To that end, the invention provides a cast mould for the purpose of manufacturing a contact lens or an intraocular lens, the cast mould being provided with:

- a first cast mould half comprising:
  - an optically accurately defined surface;
  - first positioning means:
- a second cast mould half comprising:
  - a central part with optically accurately defined surface;
  - a bearing ring which surrounds the central part and which is provided with second positioning means which are designed for engagement of the first positioning means for holding the cast mould under a bias in a closed position in which the first and the second cast mould halves are clamped onto each other, wherein a central axis of the second cast mould half extends perpendicularly to the plane in which the bearing ring extends and intersects a centre of the bearing ring; and

characterized by:

- a thin-walled, flexible connection which extends between the bearing ring and the central part and which connects the central part with the bearing ring, wherein a wall thickness of the thin-walled, flexible connection is less than 0.2 times the thickness of the central part at the location of the central axis.

It has appeared that the above-mentioned inaccuracy is caused by deformation of the optically accurately defined surfaces which occurs as a result of the material stress that is introduced into the material when the positioning means are brought in the position engaging one another. In order to be able to generate the required bias or clamping force, the positioning

means have to be brought into a deformed condition. However, this deformation appeared not to limit itself to the positioning means only but also to continue into the optically accurately defined surfaces.

provided with an end face facing the injection mould cavity and bounding the central part cavity; and with

- spring means associated with the injection mould cavity which are under a bias such that the spring action thereof urges the plunger in the direction of the central part cavity towards a pressed-in condition;

the method further comprising:

- bringing the two injection mould halves into the closed position;
- injecting plastic into the at least one injection mould cavity at a pressure which is such that the plunger is moved from the pressed-in position against spring action;
- ending the injection and then allowing the plastic to cure while the spring means continuously urge the plunger in the direction of the central part cavity to compensate for shrinkage of the plastic in the central part cavity;

wherein the distance between the first mould half and the second mould half at the connecting cavity is less than 0.2 times the distance between of the end face of the plunger and a wall part of the second mould half that is opposite the end face at said central axis when the plunger is in the pressed-in condition.

The invention further provides an injection mould for use with this method for forming at least a second cast mould half of a cast mould according to the invention, wherein the injection mould is provided with:

- a first injection mould half;
- a second injection mould half
- at least one injection mould cavity for manufacturing the second injection mould half which is formed when the two injection mould halves are in a moved together, closed position, wherein each injection mould cavity is provided with:
  - a central part cavity
  - a bearing ring cavity; and with

- a connecting cavity which connects the central part cavity to the bearing ring cavity;

wherein the injection mould for each injection mould cavity is provided with:

- a plunger associated with the injection mould cavity, which is set up in the first injection mould half so as to be movable along a central axis of the plunger, the plunger being provided with an end face facing the injection mould cavity and bounding the central part cavity; and with
- spring means associated with the injection mould cavity, which are under a bias such that the spring action thereof urges the plunger in the direction of the central part cavity towards a pressed-in position~~.~~;

wherein the distance between the first mould half and the second mould half at the connecting cavity is less than 0.2 times the distance between of the end face of the plunger and a wall part of the second mould half that is opposite the end face at said central axis when the plunger is in the pressed-in condition.

Through the presence of the plunger and spring means present per injection mould cavity, such a method and injection mould offer a solution to the shrinkage problems when manufacturing the second cast mould half of a cast mould for the purpose of contact lens or intraocular lens manufacture, which is provided with a flexible, thin-walled connection between the central part and the bearing ring. After the plastic in the connecting cavity has set and in the central part cavity the plastic is still liquid and undergoes shrinkage, the volume of the central part cavity is continuously reduced by the plunger and the spring means and thereby adapted to the decreasing volume of the setting plastic. Thus, it is ensured that the plastic remains in abutment against the injection mould surfaces and bubble formation resulting from cavitation is prevented. Thus, an accurately defined and undamaged surface of the optically accurate surface of the second cast mould halve is actually guaranteed.

The invention also provides a method for manufacturing a contact lens or an intraocular lens comprising:

- providing a first cast mould half of a cast mould according to the invention;
- using the method according to any one of claims 6 - 7 utilizing the

relative to each other and clamping them onto each other, but also of defining the relative rotational position of the two cast mould halves 12, 20.

A central axis L of the second cast mould 20 extends perpendicularly to the plane in which extends the bearing ring 28, and intersects a centre of the bearing ring 28. The second cast mould half 20 is provided with a thin-walled, flexible connection 30a, 30b which extends between the bearing ring 28 and the central part 22 and which connects the central part 22 to the bearing ring 28.

In a first embodiment of the second cast mould half 20, of which an example is shown in Figs. 1 – 4, the flexible connection 30a can be configured as an annular plastic film 30a which is connected by an outer edge thereof to the bearing ring 28 and which is connected, by an inner edge thereof to the central part 22. Such a film connection provides good flexibility and hence freedom of movement of the central part 22 relative to the bearing ring 28, which is of importance for not transmitting material stresses, which occur when clamping the second cast mould half 20 onto the first cast mould half 12, to the accurately defined optical surface 24 of the second cast mould half 20. An elaboration with an annular plastic film 30a yet offers a considerable through-flow surface, which is important for the supply of plastic from the bearing ring cavity to the central part cavity in the injection mould 50 during the manufacturing process. Furthermore, the transmission of forces over the entire circumference of the central part 22 to the bearing ring 28 is uniform, which results in minimal deformation of the central part 22 under the influence of forces applied thereto during the lens manufacturing process.

In a second alternative embodiment of the second cast mould half 20, of which an example is shown in Fig. 5, the flexible connection 30b can be implemented by a number of spokes 30b which are each connected by a first end to the central part 22 and are connected by a second end to the bearing ring 28. The spokes can extend radially from the central part 22 to the bearing

ring 28. However, in an alternative embodiment, it is also possible that the spokes extend somewhat in tangential direction.

In one embodiment, the thin-walled, flexible connection ~~30,~~ 30a, 30b has a wall thickness that is less than 0.2 times the thickness of the bearing ring 28. Preferably, the wall thickness of the flexible connection ~~30,~~ 30a, 30b is less than 0.1 times the thickness of the bearing ring.

When the wall thickness of the thin-walled, flexible connection ~~30,~~ 30a, 30b is related to the thickness of the central part 22 at the location of the central axis of the second cast mould half 20, it holds in one embodiment that the wall thickness of the thin-walled, flexible connection ~~30,~~ 30a, 30b is less than 0.2 times the thickness of the central part 22 and preferably even less than 0.1 times the thickness of the central part 22 at the location of the central axis.

Opposite the optically accurately defined surface 24, the central part 22 of the second cast mould 20 is provided with a second main surface 32 which extends substantially perpendicularly to the central axis L of the second cast mould 10. The central part 22 is further provided with a circumferential surface 34 which extends between the optically accurately defined surface 24 and the second main surface 32. One embodiment is characterized in that the circumferential surface 34 is chamfered, such that a diameter of the central part 22, viewed in the direction of the central axis L, gradually decreases from the second main surface 32 to the optically accurately defined surface 24.

Without the chamfered configuration of the circumferential surface 34 – i.e. with a circumferential surface extending perpendicularly to the second main surface 32 – a deviation occurs in the perimeter of the optically accurately defined surface 24 during the manufacture of the second cast mould half 20. This deviation seems to be the result of a cooling effect near this perimeter. It appears that the deviation in the perimeter can be considerably reduced by the chamfered configuration of the circumferential surface 34. An

angle φ between the central axis L and the chamfered circumferential edge in the range of 15-45 degrees appears to be sufficient.

A second exemplary embodiment of a cast mould 10 is shown in Figs. 6-9, wherein for similar parts, the same reference numerals are used. The second exemplary embodiment involves a cast mould 10 for manufacturing an intraocular lens. It is clear that the intraocular lens that is manufactured with this second exemplary embodiment of the cast mould 10 will have two convex optical surfaces while the first exemplary embodiment which is shown in Figs. 1-4 and Fig. 5 leads to a contact lens with a concave and an opposite convex optical surface. A further important difference between the first and the second exemplary embodiment of the cast mould 10 is that with the second exemplary embodiment, also in the first cast mould 12 an annular plastic film 21 connects a central part, which bears the optically accurately defined surface 14, to an outer part which comprises, *inter alia*, the support rib 17 and the outer edge 19 and thus forms a thin-walled flexible connection 21. For the thickness of thin-walled flexible connection 21 it holds, just as indicated hereinabove for the thin-walled flexible connection ~~30,~~ 30a, 30b of the second cast mould half 14, that it is less than 0.2 times the thickness, and preferably even less than 0.1 times the thickness of wall parts which bound the flexible thin-walled connection 21. A bounding wall part is, for example, the central part with the optically accurately defined surface 14. Another bounding wall part is, for instance, the outer part mentioned that comprises, *inter alia*, the support rib 17 and the outer edge 19.

Figs. 10 – 14 show an example of an embodiment of an injection mould 50 for the manufacture of a cast mould 10 for manufacturing contact lenses or intraocular lenses. Figs. 10 and 11 show the injection mould 50 in exploded view from different viewpoints. Fig. 12 shows a cross-sectional view of the injection mould 50 in assembled and closed condition. Figs. 13 and 14 shows details of the injection mould 50 in two different conditions which will be reverted to later. The injection mould is provided with a first injection

the first bush 72 is sealed off with a sealing lid 78. The connection between the sealing lid 78 and the first bush 72 or, when the first bush 72 is omitted, the first injection mould half 52, can be formed by, for instance, thread or by a bayonet catch. Such a detachable connection of the sealing lid 78 enables simple exchange of the plunger 64 or replacement of the spring means 68. Replacement of the plunger 64 is advisable when another optically accurately defined surface 24 is wanted. Replacing the spring means 68 can be advisable when another spring constant is desired or upon breakage or slackening of the spring means 68.

In one embodiment, of which an example is shown in Figs. 10 – 14, the spring means 68 can comprise one, or a stack of Belleville springs ~~68a~~, for instance Belleville springs ~~68a~~ according to DIN 2093. The advantage of Belleville springs ~~68a~~ is that in a very compact volume a very high spring constant can be realized. When the Belleville springs ~~68a~~ according to DIN2093 are used with an outer diameter of 15 mm and a thickness of 0.8 mm, when thirteen Belleville springs ~~68a~~ with the same orientation are stacked onto each other, a force of more than approximately 16.000 N is required for an impression of 0.4 mm. When the end face 66 of the plunger 64 has a surface of a good 1.1 cm^2, a pressure of 1450 bar is required in the injection mould cavity 58 for bringing the plunger into the stop position in which the Belleville spring packet of thirteen Belleville springs is completely compressed. This is a filling pressure which is feasible in a suitable manner with the right injection moulding machine. With such a filling pressure, furthermore, a rapid filling of the injection mould cavity 56 is obtained, which is important to prevent the occurrence of setting of plastic in the connecting cavity 62 before the complete filling of the injection mould cavity 56 is realised.

The advantage of Belleville springs is further that through suitable stacking, the spring travel length and the spring constant can be varied. When two Belleville springs 68 with the same orientation are stacked onto each other, the force required for completely compressing the Belleville spring

packet doubles. The spring travel length is equal to that of a single Belleville spring. When two Belleville springs 68 with opposite orientation are stacked onto each other, the force required for completely compressing the Belleville spring packet remains equal to the force required for compressing a single Belleville spring. However, the spring travel length doubles with such a stacking. Through suitable stacking of Belleville springs ~~68a~~, therefore, a desired spring travel length in combination with a desired compression force can be realised.

In an alternative embodiment, the spring means 68 can be configured as a coil spring.

For manufacturing a second cast mould half 20 with a chamfered circumferential surface 34 as described hereinabove, one embodiment of the injection mould 50 can be characterized in that the central part cavity 58 is bounded, on one side by the end face 66 of the plunger 64 and on an opposite side by a wall part 80 of the second injection mould half. A circumferential wall 82 of the central part cavity 58 is chamfered, such that a diameter of the central part cavity 58, viewed in the direction of the longitudinal central axis A of the plunger 64 from the plunger 64 to the second injection mould half 54, gradually increases.

For manufacturing the second cast mould 20 of the cast mould 10, a method is provided with comprises:

- providing an injection mould 50;
- bringing the two injection mould halves 52, 54 into the closed position;
- injecting plastic into the at least one injection mould cavity 56 at a pressure which is such that the plunger 64 is moved from the pressed-in position against spring action;
- ending the injection and then allowing the plastic to cure while the spring means 68 continuously urge the plunger 64 in the

direction of the central part cavity 58 to compensate for shrinkage of the plastic in the central part cavity.

One embodiment of the method, in which the injection mould 50 which is utilized further comprises a second stop 74 associated with each injection mould cavity 56 and which forms a boundary for the movement of the plunger 64 from the pressed-in position to a stop position moved away from the injection mould cavity 56, is characterized in that the pressure at which the plastic is injected into the at least one injection mould cavity 56 is sufficient for moving the plunger 64 against the spring action of the spring means 68 against the second stop 74. Thus it is realized that a sufficient filling of the injection mould cavity 56 is obtained to be able to compensate the shrinkage occurring therein.

Once the cast mould 10 is available, with it, with the aid of the following method, a contact lens or an intraocular lens ~~92~~ can be manufactured. The method comprises:

- providing a first cast mould half 12 of a cast mould 10;
- using the method for manufacturing the second cast mould 20 utilizing the injection mould 50 for obtaining the second cast mould half 20 of the cast mould 10;
- filling the first cast mould half 12 with a plastic;
- placing the second cast mould half 20 on the first cast mould half 22 such that the second positioning means 26 engage the first positioning means 16-18 and then clamp the second cast mould half 20 onto the first cast mould half 12 under a bias;
- allowing the plastic to cure in the cast mould 10 for forming the lens ~~92~~;
- removing the second cast mould half 20; and
- sealing, with a seal 36, the first cast mould half 12 in which the

lens ~~92~~ is located for forming a package from the first cast mould half 12 and the seal 36 in which package the lens is included.

The seal can be formed by, for instance, a foil 36 which is attached through sealing on an outer edge 19 of the first cast mould half 12. In an alternative elaboration, it is possible that the seal 36 is formed by a lid provided with a bayonet or thread provision which cooperates with a bayonet or thread provision on the first cast mould half 12.

In one embodiment of the method, prior to the provision of the seal 36, a liquid can be introduced into the cast mould half 12.

Although the above-described description of the injection mould related to an injection mould 50 for manufacturing the second cast mould half 20, the invention is not limited thereto. Also for manufacturing the first cast mould half 12, with advantage, an injection mould can be used where with each injection mould cavity a plunger with spring means is associated which serves for compensating shrinkage in the respective injection mould cavity.

Although the invention is represented and described in detail with reference to the drawing, this drawing and description should be regarded as a mere example. The invention is not limited to the embodiments described. Features which are described in the subclaims can be combined with each other. Reference numerals in the claims should not be construed as limitations of the claims but merely serve for clarification.

Claims

1. A cast mould for the purpose of manufacturing a contact lens or an intraocular lens, the cast mould (10) being ~~is~~ provided with:

- a first cast mould half (12) comprising:
  - an optically accurately defined surface (14);
  - first positioning means (16-18):
- a second cast mould half (20) comprising:
  - a central part (22) with optically accurately defined surface (~~14~~24);
  - a bearing ring (28) which surrounds the central part and which is provided with second positioning means (26) which are designed for engagement of the first positioning means (16 - 18) for holding the cast mould (10) under a bias in a closed position in which the first and the second cast mould halves (12, 20) are clamped onto each other, wherein a central axis (L) of the second cast mould half (20) extends perpendicularly to the plane in which the bearing ring (28) extends and intersects a centre of the bearing ring (28); and

characterized by:

- a thin-walled, flexible connection (30a, 30b) which extends between the bearing ring (28) and the central part (22) and which connects the central part (22) with the bearing ring (28), wherein a wall thickness of the thin-walled, flexible connection (~~30,~~ 30a, 30b) is less than 0.2 times the thickness of the central part (22) at the location of the central axis (L).

2. A cast mould according to claim 1, wherein the thin-walled, flexible connection (30a) is formed by an annular plastic film (30a) which is connected by an outer edge thereof to the bearing ring (28) and which is connected by an inner edge thereof to the central part (22).

3. A cast mould according to claim 1, wherein the thin-walled, flexible connection (30b) is formed by a number of spokes (30b) which are each connected by a first end to the central part (22) and are connected by a second end to the bearing ring (28).

4. A cast mould according to any one of claims 1 – 3, wherein ~~a~~ the wall thickness of the thin-walled, flexible connection (~~30,~~ 30a, 30b) is less ~~than 0.2 times the thickness of the central part (22) at the location of the central axis (L) and preferably even less~~ than 0.1 times the thickness of the central part at the location of the central axis (L).

5. A cast mould according to any one of claims 1 - 4, wherein the central part (22) of the second cast mould half (20) opposite the optically accurately defined surface (24) is provided with a second main surface (32) which extends substantially perpendicularly to the central axis (L) of the second cast mould half (20), wherein the central part (22) is provided with a circumferential surface (34) which extends between the optically accurately defined surface (24) and the second main surface (32), wherein the circumferential surface (34) is chamfered, such that a diameter of the central part (22), viewed in the direction of the central axis (L) from the second main surface (32) towards the optically accurately defined surface (24), gradually decreases.

6. A method for manufacturing at least the second cast mould half of a cast mould according to any one of claims 1 – 5, the method comprising:

- providing an injection mould (50) which is provided with
  - a first injection mould half (52);
  - a second injection mould half (54);

wherein the two injection mould halves (52, 54) in a moved together, closed position define at least one injection mould cavity (56) for manufacturing the second cast mould half (20), each injection mould cavity (56) being provided with:

- a central part cavity (58);
- a bearing ring cavity (60) which surrounds the central part cavity (58); and with
- a connecting cavity (62) which connects the central part cavity (58) with the bearing ring cavity (60);

wherein the injection mould (50) for each injection mould cavity (56) thereof is provided with:

- a plunger (64) associated with the injection mould cavity (50), which is set up in the first injection mould half (52) so as to be movable along a central axis (A) of the plunger (64), the plunger (64) being provided with an end face (66) facing the injection mould cavity (56) and bounding the central part cavity (58); and with
- spring means (68) associated with the injection mould cavity (56), which are under a bias such that the spring action thereof urges the plunger (64) in the direction of the central part cavity (58) towards a pressed-in condition;

the method further comprising:

- bringing the two injection mould halves (52, 54) into the closed position;
- injecting plastic into the at least one injection mould cavity (56) at a pressure which is such that the plunger (64) is moved from the pressed-in position against spring action;
- ending the injection and then allowing the plastic to cure while the spring means (68) continuously urges the plunger (64) in the

direction of the central part cavity (58) to compensate for shrinkage of the plastic in the central part cavity (58);

wherein the distance between the first mould half (52) and the second mould half (54) at the connecting cavity is less than 0.2 times the distance between of the end face (66) of the plunger (64) and a wall part (80) of the second mould half (54) that is opposite the end face (66) at said central axis (A) when the plunger is in the pressed-in condition.

7. The method according to claim 6, wherein in the injection mould (50) which is utilized further comprises:

- for each injection mould cavity (56) a second stop (74) associated with this injection mould cavity (56), which stop forms a boundary for the movement of the plunger (64) from the pressed-in position to a stop position moved away from the injection mould cavity (56);

wherein the method is characterized in that the pressure at which the plastic is injected into the at least one injection mould cavity (56) is sufficient for moving the plunger (64) against the spring action of the spring means (68) against the second stop (74).

8 An injection mould for use with the method according to any one of claims 6 or 7 for forming at least a second cast mould half (20) of a cast mould (10) according to any one of claims 1 – 5, wherein the injection mould is provided with:

- a first injection mould half (52);
- a second injection mould half (54);
- at least one injection mould cavity (56) for manufacturing the second injection mould half (20) which cavity is formed when the two injection mould halves (52, 54) are in a moved together, closed position, wherein each injection mould cavity (56) is provided with:

- a central part cavity (58);
- a bearing ring cavity (60); and
- a connecting cavity (62) which connects the central part cavity (58) to the bearing ring cavity (60);

wherein the injection mould (50) for each injection mould cavity (56) is provided with:

- a plunger (64), associated with the injection mould cavity (56), which is set up in the first injection mould half (52) so as to be movable along a central axis (A) of the plunger (64), the plunger (64) being provided with an end face (66) facing the injection mould cavity and bounding the central part cavity (58); and with
- spring means (68), associated with the injection mould cavity (56), which are under a bias such that the spring action thereof urges the plunger (64) in the direction of the central part cavity (58) towards a pressed-in position

wherein the distance between the first mould half (52) and the second mould half (54) at the connecting cavity is less than 0.2 times the distance between of the end face (66) of the plunger (64) and a wall part (80) of the second mould half (54) that is opposite the end face (66) at said central axis (A) when the plunger is in the pressed-in condition.

9. An injection mould according to claim 8, comprising for each injection mould cavity (56) a first stop (70) associated with this injection mould cavity (56), and which forms a boundary for the movement of the plunger (64) towards the pressed-in position.

10. An injection mould according to claim 8 or 9, comprising for each injection mould cavity (56) a second stop (74) associated with this injection mould cavity (56) and which forms a boundary for the movement of the plunger (64) from the pressed-in position to a stop position moved away from the injection mould cavity (56).

11. An injection mould according to any one of claims 8 – 10, wherein the spring means (68) comprise one or a stack of Belleville springs ~~(68a)~~, for example, Belleville springs ~~(68a)~~ according to DIN 2093.

12. An injection mould according to any one of claims 8 – 11, wherein the central part cavity (58) is bounded on one side by the end face (66) of the plunger (64) and on an opposite side by a wall part (80) of the second injection

mould ~~cavity~~ (54), wherein a circumferential wall (82) of the central part cavity (58) is chamfered, such that a diameter of the central part cavity (58), viewed in the direction of the longitudinal central axis (A) of the plunger, gradually increases from the plunger (64) towards the second injection mould half (54).

13. A method for manufacturing a contact lenses ~~(92)~~ or an intraocular lens, comprising:

- providing a first cast mould half (12) of a cast mould (10) according to any one of claims 1 – 5;
- using the method according to any one of claims 6-7 utilizing the injection mould (50) according to any one of claims 8-12 for obtaining a second cast mould half (20) of the cast mould (10) according to any one of claims 1 – 5;
- filling the first cast mould half (12) with a plastic;
- placing the second cast mould half (20) on the first cast mould half (12) such that the second positioning means (26) engage the first positioning means (16 – 18) and then clamp the second cast mould half (20) on the first cast mould half (12) under a bias;
- allowing the plastic to cure in the cast mould (10) for forming the lens ~~(92)~~;
- removing the second cast mould half (20); and
- sealing with a seal (36) the first cast mould half (12) in which the lens ~~(92)~~ is located for forming a package from the first cast mould half (12) and the seal (36) in which package the lens ~~(92)~~ is included.

14. A method according to claim 13, wherein prior to the provision of the seal (36) a liquid is introduced into the first cast mould half (12).

15. A contact lens or an intraocular lens ~~(92)~~ manufactured with the method according to claim 13 or 14, utilizing a cast mould (10) according to claims 1 – 5.