

PATENT SPECIFICATION

(11) 1 577 541

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- (21) Application No. 24968/77 (22) Filed 15 June 1977
(31) Convention Application No. 2626968
(32) Filed 16 June 1976 in
(33) Federal Republic of Germany (DE)
(44) Complete Specification published 22 Oct. 1980
(51) INT CL³ B29B 1/03 3/00 B29D 27/00
(52) Index at acceptance

B5A 1R214B 1R314C12 1R314C1C 1R314C1F 20N10 20N1
20N6 20T17 20T22 A2 T17C
C3C 104 106 112 135 151 153 154 155 164 181 350 351 354 362
369 375 452 453 455 500 520 521 522 543



(54) MANUFACTURE OF FOAMABLE PARTICLES OF OLEFIN POLYMERS

(71) We, BASF AKTIEN-GESELLSCHAFT, a German Joint Stock Company of 6700 Ludwigshafen, Federal Republic of Germany, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following Statement:—

The present invention relates to a process for the manufacture of foamable particles of an olefin polymer, in which process the olefin polymer is mixed homogeneously with a blowing agent (i.e. a material which emits gas when heated above a decomposition point) to form a mixture, the mixture is heated below the decomposition point of the blowing agent and is extruded, whilst plastic, to give a continuous foamable strand of substantially circular cross-section and from 0.5 to 5 mm in diameter, and the strand is then comminuted to give foamable cylindrical particles.

A plurality of processes for the manufacture of olefin polymer foams has been disclosed. For example, a foamed web has been manufactured by incorporating a solid blowing agent into an olefin polymer, extruding the mixture to give an unfoamed web, crosslinking this web by means of ionizing radiation and passing the web, hanging unsupported, vertically through a heating tunnel, thereby producing a foamed web with predominantly closed cells.

In another process, a foamable web is foamed by slowly passing it, on a hot air cushion, through a horizontal hot air tunnel, thereby allowing the web to foam up freely in all three dimensions.

In yet another process, foaming is effected by causing a foamable structure to expand whilst it floats on a heat transfer medium.

In all the above processes, expensive equipment is used to produce webs or sheets which are supplied, as bulky semi-finished

goods, to the processor, who converts them to the ultimately used articles, which have a relatively simple geometrical shape, by punching, sawing, deep-drawing and other shaping processes.

The foam webs can also be comminuted by means of suitable cutters to give cubic or cuboid granules, which can be compression-molded, by suitable methods, to give foam articles of any desired shape. However, because of the unfavorable close packing achievable with such rectangular foam granules, the moldings obtained suffer from the disadvantage of having a large void space and a low strength, resulting from the unfavorable conditions for surface adhesion between the foam particles, and therefore the above process gives unsatisfactory results at the molding stage.

Closer packing is achievable with spherical or cylindrical foam particles. The processes disclosed for the manufacture of such particles include some in which organic blowing agents which are gaseous or liquid at room temperature are worked into a polyolefin resin and the gel thus obtained is extruded at above the boiling point of the blowing agent and above the softening point of the resin, to give foam strands, which are cut, whilst still hot, so as to produce cylindrical particles with an advantageous ratio of diameter to length. However, because of the low softening point of the resin and the consequent instability of the foam structure these particles cannot be compression-molded directly and instead must first be crosslinked by an after-treatment with ionizing radiation.

The above possible methods of manufacturing olefin polymer foam particles of irregular shape exhibit the common feature that because of the expense of the method, the processor can only be provided with granules which have already been foamed. Because such granules

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are very bulky, they present transport problems which can only be overcome with difficulty and which would make it uneconomical to manufacture moldings from foamed polyolefin particles.

The present invention seeks to provide the manufacturer with a material which can be prefoamed, and further processed, by means of suitable processes in one and the same location and therefore can eliminate the expensive transport of material which has already been foamed.

According to the present invention, there is provided a process for the manufacture of foamable particles of an olefin polymer which includes mixing the polymer with a blowing agent to form a mixture, heating the mixture below the decomposition point of the blowing agent, extruding the mixture in the plastic state to give a continuous foamable strand which is from 0.5 to 5 mm in diameter and has a substantially circular cross-section, wherein the strand is passed, after leaving the extruder, through a cooling waterbath and is at the same time drawn at a draw ratio of from 2 to 40, and the cooled and drawn strand is comminuted to form cylindrical foamable particles which conform to the equation:

$$\frac{l_r}{d_r} \cdot R^{-3/2} = 0.025 - 0.25,$$

preferably 0.04—0.10, where l_r and d_r are respectively the length and diameter of the drawn and comminuted particles and R is the draw ratio, and the comminuted particles thus obtained are then irradiated substantially uniformly on all sides by means of ionizing radiation.

The irradiation of the particles from all sides may preferably be carried out whilst the particles are on a vibrating conveyor on which the particles are subjected to a continual change of position, in rapid sequence. The conveying surface of the vibrating conveyor is preferably manufactured from a metal having a high reflectance for electrons.

The olefin polymers used for the manufacture of the products of the invention are suitably low pressure or high pressure polyethylene, polypropylene or a copolymer of ethylene with up to 50% by weight of vinyl acetate, butadiene, propylene or an acrylic ester. Minor amounts of polybutadiene or polyisobutylene may also be admixed to the polyethylene, to increase the modulus of elasticity.

The blowing agent is suitably an organic, normally solid compound which has a sufficiently high decomposition temperature that it does not undergo

decomposition when incorporated into the olefin polymer, and when the mixture with the olefin polymer is heated for extrusion, for example at somewhat above 100°C. Specifically, the process of the invention may be carried out with p,p'-diphenylsulfhydrazone, N,N'-dinitrosopentamethylenetetramine or azodicarboxamide, used in the conventional amounts. However, the use of azodicarboxamide is preferred.

To lower the decomposition temperature of the blowing agent, one or more activators may be added to the mixture, provided the processing temperatures permit this. In general, salts or oxides of polyvalent heavy metals are effective activators. However, zinc oxide and zinc stearate are particularly suitable. These compounds may be added in amounts of from 0.1 to 25% by weight, based on the blowing agent employed. The concentration range of from 0.25 to 5% by weight has proved the most advantageous.

Suitable stabilizers for stabilizing the polymer against light, heat and/or oxygen may be added to the mixture.

The tendency of the particles produced according to the invention to adhere during foaming may make it necessary to surface-coat the particles. Depending on requirements, this coating may be applied as a solid, a solution, a suspension or a dispersion. The coating can be effected by mixing the coating material with the foamable granules, preferably after irradiation of the latter, whilst they are cold or whilst they are at an elevated temperature provided this is below the softening point of the olefin polymer.

Preferred coating materials adhere well to the granules but do not diffuse into the polymer and are either not in the molten state at the foaming temperature or, if they are in the molten state, are immiscible with the polymer. Coating with pulverulent inorganic compounds has proved the most advantageous. For example, finely divided silica gel, zinc oxide, kaolin and talc give equally good results. It is also possible to apply organic resins which are incompatible with the olefin polymer. For example, sticking-together of the foaming particles can be effectively prevented by applying pulverulent nylon, polytetrafluoroethylene or polyvinyl chloride to the surface of the granules. Reactive mixtures of, for example, polyepoxy compounds and polyamines may also be used.

The amount required in order effectively to suppress the sticking-together of the granules may be from 0.05 to 5% by weight, based on the weight of the foamable granules, depending on the nature of the coating material and the effectiveness of its

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distribution. The most advantageous amount of coating is, according to our practical experience, from 0.25 to 1% by weight.

5 In a preferred embodiment of the process according to the invention the cylindrical particles are crosslinked by passing them, by means of a rapidly vibrating conveyor, under a source of radiation in such a way that the particles repeatedly change their position in rapid sequence and as a result are exposed uniformly on all sides to about the same radiation dose, so that very homogeneous crosslinking is achieved. If an electron beam generator—which, as is known from experience, only gives a limited depth of penetration—is used as the source of ionizing radiation then a vibrating conveyor must be used to provide the necessary exposure of the particles for achieving uniform crosslinking on all sides.

10 The vibrating conveyor can consist of a continuously circulating conveyor belt which in addition is caused to undergo periodic vibrations by means of a vibration generator; however, the vibrating conveyor can also consist of a fixed sheet-like structure which is suitably caused to undergo longitudinal vibrations and thus simultaneously provides a conveying action and brings about the desired change in position of the particles which are to be crosslinked.

15 The effect of uniform crosslinking on all sides can be additionally improved by manufacturing the conveyor belt or vibrating sheet of a metal which has a high reflectance for electrons, causing scattered radiation which impinges simultaneously from several directions on the particles to be cross-linked.

20 The proportion of insoluble gel—produced by the treatment with ionizing radiation—in the irradiated polymer should preferably be at least 5% by weight and at most 70% by weight. A particularly preferred gel content is between 25% and 60% by weight. The gel content is determined analytically in the conventional manner, in boiling toluene.

25 An essential characteristic of the invention relates to the shape of the cylindrical granules containing blowing agent. We have in fact found that unsatisfactory results are achieved, when manufacturing irregular moldings, if the length to diameter ratio of the cylindrical foamable particles is either too large or too small. In both cases, moldings which exhibit inadequately close packing and little mutual surface adhesion of the foamed particles are obtained. If, on the other hand, the extruded strands of circular cross-section are cut into such lengths as to produce particles which in the foamed state have a

length to thickness ratio of at most 1.5 and at least 0.5, the particles can be used to manufacture irregular moldings with close packing and good internal cohesion. In a preferred embodiment, the length to thickness ratio is from 1.25 to 0.75.

70 The most advantageous shape of the non-foamed particles cannot, however, be deduced directly from these statements, since deformation of the continuous strands of circular cross-section in the semi-plastic state, after issuing from the extruder, leads to frozen-in stresses which, after the treatment with ionizing radiation, are only released, at least partially, during foaming. If, therefore, the advantageous length to thickness ratio used above in connection with the foamed particles were also to be applied to the non-foamed particles, shrinkage phenomena would give foam particles with a length to thickness ratio unfavorable for the manufacture of moldings.

75 Hence, when manufacturing non-foamed particles which can be expanded to give foam particles with substantially identical length and thickness dimensions, the procedure followed is that after extrusion the continuous strands are first drawn at a draw ratio of from 2 to 40, whilst they are in a partially cooled state, i.e. after having been quenched in a cooling waterbath, which is preferably kept at room temperature. After the drawn strands have cooled completely, they are cut into lengths, taking their draw ratio into account, so that the quotient of the length to the diameter, multiplied by the reciprocal of the square root of the cube of the draw ratio assumes a value of from 0.025 to 0.25, though in the preferred embodiment the equation

$$\frac{l_r}{d_r} \cdot R^{-3/2} = 0.04 - 0.10$$

105 is satisfied. Here, draw ratio means the ratio of the draw-off speed of the strands using an external draw-off force, to the speed at which the strands leave the die when no external draw-off force is exerted.

EXAMPLE 1

115 A homogeneous mixture consisting of 85 parts by weight of high pressure polyethylene of melt index 2, 15 parts by weight of azodicarboxamide and 3 parts by weight of zinc stearate is gently fused at 130°C in an extruder with an L/D ratio of 15 and extruded through a die plate with 40 holes, each of 2.2 mm, the plate being heated to 140°C. The throughput of the mixture is about 32.5 kg/hour. Using a strand granulator with two independently driven draw-off rollers and a 12-blade

chopper drum, the extruded continuous strands are drawn through a waterbath, kept at room temperature, immediately after the die plate, and are thus quenched. The speed of the chopper drum is selected so as to cut the strands into cylindrical particles of mean length $\bar{l}_R=3.02$ mm (this being the mean value of 20 individual measurements). At this draw-off speed, the chopped particles have a mean diameter of $\bar{d}_R=1.02$ mm.

If the strands are allowed to enter the waterbath directly, without applying an external draw-off force, they have a mean diameter of $d_{R=1}=3.94$ mm. From these figures, the draw ratio R can be calculated using the equation

$$d_R = d_{R=1} / \sqrt{R}$$

and

$$R = \left(\frac{d_{R=1}}{d_R} \right)^2$$

Introducing the experimentally found values gives a value of $R=14.92$, whilst

$$\frac{\bar{l}_R}{d_R} \cdot R^{-3/2} = 0.051$$

and

$$\frac{\bar{l}_R}{d_R} = 2.96.$$

The particles are crosslinked by spreading them on a sheet of tungsten-plated steel firmly fixed to a mechanical vibration generator and passing them, under conditions where they constantly undergo a change of position, under an electromagnet using a voltage of 500 kV and a radiation current of 40 mA, at a mean conveying speed of 2.5 m/minute. The foamable particles obtained after this treatment have an insoluble gel content (in boiling toluene) of about 45% by weight.

To carry out the foaming process, the particles are first coated with 0.5% by weight of a hydrophobic silica gel which has a mean particle size of 5 mm and are then passed through an infrared radiation field of 0.5 W/cm² on a coarse-mesh conveyor belt of PTFE-coated glass fiber. The pressure under which the particles rest on the conveyor belt can be reduced by blowing hot air against the particles through the perforated conveyor belt. During this treatment, the particles foam uniformly to give approximately spherical foam particles. However, in order to measure the degree of foaming accurately, groups of 20 primary particles having the above dimensions were spiked on a fine needle and foamed in an infrared radiation field of 0.50 W/cm² whilst

continuously rapidly rotating the needle about its vertical axis. The particles foamed in this way and then cooled has a mean length L of 4.20 mm and a mean diameter D of 4.25 mm and hence an L/D ratio of 0.988. The density of the foam is from 29 to 32 grams per liter.

COMPARATIVE EXAMPLE 2

If, in the above extrusion experiment, the (extrusion) conditions are kept the same, the draw-off speed is kept unchanged at 17 m/minute, but the chopper drum speed is altered so that on average (based on 20 individual measurements) particles of identical length and diameter ($\bar{d}_R = \bar{l}_R = 1.02$) are obtained, the following values may be calculated

$$\frac{\bar{l}_R}{\bar{d}_R} R^{-3/2} = 0.017 \frac{\bar{l}_R}{\bar{d}_R} = 1$$

These particles are then crosslinked as described above and foamed individually. After this treatment, they have a mean diameter \bar{D} of 4.25 mm and a mean length \bar{L} of 1.40 mm, so that the \bar{L}/\bar{D} ratio is 0.329.

COMPARATIVE EXAMPLE 3

If, whilst keeping all other conditions the same, the draw-off speed is increased to 31 m/minute, the cylindrical strands have a diameter of $\bar{d}_R=0.76$ mm. From this, the draw ratio—based on the diameter of the undrawn strands entering the waterbath—is calculated to be $R=26.88$.

If the speed of the chopper drum used to cut these strands is chosen so as to produce particles with a mean length $\bar{l}_R=2.24$, approximately the same \bar{l}_R/\bar{d}_R ratio of 2.95 as in the advantageous Experiment 1 is obtained. However, due to the higher draw ratio, the identical further treatment of the primary particles results in foam particles in which the length and diameter differ substantially from one another, with values of $L=2.19$ and $D=3.80$ mm ($L/D=0.576$). For this experiment the value of $\bar{l}_R/\bar{d}_R \cdot R^{-3/2}$ of the non-foamed primary particles is 0.021.

Manufacture of moldings from the particles obtained in 1 to 3 above

The moldings were manufactured in a rectangular metal mold of dimensions length×width×height=400×300×120 mm. The bottom consisted of a PTFE-coated coarse-mesh glass fiber fabric. Foam particles produced as described in Example 1 or in Comparative Example 2 or 3 were loosely poured into this mold to a height of 100 mm. The particles were then surface-heated for 3 minutes by blowing air, heated to 145°C, through the

coarse-mesh glass fiber fabric which formed the bottom of the mold; thereafter the mold, containing the particles, was transferred into a hydraulic press and the particles were compressed to a height of about 40 mm and the mold cooled. After 15 minutes it was possible to take the molding out of the press, the ejection being facilitated if the inner walls of the mold and the fabric which formed the bottom of the mold were coated beforehand with a silicone oil release agent.

The molding thus produced substantially has the imposed contours and dimensions of the mold. If the molding process has been carried out with foam particles manufactured as described in Example 1, i.e. in which the non-foamed primary particles have a value of $l_r/d_r \cdot R^{-3/2}=0.051$, the molding has a pleasing uniform structure with negligibly small void space.

The use of the foam particles obtained in Comparative Examples 2 and 3, for which the corresponding values were 0.017 and 0.021 respectively, on the other hand results in a very inhomogeneous foam molding with many unfilled inter-particle voids and low mechanical strength.

EXAMPLE 4

A homogenized mixture of 85 parts by weight of high pressure polyethylene (melt index=2), 15 parts by weight of azodicarboxamide and 1 part by weight of zinc oxide was fused at 135°C in an extruder with an L/D ratio of 15 and extruded through a die plate with 15 holes each of 3.5 mm diameter, the plate being at 115°C. the throughput was 31 kg/hour of the pregranulated mixture.

The material was extruded directly into a waterbath kept at room temperature, the strands being drawn off at a speed of 30 m/minute. At this draw-off speed, the strand assumes a thickness of $\bar{d}_r=1.21$ mm. If the strands are allowed to enter the waterbath without applying a draw-off force, they have a mean diameter of $\bar{d}_{r=1}=6.54$ mm. From this, the draw ratio is calculated to be $R=29.21$.

If in this experiment, the speed of the chopper drum is chosen so as to chop the strands to a mean length of $\bar{l}_r=7.84$ mm, and if the cylindrical particles, having an l_r/d_r ratio of 6.48 and a value of $l_r/d_r \cdot R^{-3/2}=0.041$, are crosslinked in the manner which has been described, heating in an infrared radiation field gives foam particles having an ideal length to diameter ratio L/D of 1.00 ($L=6.69$; $D=6.65$).

COMPARATIVE EXAMPLE 5

If, using the same experimental arrangement, the speed of the chopper drum is chosen so as to chop the strands to a mean length of $\bar{l}_r=1.22$, whilst keeping the

same diameter, hence giving an \bar{l}_r/\bar{d}_r ratio of about 1, resulting in an extremely unfavorable value of $\bar{l}_r/\bar{d}_r \cdot R^{-3/2}=0.0064$, the discus-like foam particles obtained after the conventional further treatment have a very unsatisfactory length to diameter ratio of $L/D=0.155$ ($L=1.03$; $D=6.65$).

The manufacture of moldings by heating the foam particles with air at 145°C and compression-molding results the foam particles having a high porosity, numerous channels and passages and accordingly, an unsatisfactory mechanical strength.

COMPARATIVE EXAMPLE 6

In a further comparative experiment, the extrusion conditions were kept unchanged and the draw off speed was increased to 45 m/minute, resulting in strands exactly 1.00 mm thick. If these are chopped so as to give an l_r/d_r ratio of 6.45, comparable with Example 4, the length-diameter ratio of foam particles which have been crosslinked and foamed under strictly comparable conditions is $L/D=0.64$ and thus, it is true, more advantageous than in Comparative Example 5; the value of $\bar{l}_r/\bar{d}_r \cdot R^{-3/2}=0.023$, however, shows that once again foam particles with optimum close packing were not to be expected.

EXAMPLE 7

The extrusion conditions of Example 4 were retained but the draw-off speed was reduced to $v=17$ m/minute and the strands, of mean diameter $\bar{d}_r=1.64$ were chopped to a mean length of $\bar{l}_r=5.78$. From this it is calculated that $R=15.90$, $\bar{l}_r/\bar{d}_r=3.52$ and $\bar{l}_r/\bar{d}_r \cdot R^{-3/2}=0.056$.

CROSSLINKING EXPERIMENT 1

In one experiment, crosslinking was carried out under a industrial linear accelerator with a voltage of 500 kV, by passing the elongate cylindrical foamable particles continuously under the 1.5 m wide accelerator window, on several parallel flat chromium-nickel steel sheets caused to undergo a characteristic vibration of 50 c/s by means of electromagnetic vibrators. The throughput was about 80 kg per hour, the beam current being 40 mA. The treated particles had an insoluble gel content, in boiling toluene, of 46% by weight.

The crosslinked granules were then coated with 1% by weight, based on the weight of the particles, of a mixture consisting of equal parts of talc and fine PVC powder. The coating could best be applied in a high-speed mixer in the presence of 1% by weight of paraffin oil as an adhesive. Foaming of the material, treated as described above to prevent premature sticking-together, was carried

5 out continuously on an endless conveyor
 belt of PTFE-coated glass fiber fabric,
 having a mesh size of 1×1 mm. The
 conveyor belt, loosely laden with the
 foamable particles, passed through a
 heating zone of total length 1 meter,
 comprising infrared radiators mounted
 above and below the conveyor belt. The
 surface temperature of the radiators was
 chosen so as to achieve a radiation density
 of 0.6 watt/cm² in each direction of
 radiation at the location of the foamable
 particles. With a mean residence time of 2.8
 minutes, the particles foamed substantially
 uniformly in all directions and adhered only
 slightly to the conveyor mesh. On leaving
 the heating zone, they could easily be lifted
 off the belt by means of an air jet directed
 against the belt at an acute angle, and be
 collected.

10 The measurement of a substantial number
 of foam particles gave a mean length of 7.63
 mm and a mean diameter of 7.59 mm, with a
 foam density of 28.5 grams per liter.

15 However, on cutting the particles open it
 was found that the majority had a central
 void. As a result of adopting an unfavorable
 draw ratio when manufacturing the primary
 particles, this experiment gave a particle
 diameter which, even under the favorable
 precondition of continuous change of
 position of the particles, prevented the
 particles from being adequately penetrated
 by the radiation and homogeneously
 crosslinked.

CROSSLINKING EXPERIMENT 2

20 Foamable particles (of the same
 composition as in Crosslinking Experiment
 1), in a layer only one particle deep, were
 passed on a flat conveyor belt at a speed of
 V=90 cm/minute under an electron source
 of 1MeV, with a beam current of 110 μA.
 After the first pass, the particles were
 manually shaken on the conveyor belt in
 order to alter their position. Thereafter,
 they were passed 7 more times under the
 radiation source, their position being
 altered, after each pass, by brief shaking.
 Foaming gave particles which were mostly
 approximately round, with dimensions
 L=7.35 mm and D=7.32 mm. The average
 gel content was 41.5% by weight and the
 foam density was 432 g/l.

25 In spite of the repeated change of position
 of the primary particles, this experiment
 gives a number of foam particles which,
 because of inadequate change of position,
 foam asymmetrically and exhibit an
 inhomogeneous foam structure.

60 CROSSLINKING EXPERIMENT 3

If, in the above crosslinking Experiment
 2, the conveyor belt is replaced by a
 vibratory conveyor according to the

invention, consisting of a flat chromium-
 nickel steel sheet with side stops, and a
 stream of the product particles, only one
 particle deep, is conveyed by means of this
 device at a speed of 0.11 m per minute
 under a linear accelerator with a potential
 of 10⁶ volt, a beam current of 1.1×10⁴
 ampere and a beam width of 0.375 m, the
 primary particles are uniformly crosslinked
 from all sides. They have an insoluble gel
 content, in boiling toluene, of 47% by
 weight.

If these particles are coated and foamed,
 as described in Experiment 1, almost
 spherical foam particles having a mean
 length of $\bar{L}=7.21$ mm and a diameter of
 $\bar{D}=7.39$ mm (L/D=0.98) are obtained. The
 cell structure of these particles proved to be
 uniformly fine and substantially free from
 voids. The density of the foam was 29.5 g/l.

A broadly similar process for the
 manufacture of foamable particles of an
 olefin polymer is also described and claimed
 in our copending GB patent application
 24969/77 (Serial No. 1,577,542), the
 extruded continuous strand being chopped,
 however, into particles having a length to
 diameter ratio of from 1.3 to 1.8 whilst still
 hot and cooling and drawing of the strand
 prior to comminution playing no part in the
 definition of the invention.

WHAT WE CLAIM IS:—

1. A process for the manufacture of
 foamable particles of an olefin polymer,
 which includes mixing the polymer with a
 blowing agent to form a mixture, heating the
 mixture below the decomposition point of
 the blowing agent, extruding the mixture in
 the plastic state to give a continuous
 foamable strand which is from 0.5 to 5 mm
 in diameter and has a substantially circular
 cross-section, and then comminuting the
 strand to give foamable cylindrical particles,
 wherein the strand is passed, after leaving
 the extruder, through a cooling waterbath
 and is at the same time drawn at a draw ratio
 of from 2 to 40, the cooled and drawn strand
 is comminuted to form cylindrical foamable
 particles which conform to the equation:

$$0.025 \leq \frac{l_r}{d_r} \cdot R^{-3/2} \leq 0.25$$

where l_r and d_r are respectively the length
 and diameter of the drawn and comminuted
 particles and R is the draw ratio, and the
 comminuted particles thus obtained are
 then irradiated substantially uniformly on
 all sides by means of ionizing radiation.

2. A process as claimed in claim 1,
 wherein the particles produced satisfy the
 equation

$$0.04 \leq \frac{l_R}{d_R} \cdot R^{-3/2} \leq 0.10$$

3. A process as claimed in claim 1 or 2, wherein the irradiation treatment, from all sides, is carried out with ionizing radiation whilst the particles are on a vibrating conveyor, the particles being subjected to a continual change of position in rapid sequence.
4. A process as claimed in claim 3, wherein the ionizing radiation is derived from an electron beam generator.
5. A process as claimed in claim 4, wherein the conveying surface of the vibrating conveyor is made of a metal of high reflectance for electrons.
6. A process as claimed in any of claims 1 to 5, wherein the olefin polymer is polyethylene, polypropylene or a copolymer of ethylene with up to 50% by weight of vinyl acetate, butadiene, propylene or an acrylic ester and the blowing agent is an organic normally solid compound.
7. A process as claimed in claim 6, wherein the mixture of polymer and blowing agent is heated for extrusion at above 100°C and the cooling waterbath is maintained at room temperature.
8. A process as claimed in any of claims 1

- to 7, wherein the blowing agent is azodicarboxamide.
9. A process as claimed in any of claims 1 to 8, wherein the polymer-containing mixture contains an activator to lower the decomposition temperature of the blowing agent.
10. A process as claimed in any of claims 1 to 9, wherein the foamable particles are surface-coated with a coating material to reduce the tendency to adhesion during foaming.
11. A process as claimed in any of claims 1 to 10, wherein the irradiation is sufficient to provide a gel content of from 25 to 70% by weight in the irradiated particles.
12. A process for the manufacture of foamable particles of an olefin polymer carried out substantially as described in any of the foregoing Examples 1, 4 and 7.
13. Foamable olefin polymer particles when manufactured by a process as claimed in any of claims 1 to 12.
14. Foam moldings made from foamable olefin polymer particles claimed in claim 13.

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