

PATENT SPECIFICATION

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(54) METHOD FOR THE RELEASE OF SILICONE RUBBER MOULDED BODIES FROM MOULDING DIES

(71) We, AGFA-GEVAERT, AKTIEN-GESELLSCHAFT, a body corporate organised according to the laws of the Federal Republic of Germany, of Leverkusen, 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:

This invention relates to a method for the release of silicone rubber moulded bodies from moulding dies.

The release of moulded bodies made of silicone rubber from moulding dies has hitherto been effected by mechanical methods such as for example, by gripping the moulded body with pincers and removing it from the die.

Thin moulded bodies, of silicone rubber, however, especially those which are thin towards the periphery such as, for example, contact lenses, are frequently damaged or destroyed by mechanical removal from the moulding tool. Furthermore, mechanical removal is relatively time-consuming as a result of the care which must be taken. The disadvantages of mechanical removal are particularly serious in the mass production of such moulded bodies.

It is an object of the present invention to provide a method for the removal of silicone rubber moulded bodies from moulding dies without damage or destruction. It is a further object of the invention to provide a method which is suitable for use in mass production.

The present invention provides a method for releasing a moulded body made of a silicone rubber from a moulding die, wherein the release is effected by causing the moulded body to swell under the action of a swelling agent, and the swelling agent is substantially removed from the moulded body after release thereof.

It is advantageous to effect the swelling by immersing the moulding die bearing the adhering silicone rubber moulded body in a bath of the swelling agent. By appropriate selection of the swelling agent the shaped bodies can be made to float after they are released, and may then easily be lifted from the surface of the liquid swelling agent in the bath.

Advantageously, release of the silicone rubber body from the moulding die is assisted by the action of ultrasonics.

After the release operation, the swelling agent is removed from the moulded body, preferably substantially quantitatively.

The swelling agent advantageously comprises a solvent, preferably an organic solvent material. As organic solvents there may be mentioned aliphatic hydrocarbons such as, for example, the benzene mixture; aromatic hydrocarbons, for example, benzene, toluene, and xylene; halogenated hydrocarbons, for example, carbon tetrachloride, trichloroethylene and, more especially, fluorinated hydrocarbons such as, for example, those sold under the registered Trade Marks "KALTRON", "FRIGEN" and "FREON".

Other organic solvents which may be used as swelling agent in the method of the invention include ethers, preferably lower alkyl ethers such as, for example, diethyl ether; esters, preferably lower alkyl esters of lower carboxylic acids, for example, ethyl acetate; ketones, for example, methyl butyl ketone; and miscellaneous solvents such as, for example, tetrahydrofuran, dioxane, dimethylformamide and dimethyl acetamide.

It will be appreciated that the swelling agents mentioned above may be used alone or in admixture with other such agents.

It will further be appreciated that the use of the term "organic solvent" to designate certain materials which may be used as

swelling agents in accordance with the invention is not intended to imply that the silicone rubber necessarily undergoes any appreciable degree of dissolution, but is designated rather to indicate the general nature of certain materials which may be used.

An especially important form of the method of the invention is that in which the silicone rubber moulded body comprises a contact lens, and the invention accordingly also provides a contact lens (or other moulded body) obtained by the method of the invention.

The increase in the volume of the moulded body caused by the swelling agent may be at least 60%, and, depending on the choice of swelling agent, increases of up to 250% or more may be obtained.

A method in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of a bath of swelling agent with a die and shaped body adhering thereto immersed in the bath;

Fig. 2 shows a stage of the method after the moulded body has begun to swell; and

Fig. 3 shows the position after release of the moulded body from the moulding tool.

When moulding shaped bodies of silicone rubber, for example contact lenses, pressures of up to 100 atm/cm² are applied. As a result the moulded bodies become intimately joined to the moulding tools and can be removed therefrom by mechanical means only with the utmost care and by a relatively time-consuming operation.

After moulding, the two portions of the moulding die are separated from each other; the portions are normally hinged for this purpose. The moulded body adheres to one portion of the tool, and has hitherto had to be removed mechanically. For this purpose, the material which has flowed off over the edge of the moulded body to the inside of the moulding die had first to be removed.

By careful lifting of the edge of the moulded body from the surface of the moulding tool the moulded body was then loosened at various points and gradually freed. Such operations proved particularly difficult with contact lenses which generally have edge thickness of no more than 1/10 mm. Even with extreme care it was not possible in many cases to prevent the tools used for the removal from leaving imprints on the contact lenses or from scratching and thus destroying them.

The avoidance of destruction of such contact lenses by previously proposed mechanical release processes was made more difficult by the fact that the silicone rubber material, even a considerable time after moulding, has

only limited mechanical strength.

Referring now to Figure 1 of the accompanying drawings, a portion P of a moulding die, with a contact lens K adhering thereto is immersed in a solvent bath L in a container B. By the action of the solvent L, as shown in Figure 2, the lens K begins to increase in volume. Depending on the choice of solvent it is possible to achieve a volume increase of up to 250% or more. As a result of the swelling, the lens K becomes released from the moulding tool P and, with an appropriate solvent, floats to the surface of the bath L, as shown in Figure 3, from which it can easily be removed. The speed of release of the lens K from the moulding die P may be increased by the action of an ultrasonic vibrator. The container B with the solvent L contained therein may be immersed briefly in an ultrasonically agitated container. Instead, the container B may itself be part of a conventional ultrasonic cleaning plant.

After release of the moulded body K, the solvent is quantitatively removed therefrom, to prevent damaging physiological effects on eyes fitted with such contact lenses which might otherwise occur. Removal of the solvent is preferably effected by heating the lens in a heating cabinet flushed with fresh air, in which the lens remains for from one to several minutes, depending on the temperature and the type of solvent used.

It is also possible to achieve quantitative removal of the solvent by placing the lens in a sealed heating furnace operated under reduced pressure. Although many solvents have very low boiling points, so that evaporation will in many cases occur even at room temperature, heating is nevertheless still preferred, to attain a relatively high degree of cleanliness of the lens.

As a result of removal of the swelling agent the lens recovers its original shape. It has been found that even if the lenses are treated a hundred times with appropriate solvents, no measurable changes occur in the optical and mechanical properties of the lens.

The swelling agent is preferably an organic solvent, more especially an aromatic, aliphatic or halogenated hydrocarbon, for example, benzene, benzene or xylene. Preferred solvents include diethyl ether, ethyl acetate, carbon tetrachloride, trichloroethylene and fluorohydrocarbons, for example, those sold under the registered Trade Marks KALTRON, FREON, and FRIGEN. Fluorohydrocarbons are especially suitable because of their inert character, their favourable boiling point and their relative physiological innocuity. Where good physiological compatibility is required, the purity of the solvent is of particular importance. Further purification of commercially avail-

able products, for example by an accurately performed distillation, may be necessary to achieve good physiological compatability of a contact lens of silicone rubber that has been released according to the invention.

Physiological tests conducted with humans and have demonstrated the harmlessness of the method of the invention from the medical point of view.

The following Example illustrates the invention:

A moulding die having a silicone rubber lens adhering thereto is immersed in a bath of the solvent sold under the trade name KALTRON MDR 113 (manufacturer: Kalichemie, Federal Republic of Germany, which had been purified by distillation), at room temperature. After 2 to 3 minutes the swelling process in the lens has advanced to such an extent that it becomes released from the die and floats to the surface of the bath. After being removed carefully from the bath, the lens is subjected to a temperature of 170°C for a period of 2 to 3 minutes in a heating furnace flushed with fresh air, to remove the solvent therefrom. Subsequently, the lens, which has shrunk back to its original size, is removed from the heating furnace. The further processing may comprise edging (for example, as referred to in British Patent Specification No. 1 476 356) and possibly hydrophilizing (for example, as referred to in British Patent Specification No. 1,362,939 or in British Patent Specification No. 1 487 965).

The structure and materials used for making moulding dies will be well-known to those skilled in the art. The die is preferably convex and may have a diameter of about 14 mm. A suitable material for the die is, for example, steel. To prevent corrosion, the die may be coated with, for example, gold or glass.

The method according to the invention is applicable to silicone rubbers in general. Parameters such as molecular weight, chemical character, degree of cross-linking, chemical composition or proportion of filler may well affect the increase in volume of the silicone rubber, but are not of critical importance.

WHAT WE CLAIM IS:

1. A method for releasing a moulded body made of a silicone rubber from a moulding die, wherein the release is effected by causing the moulded body to swell under the action of a swelling agent, and the swelling agent is substantially removed from the moulded body after release thereof.
2. A method as claimed in claim 1, wherein the moulding die bearing the silicone rubber body is immersed in a bath of said swelling agent.
3. A method as claimed in claim 1 or claim 2, wherein release of the silicone rubber

body from the moulding die is assisted by the action of ultrasonics.

4. A method as claimed in any one of claims 1 to 3, wherein the swelling agent comprises an organic solvent.

5. A method as claimed in claim 4, wherein the organic solvent comprises an aliphatic hydrocarbon.

6. A method as claimed in claim 5, wherein the solvent comprises benzene.

7. A method as claimed in claim 4, wherein the organic solvent comprises an aromatic hydrocarbon.

8. A method as claimed in claim 7, wherein the solvent comprises benzene or xylene.

9. A method as claimed in claim 4, wherein the organic solvent comprises a halogenated hydrocarbon.

10. A method as claimed in claim 9, wherein the solvent comprises a fluorinated hydrocarbon.

11. A method as claimed in claim 9, wherein the solvent comprises carbon tetrachloride.

12. A method as claimed in claim 9, wherein the solvent comprises trichloroethylene.

13. A method as claimed in claim 4, wherein the solvent comprises a lower alkyl ether.

14. A method as claimed in claim 13, wherein the solvent comprises diethyl ether.

15. A method as claimed in claim 4, wherein the solvent comprises a lower alkyl ester of a lower carboxylic acid.

16. A method as claimed in claim 15, wherein the solvent comprises ethyl acetate.

17. A method as claimed in claim 4, wherein the solvent comprises a ketone.

18. A method as claimed in claim 5, wherein the solvent comprises a paraffin.

19. A method as claimed in any one of claims 4 to 18, wherein the swelling agent comprises a mixture of organic solvents.

20. A method as claimed in any one of claims 1 to 19, wherein the swelling agent is substantially free from impurities.

21. A method as claimed in claim 2 or in any one of claims 3 to 20 as appended thereto, wherein the moulded body floats in the bath of swelling agent after being released from the die.

22. A method as claimed in any one of claims 1 to 21, wherein the swelling agent is removed from the moulded body by the action of heat.

23. A method as claimed in claim 22, wherein the swelling agent is removed from the moulded body under a reduced ambient pressure.

24. A method as claimed in any one of claims 1 to 23, wherein the swelling agent causes an increase in the overall volume of the moulded body of at least 60%.

25. A method as claimed in any one of

able products, for example by an accurately performed distillation, may be necessary to achieve good physiological compatability of a contact lens of silicone rubber that has been released according to the invention.

Physiological tests conducted with humans and have demonstrated the harmlessness of the method of the invention from the medical point of view.

10 The following Example illustrates the invention:

A moulding die having a silicone rubber lens adhering thereto is immersed in a bath of the solvent sold under the trade name 15 KALTRON MDR 113 (manufacturer: Kalichemie, Federal Republic of Germany, which had been purified by distillation), at room temperature. After 2 to 3 minutes the swelling process in the lens has advanced 20 to such an extent that it becomes released from the die and floats to the surface of the bath. After being removed carefully from the bath, the lens is subjected to a temperature of 170°C for a period of 2 to 3 25 minutes in a heating furnace flushed with fresh air, to remove the solvent therefrom. Subsequently, the lens, which has shrunk back to its original size, is removed from the heating furnace. The further processing 30 may comprise edging (for example, as referred to in British Patent Specification No. 1 476 356) and possibly hydrophilizing (for example, as referred to in British Patent Specification No. 1,362,939 or in British 35 Patent Specification No. 1 487 965).

The structure and materials used for making moulding dies will be well-known to those skilled in the art. The die is preferably convex and may have a diameter of 40 about 14 mm. A suitable material for the die is, for example, steel. To prevent corrosion, the die may be coated with, for example, gold or glass.

The method according to the invention 45 is applicable to silicone rubbers in general. Parameters such as molecular weight, chemical character, degree of cross-linking, chemical composition or proportion of filler may well affect the increase in volume of the 50 silicone rubber, but are not of critical importance.

WHAT WE CLAIM IS:

1. A method for releasing a moulded body made of a silicone rubber from a moulding 55 die, wherein the release is effected by causing the moulded body to swell under the action of a swelling agent, and the swelling agent is substantially removed from the moulded body after release thereof.

60 2. A method as claimed in claim 1, wherein the moulding die bearing the silicone rubber body is immersed in a bath of said swelling agent.

3. A method as claimed in claim 1 or claim 65 2, wherein release of the silicone rubber

body from the moulding die is assisted by the action of ultrasonics.

4. A method as claimed in any one of claims 1 to 3, wherein the swelling agent 70 comprises an organic solvent.

5. A method as claimed in claim 4, wherein the organic solvent comprises an aliphatic hydrocarbon.

6. A method as claimed in claim 5, wherein the solvent comprises benzene. 75

7. A method as claimed in claim 4, wherein the organic solvent comprises an aromatic hydrocarbon.

8. A method as claimed in claim 7, wherein the solvent comprises benzene or xylene. 80

9. A method as claimed in claim 4, wherein the organic solvent comprises a halogenated hydrocarbon.

10. A method as claimed in claim 9, wherein the solvent comprises a fluorinated 85 hydrocarbon.

11. A method as claimed in claim 9, wherein the solvent comprises carbon tetrachloride.

12. A method as claimed in claim 9, 90 wherein the solvent comprises trichloroethylene.

13. A method as claimed in claim 4, wherein the solvent comprises a lower alkyl 95 ether.

14. A method as claimed in claim 13, wherein the solvent comprises diethyl ether.

15. A method as claimed in claim 4, wherein the solvent comprises a lower alkyl 100 ester of a lower carboxylic acid.

16. A method as claimed in claim 15, wherein the solvent comprises ethyl acetate.

17. A method as claimed in claim 4, wherein the solvent comprises a ketone.

18. A method as claimed in claim 5, 105 wherein the solvent comprises a paraffin.

19. A method as claimed in any one of claims 4 to 18, wherein the swelling agent comprises a mixture of organic solvents.

20. A method as claimed in any one of 110 claims 1 to 19, wherein the swelling agent is substantially free from impurities.

21. A method as claimed in claim 2 or in any one of claims 3 to 20 as appended thereto, wherein the moulded body floats 115 in the bath of swelling agent after being released from the die.

22. A method as claimed in any one of claims 1 to 21, wherein the swelling agent is removed from the moulded body by the 120 action of heat.

23. A method as claimed in claim 22, wherein the swelling agent is removed from the moulded body under a reduced ambient 125 pressure.

24. A method as claimed in any one of claims 1 to 23, wherein the swelling agent causes an increase in the overall volume of the moulded body of at least 60%.

25. A method as claimed in any one of 130



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claims 1 to 24, wherein the moulded body is a contact lens.

26. A method for releasing a silicone rubber moulded body from a moulding die, substantially as described herein with reference to the accompanying drawings.

27. A method for releasing a silicone rubber moulded body from a moulding die, substantially as described with reference to

the Example herein.

28. A silicone rubber moulded body, whenever obtained by a method as claimed in any one of claims 1 to 27.

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