fractions.

16. An apparatus for performing the process according to any of claim 1 – 15, wherein the apparatus comprises a reactor system comprising at least one reactor having a reactor vessel and a system for recycling and cooling part of reactor vessel outlet stream, means for introducing to at least one reactor vessel at least α-olefin monomers, recycled reactor outlet stream, catalyst and co-catalyst, and an outlet for withdrawing an outlet stream from the reactor vessel, wherein

the at least one reactor vessel is a cone reactor, which cone reactor has a first cross sectional area in an upper part of the vessel and the cross sectional area decreases downwards to a second cross sectional area, which is smaller than the first cross sectional area.

17. The apparatus of claim 16, wherein the apparatus further comprises means for splitting the outlet stream to a first stream and a product stream; and means for cooling the first stream and recycling the first stream to the reactor vessel.