Claims

1. A process for extruding plastic compositions using screw elements for multi-screw extruders with screws co-rotating in pairs and being fully self-wiping in pairs, with two or more screw flights, characterized in that the screw profiles may in each case be represented over the entire cross-section by a constantly differentiable profile curve.

2. The process as claimed in claim 1, characterized in that the screw profile over the entire cross-section is composed of four or more circular arcs, wherein the circular arcs merge tangentially into one another at their start and end points.

3. The process as claimed in claim 2, characterized in that

   - a generating and a generated screw profile have a centerline distance a from one another,
   - the number of the circular arcs of the generating screw profile is n,
   - the outer radius ra of the generating screw profile is greater than 0 ($ra>0$) and less than the centerline distance ($ra<a$),
   - the core radius ri of the generating screw profile is greater than 0 ($ri>0$) and less than or equal to ra ($ri \leq a$),
   - all the circular arcs of the generating screw profile merge tangentially into one another,
   - the circular arcs form a closed screw profile, i.e. the sum of the angles α_j of all the circular arcs j is equal to 2π, wherein π is the circle constant ($\pi \approx 3.14159$),
   - the circular arcs form a convex screw profile,
   - each of the circular arcs of the generating screw profile lies within or at the limits of a circular ring with the outer radius ra and the core radius ri, the center point of which lies on the point of rotation of the generating screw profile,
   - at least one of the circular arcs of the generating screw profile touches the outer radius ra of the generating screw profile at a point P_A,

- at least one of the circular arcs of the generating screw profile touches the core radius ri of the generating screw profile at a point P_I,

- the number of circular arcs n' of the generated screw profile is equal to the number of circular arcs n of the generating screw profile,

- the outer radius ra' of the generated screw profile is equal to the difference of the centerline distance minus the core radius ri of the generating screw profile (ra' = a-ri),

- the core radius ri' of the generated screw profile is equal to the difference of the centerline distance minus the outer radius ra of the generating screw profile (ri' = a-ra),

- the angle α_j' of the j'th circular arc of the generated screw profile is equal to the angle α_j of the jth circular arc of the generating screw profile, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively,

- the sum of radius r_j' of the j'th circular arc of the generated screw profile and radius r_j of the jth circular arc of the generating screw profile is equal to the centerline distance a, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively,

- the center point of the j'th circular arc of the generated screw profile is at a distance from the center point of the jth circular arc of the generating screw profile which is equal to the centerline distance a, and the center point of the j'th circular arc of the generated screw profile is at a distance from the point of rotation of the generated screw profile which is equal to the distance of the center point of the jth circular arc of the generating screw profile from the point of rotation of the generating screw profile, and the connecting line between the center point of the j'th circular arc of the generated screw profile and the center point of the jth circular arc of the generating screw profile is a line parallel to a connecting line between the point of rotation of the generated screw profile and the point of rotation of the generating screw profile, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively,

- a starting point of the j'th circular arc of the generated screw profile lies in a direction relative to the center point of the j'th circular arc of the generated screw profile which is opposite to that direction which a starting point of the jth circular arc of the generating screw profile has relative to the center point of the jth circular arc of the generating screw profile, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively.

4. The process as claimed in one of claims 1 to 3, characterized in that the screw elements are point-symmetrical and, in one sector of $360°/(2 \cdot Z)$, the profile curve is composed of at least two circular arcs, wherein Z is the number of flights of the screw elements.

5. The process as claimed in one of claims 1 to 3, characterized in that the screw elements are axially symmetrical and, in one sector of $360°/(2 \cdot Z)$, the profile curve is composed of at least two circular arcs, wherein Z is the number of flights of the screw elements.

6. The process as claimed in claim 5, characterized in that the profile curve in the sector is composed of two circular arcs, wherein at a point P_{FP} the circular arcs merge constantly differentiably into one another, wherein the point P_{FP} lies on a straight line FP, the orthogonal line of which passes through the center points of the two circular arcs at the point P_{FP}.

7. The process as claimed in claim 6, characterized in that the screw elements with a point of rotation D, a point P_A, which lies on a circle about the point of rotation with the outer radius ra of the screw element, a point P_I, which lies on a circle about the point of rotation with the internal radius ri of the screw element, a straight line DP_A, which passes through the points P_A and D, and a straight line DP_I, which passes through the points P_I and D, which, when using a Cartesian system of coordinates with the point D at the origin and the point P_A on the x axis, is characterized in that the orthogonal line intersects the straight line DP_A at the center point of one of the circular arcs and the straight line DP_I at the center point of the other circular arc, and in that the straight line FP is at a distance corresponding to half the centerline distance a from the point of rotation and has a gradient in radians of $-1/\tan(\pi/(2 \cdot Z))$.

8. The process as claimed in one of the preceding claims, characterized in that the screw elements are constructed as mixing elements or conveying elements.

9. The process as claimed in one of the preceding claims, characterized in that the screw elements are constructed as kneading elements.

10. The process as claimed in one of the preceding claims, characterized in that the screw elements are used in a degassing or conveying zone.

11. The process as claimed in one of the preceding claims, characterized in that clearances in the range from 0.1 to 0.001 relative to the diameter of the screw profile are present between screw elements and barrel and/or between neighboring screw elements.

12. The process as claimed in one of the preceding claims, characterized in that the plastic compositions are thermoplastics or elastomers.

13. The process as claimed in claim 12, characterized in that the thermoplastics used are polycarbonate, polyamide, polyester, in particular polybutylene terephthalate and polyethylene terephthalate, polyether, thermoplastic polyurethane, polyacetal, fluoropolymer, in particular polyvinylidene fluoride, polyether sulfones, polyolefin, in particular polyethylene and polypropylene, polyimide, polyacrylate, in particular poly(methyl)methacrylate, polyphenylene oxide, polyphenylene sulfide, polyether ketone, polyarylether ketone, styrene polymers, in particular polystyrene, styrene copolymers, in particular styrene-acrylonitrile copolymer, acrylonitrile-butadiene-styrene block copolymers, polyvinyl chloride or a blend of at least two of the stated thermoplastics.

14. The process as claimed in claim 13, characterized in that polycarbonate or a blend of polycarbonate with other polymers is used as the thermoplastic.

15. The process as claimed in claim 12, characterized in that the elastomer used is styrene-butadiene rubber, natural rubber, butadiene rubber, isoprene rubber, ethylene-propylene-diene rubber, ethylene-propylene rubber, butadiene-acrylonitrile rubber, hydrogenated nitrile rubber, butyl rubber, halobutyl rubber, chloroprene rubber, ethylene-vinyl acetate rubber, polyurethane rubber, thermoplastic polyurethane, gutta percha, acrylate rubber, fluororubber, silicone rubber, sulfide rubber, chlorosulfonyl-polyethylene rubber or a combination of at least two of the stated elastomers.

16. The process as claimed in one of the preceding claims, characterized in that fillers or reinforcing materials or polymer additives or organic or inorganic pigments, or mixtures thereof, are added to the polymer.

Claims

1. A process for extruding plastic compositions using screw elements for multi-screw extruders with screws co-rotating in pairs and being fully self-wiping in pairs, with two or more screw flights, characterized in that the screw profiles may in each case be represented over the entire cross-section by a constantly differentiable profile curve, characterized in that the screw profile over the entire cross-section is composed of four or more circular arcs, wherein the circular arcs merge tangentially into one another at their start and end points, and

   - a generating and a generated screw profile have a centerline distance a from one another,
   - the number of the circular arcs of the generating screw profile is n,
   - the outer radius ra of the generating screw profile is greater than 0 ($ra>0$) and less than the centerline distance ($ra<a$),
   - the core radius ri of the generating screw profile is greater than 0 ($ri>0$) and less than or equal to ra ($ri \leq a$),
   - all the circular arcs of the generating screw profile merge tangentially into one another,
   - the circular arcs form a closed screw profile, i.e. the sum of the angles α_j of all the circular arcs j is equal to 2π, wherein π is the circle constant ($\pi \approx 3.14159$),
   - the circular arcs form a convex screw profile,
   - each of the circular arcs of the generating screw profile lies within or at the limits of a circular ring with the outer radius ra and the core radius ri, the center point of which lies on the point of rotation of the generating screw profile,
   - at least one of the circular arcs of the generating screw profile touches the outer radius ra of the generating screw profile at a point P_A,
   - at least one of the circular arcs of the generating screw profile touches the core radius ri of the generating screw profile at a point P_I,

- the number of circular arcs n' of the generated screw profile is equal to the number of circular arcs n of the generating screw profile,

- the outer radius ra' of the generated screw profile is equal to the difference of the centerline distance minus the core radius ri of the generating screw profile (ra' = a-ri),

- the core radius ri' of the generated screw profile is equal to the difference of the centerline distance minus the outer radius ra of the generating screw profile (ri' = a-ra),

- the angle α_j' of the j'th circular arc of the generated screw profile is equal to the angle α_j of the jth circular arc of the generating screw profile, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively,

- the sum of radius r_j' of the j'th circular arc of the generated screw profile and radius r_j of the jth circular arc of the generating screw profile is equal to the centerline distance a, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively,

- the center point of the j'th circular arc of the generated screw profile is at a distance from the center point of the jth circular arc of the generating screw profile which is equal to the centerline distance a, and the center point of the j'th circular arc of the generated screw profile is at a distance from the point of rotation of the generated screw profile which is equal to the distance of the center point of the jth circular arc of the generating screw profile from the point of rotation of the generating screw profile, and the connecting line between the center point of the j'th circular arc of the generated screw profile and the center point of the jth circular arc of the generating screw profile is a line parallel to a connecting line between the point of rotation of the generated screw profile and the point of rotation of the generating screw profile, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively,

- a starting point of the j'th circular arc of the generated screw profile lies in a direction relative to the center point of the j'th circular arc of the generated

screw profile which is opposite to that direction which a starting point of the jth circular arc of the generating screw profile has relative to the center point of the jth circular arc of the generating screw profile, j and j' being integers which pass jointly through all the values in the range from 1 to the number of circular arcs n or n' respectively.

2. The process as claimed in claim 1, characterized in that the screw elements are point-symmetrical and, in one sector of 360°/(2·Z), the profile curve is composed of at least two circular arcs, wherein Z is the number of flights of the screw elements.

3. The process as claimed in claim 1, characterized in that the screw elements are axially symmetrical and, in one sector of 360°/(2·Z), the profile curve is composed of at least two circular arcs, wherein Z is the number of flights of the screw elements.

4. The process as claimed in claim 3, characterized in that the profile curve in the sector is composed of two circular arcs, wherein at a point P_{FP} the circular arcs merge constantly differentiably into one another, wherein the point P_{FP} lies on a straight line FP, the orthogonal line of which passes through the center points of the two circular arcs at the point P_{FP}.

5. The process as claimed in claim 4, characterized in that the screw elements with a point of rotation D, a point P_A, which lies on a circle about the point of rotation with the outer radius ra of the screw element, a point P_I, which lies on a circle about the point of rotation with the internal radius ri of the screw element, a straight line DP_A, which passes through the points P_A and D, and a straight line DP_I, which passes through the points P_I and D, which, when using a Cartesian system of coordinates with the point D at the origin and the point P_A on the x axis, is characterized in that the orthogonal line intersects the straight line DP_A at the center point of one of the circular arcs and the straight line DP_I at the center point of the other circular arc, and in that the straight line FP is at a distance corresponding to half the centerline distance a from the point of rotation and has a gradient in radians of $-1/\tan(\pi/(2\cdot Z))$.

6. The process as claimed in one of the preceding claims, characterized in that the screw elements are constructed as mixing elements or conveying elements.

7. The process as claimed in one of the preceding claims, characterized in that the screw elements are constructed as kneading elements.

8. The process as claimed in one of the preceding claims, characterized in that the screw elements are used in a degassing or conveying zone.

9. The process as claimed in one of the preceding claims, characterized in that clearances in the range from 0.1 to 0.001 relative to the diameter of the screw profile are present between screw elements and barrel and/or between neighboring screw elements.

10. The process as claimed in one of the preceding claims, characterized in that the plastic compositions are thermoplastics or elastomers.

11. The process as claimed in claim 10, characterized in that the thermoplastics used are polycarbonate, polyamide, polyester, in particular polybutylene terephthalate and polyethylene terephthalate, polyether, thermoplastic polyurethane, polyacetal, fluoropolymer, in particular polyvinylidene fluoride, polyether sulfones, polyolefin, in particular polyethylene and polypropylene, polyimide, polyacrylate, in particular poly(methyl)methacrylate, polyphenylene oxide, polyphenylene sulfide, polyether ketone, polyarylether ketone, styrene polymers, in particular polystyrene, styrene copolymers, in particular styrene-acrylonitrile copolymer, acrylonitrile-butadiene-styrene block copolymers, polyvinyl chloride or a blend of at least two of the stated thermoplastics.

12. The process as claimed in claim 11, characterized in that polycarbonate or a blend of polycarbonate with other polymers is used as the thermoplastic.

13. The process as claimed in claim 10, characterized in that the elastomer used is styrene-butadiene rubber, natural rubber, butadiene rubber, isoprene rubber, ethylene-propylene-diene rubber, ethylene-propylene rubber, butadiene-acrylonitrile rubber, hydrogenated nitrile rubber, butyl rubber, halobutyl rubber, chloroprene rubber, ethylene-vinyl acetate rubber, polyurethane rubber, thermoplastic polyurethane, gutta percha, acrylate rubber, fluororubber, silicone rubber, sulfide rubber, chlorosulfonyl-polyethylene rubber or a combination of at least two of the stated elastomers.

14. The process as claimed in one of the preceding claims, characterized in that fillers or reinforcing materials or polymer additives or organic or inorganic pigments, or mixtures thereof, are added to the polymer.