

Description

This invention relates to apparatus and methods for making lens casting molds for use in the manufacture of toric contact lenses, in particular the invention relates to the production of casting molds for the manufacture of toric lenses having prism ballast oriented properly with respect to the cylinder axis of the toric curves.

The cornea of the human eye has a generally spherical configuration, and therefore when contact lenses are fitted it is usual to use a lens the surface of which contacting the eye is also of a generally spherical base curve. However, a complication is introduced when the eye being fitted has a degree corneal toricity great enough to prevent the adequate use of a spherical base curve in the lens being fitted.

One of the methods frequently used for overcoming this complication is to provide a lens with a toric base curve generally matching the configuration of the toric corneal surface. The use of such a lens of course adds another prerequisite to the configuration of the lens - namely, that it be essentially non-rotating in the eye, so that the toric axis in the lens remains aligned with the toric axis of the cornea. A commonly used technique for maintaining this meridional orientation of the lens is to provide the lens with prism ballast, so that gravity causes the thicker prism base to seek a natural position adjacent the bottom eyelid. The use of prism ballast in turn dictates that the lens be manufactured with a predetermined relationship or offset between the cylinder axis of the toric curves and the orientation axis of the prism ballast.

In the current commercial procedure for manufacturing lenses of the above nature it is common to use a precision lathe to generate the toric curve on the back surface of the lens, as well as the prism on the front surface. Therefore, the procedure is heavily dependent on the skill and reliability of the lathe operator who must make numerous precision measurements and adjustments in the preparation of each individual lens. Thus, for example, in the current procedure, the raw lens button is first sized and then mounted in a lathe collet where the base curve is cut. Following this, the button is crimped until the desired toric cylinder is attained, as viewed in a radiuscope, and then the crimped button is ground to a sphere and de-crimped to create the toric surface. Next, the operator aligns the cylinder axis with a radiuscope and marks the button to the desired axis, and finally the button is re-mounted in the lathe collet, where the spherical cut for power and the slabbing for prism ballast are performed on the front surface. Mounting and blocking of the button, and use of the radiuscope for creating and marking the toric axis, are steps which demand precision on the part of the lathe operator, and the cumulative effect of variations in each of the steps can easily lead to off-target axes and rejection of the lenses. Further, the pressure created on the button during the crimping and de-crimping steps results in unavoidable creep which is demonstrated by almost all glassy polymers under pres-

sure; hence additional power and cylinder variations are introduced.

When it is considered that lens making companies routinely keep stocks of contact lenses numbering in the tens of thousands, and the lathe operators have a full time job of maintaining such inventories by constant reiteration of the above-described procedure throughout the day for each type of lens produced, it will be understood that eye-strain and fatigue take their toll on the precision of the operators. As a result of all the above factors, current production procedures are geared to endure a 90% to 98% reject rate.

The prior art includes various approaches for reducing this undesirably high scrap rate. For example, Neeff US patents No 4,188,353, No 4,229,390 and No 4,239,712 describe methods and apparatus for molding, rather than lathing, the base curve of contact lenses. The procedure involves casting a liquid monomer in a plastic cup-like molding cavity having the desired base curve in the bottom, polymerizing the monomer to form a lens button with the base curve thus formed, and then using the mold, with the lens button still retained, as a lathe arbor to machine the desired convex curves on the anterior surface of the lens. The procedure partially reduces the work-load of the lathe operator, since the precision steps of sizing, crimping and grinding to sphere are accomplished in the molding step rather than in the lathing. However, if the procedure is applied to the production of lenses with toric base curves, no means are provided for locating the toric axis or orienting it with respect to the axis of the prism ballast. The lathe operator must still, with respect to each individual lens, use the radiuscope to locate and mark the toric axis, and then make the necessary lathe adjustments for each lens before performing the desired power and prism cuts.

Kunzler US patent No 4,749,530 suggests an improvement over the above, involving modification of the cup-like molding cavity to include a hollow hemispherical base having one or more key ways or slots on the exterior surface. After liquid monomer is polymerized in the cup-like cavity to produce a lens blank having the desired base curve, the mold containing the lens blank is placed on a lens generating lathe having a hemispherical shaped locating ring, in such manner that the key way on the exterior surface of the mold base mates with a guide key on the locating ring of the lathe. In this manner, the location of the posterior lens surface curves is established when the mold is mounted on the lens. Thus, the cutting tool of the lathe can be set at one position, and the front surfaces of successive similar lenses can be cut without measuring the base curve axis and resetting the cutting tool for each lens. However, this approach still requires lathe operator intervention when switching between lenses having different toric axes, since the cutting tool of the lathe must be reset for each axis. Although this may be useful when limited numbers of different lenses are being produced, it presents an inefficiency and an opportunity for operator error in large volume production or when automated production lines are desired.

EP-A-0325673 discloses a mold for forming contact lenses of the type having prism or multiple curve segments. At one end of the mold there is a cup-like cavity in which the contact lens is formed. At the other end, there is a hemispherical base having a keyway enabling the mold to be installed in a lathe. A floor of the cup-like cavity has a curvature which can be toric and which defines a posterior optical surface of the lens. The anterior surface of the lens is cut in the lathe while the lens remains in the mold. The base of the mold is held in the lathe, and a guide pin of the lathe engages the keyway of the mold to precisely locate the posterior surface of the lens and to enable the mold (and lens) to be rotated while still in the lathe, so that two or more surfaces can be cut on the anterior surface of the lens.

US-A-4197266 discloses a two-part mold in which a contact lens is formed. One of the mold parts has machine reference surfaces enabling the mold to be mounted in a machining device, with the lens still carried thereby, for the machining of the anterior surface of the lens.

The present invention is concerned with providing a method for producing toric base curve cutting, measuring and alignment steps to be transferred from the lathe operator to a preliminary automatic injection molding procedure in which no operator dependent determinations are required.

In accordance with the present invention there is provided an injection molding method for producing a lens casting mold arbor, said arbor having hollow top and bottom portions separated by a partition element having a toric surface formed on its top surface, said method comprising:

- a. providing an injection molding cavity defining the lateral surfaces, the top edge surface and the toric surface of said arbor;
- b. providing a rotatable ring plate element defining in said cavity the bottom edge surface of said arbor, said ring plate element having the negative of at least one alignment means in its upper surface for forming the positive of said alignment means in the bottom end surface of said arbor;
- c. rotating and locking said ring plate element at a point where said alignment means in said ring plate element is offset a predetermined number of degrees from the toric axis of said toric surface; and
- d. introducing resinous molding material into said cavity and applying heat and pressure to produce a lens casting arbor having an alignment means in its bottom end surface, offset a predetermined number of degrees from the toric axis of its toric surface.

The invention includes the use of a calibrated rotatable ring mechanism within the injection molding body, for producing a slot or other alignment means on the lens casting mold at a point which is offset a predetermined number of degrees from the axis of the toric curve being formed in the casting mold. When the casting mold con-

taining a newly cast lens is mounted on the precision lathe, the mating of the slot with a permanent ridge on the lathe spud ensures that the mold seats on the lathe at the same established place each time with respect to the position of the cutting tool. The offset between the toric axis and the position of the cutting tool has already been established, and therefore there is no need for the lathe operator to make any measurements or resetting of the cutting tool. The lathe tool remains in a permanent position for making the ballast and other cuts on successive batches of lenses, even though the toric axis offset may vary from batch to batch, because the offset is built into the casting mold arbor used for each batch.

Further details of the injection molding method are defined in the features of dependent claims 2 and 3.

In accordance with a second aspect of the present invention there is provided injection molding apparatus for producing a lens casting mold arbor, said arbor having hollow top and bottom portions separated by a partition element, said injection molding apparatus comprising:

- a. an injection molding body having an interior opening shaped to form the exterior lateral surface of said arbor;
- b. a first core pin inserted in the bottom portion of said interior opening of said molding body, the external surface of said core pin being spaced apart from the surface of the interior opening of said molding body to provide a cavity having the shape of the lower portion of said arbor;
- c. a toric core pin having the positive of a toric lens curve on its bottom end, said toric core pin being inserted in the upper portion of said interior opening of said molding body and having its external lateral surface of said molding body to provide a cavity having the shape of the upper portion of said arbor, and the toric lower end of said toric pin being spaced apart from the upper end of said first core pin to provide a cavity having the shape of said partition element separating the upper and lower portions of said arbor;
- d. alignment means formed in said toric pin for mating with corresponding alignment means in the upper portion of said molding body, whereby the toric axis of said toric pin is maintained in a stationary position;
- e. a rotatable ring plate inserted in said molding body for forming the bottom end surface of said arbor, said rotatable ring plate having the negative of at least one alignment means in its upper surface for forming the positive of said alignment means in the bottom end surface of said arbor;
- f. means for rotating and locking said rotatable ring plate at a point where said alignment means in said ring plate is offset a predetermined number of degrees from the toric axis of said toric pin; and

g. means for introducing resinous molding material into said cavities and applying heat and pressure to produce said lens casting arbor.

Further details of the injection molding apparatus are defined in the features of the dependent claims 5 to 7.

By providing a rotatable ring for producing an alignment means on the lens casting mold, that alignment means can be located at any angular relationship relative to the axis of the toric surface defined by the mold. Thus, there is no need for the lathe operator to make any measurements or reset the cutting tool.

DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the invention will be apparent to those skilled in the art from the following detailed description, taken together with the accompanying drawings, in which:-

Figure 1 is a perspective view of the toric casting mold arbor of the present invention, showing an alignment slot in its lower edge.

Figure 2 is a longitudinal section of the arbor, taken along lines 2-2 of Figure 1.

Figure 3 is a top view of the arbor, showing the bottom of the cup-shaped container, with the toric curve aligned along line A-A.

Figure 4 is a bottom view of the arbor, showing the alignment slots in the bottom edge.

Figure 5 is a longitudinal section of a precision lathe having the toric casting mold arbor mounted on the spud thereof.

Fig 6 is a longitudinal section of the injection molding apparatus of the present invention.

Fig 7 is a top view of the injection molding apparatus, with the toric core pin in place, showing the timing pins aligning the core pin and the injection molding body.

Fig 8 is a bottom view of the toric core pin, showing the toric axis in the bottom end, and its relationship to the timing pins.

Fig 9 is an enlarged and exploded sectional view of the rotatable ring plate, ready to be dropped into position in the base plate of the injection molding apparatus.

Fig 10 is a perspective bottom view of the rotatable ring plate, showing the indexed location holes.

Fig 11 is a perspective top view of the rotatable ring plate, showing the shoulders in the upper edge for forming the alignment slots in the bottom edge of the casting mold arbor.

Fig 12 is a longitudinal section of an alternative embodiment of the casting mold arbor, having the lathe-mounting taper on the outside.

The toric lens casting mold arbor produced by the method and apparatus of the present invention is illustrated in Figs 1 through 4. The arbor is comprised essen-

tially of a hollow top portion 10 and a hollow bottom portion 11, separated by a partition member 12. The top portion 10 comprises a cup-shaped container in which the optical lens blank 13 may be cast and cured. The hollow bottom portion 11 serves as a lathe-mounting member and has a precision taper on its inside surface 14 designed to mate with a matching taper on a lathe spud.

A precision toric base curve 15 is formed in the bottom of cup 10 on the upper surface of the partition member 12. The toric curve 15 in the bottom of cup 10 is viewed from the top in Fig 3, prior to casting of the lens button, with the line A -- A' generally indicating the location of the toric axis. Alignment slots 16 are formed in the bottom edge 17 of the lathe mounting member 11. As best shown in Fig 4, the alignment slots 16 may be placed at any desired location around the circumference of bottom edge 17, so that the axis line B -- B' drawn through them can form any desired or predetermined offset angle with respect to the toric axis A -- A' shown in Fig 3. The casting mold arbor contains a step 18 which is designed to co-operate with an LVDT on the lathe to determine the base line height from which the target centre thickness of the lens button is calculated.

The toric casting mold arbor shown in Figs 1 through 4 is used for the production of lens buttons having a precision toric base curve and a generally flat front surface, which is ready for lathe cutting of the desired anterior power and prism curves while the button is still retained within the mold. Production of the lens button is initiated by filling the cup-shaped mold 10 with a liquid monomer material containing a suitable polymerization catalyst. The casting liquid may be any of the conventional monomers and mixtures thereof which are known in the art for the production of hard or soft contact lenses, such as acrylic esters, hydrophilic and hydrophobic monomer mixtures, silicone elastomers, cellulose esters, and the like. After the lens forming liquid and catalysts are filled into the casting mold 10, polymerization is initiated and completed under appropriate known curing conditions, which include curing in an oven or the use of other techniques such as radiation, including U.V. and microwave and the use of a bath with a heat transfer fluid, such as water and silicone oil.

After curing and stabilizing of the lens blank, the toric casting mold arbor, with the lens button still retained therein, is next mounted on a precision lathe for cutting the front surfaces. As shown in Fig 5, the arbor is mounted in such manner that its interior tapered surface 14 mates with the exterior tapered surface 19 of the lathe spud, and the alignment slots 16 on the bottom edge 17 of the arbor portion 11 mates with the alignment lugs 20 of the alignment ring 21 of the lathe.

With the arbor mounted as in Fig 5, the front surface of the lens blank may be machined by the lathe cutting tool (not shown) to provide the desired power and prism curves. In the process of generating the front optical surfaces, the lens blank 13 is held securely by the lens mold 10, and both the lens blank and the side walls of the lens

mold, being made of plastic, are cut simultaneously. It is a feature of the casting mold arbor produced by the present invention that it is not necessary to measure the lens for toric axis or reset the lathe tool to obtain the desired offset between the toric axis and the prism cut. The lathe tool may be allowed to remain in a fixed position, as far as the toric axis is concerned, regardless of what offset angle is desired, because the offset angle has been predetermined by prior location of the alignment slots 16 in the injection molding production of the mold arbor itself. Thus the entire error-prone lathe operator procedure with respect to the toric feature has been transferred away from the operator to a precision injection molding operation, in which operator skill and fatigue are not involved. The precision injection molding method and apparatus of the present invention are described in the sections to follow.

Fig 6 is a schematic sectional view of the injection molding apparatus. Although not limited to the arrangement shown, it is the preferred embodiment of the invention that the injection molding body be an assembly of plates or cartridges which are inserted into a frame and locked together to form the desired mold cavity 22. As shown, the apparatus includes a base plate 23 and, immediately above it, a first molding body plate 24 which has an interior opening whose lateral surface is shown at 25. The plate 24 serves as a seat for a rotatable ring plate 26, which has a flange 27 adapted to seat on shoulder 28 of plate 24. Located on top of first plate 24 is a second molding body plate 29 having an interior opening whose lateral internal surface is shown at 30. The interior opening of the second plate 29 is in registration with the interior opening of first plate 24, and the lateral internal surface 30 of plate 29 is shaped to form the exterior lateral surface of the bottom portion of the arbor to be formed in cavity 22.

A first core pin 31 is located within the interior openings of the first and second molding body plates 24 and 29, the external surface 32 of core pin 31 being spaced apart from the internal lateral surface 30 of body plate 29 to provide the shape of the lower portion of cavity 22. The core pin 31 may, if desired, be fixed to base 23, since the pin has a permanent, unchanging external configuration and does not need to be changed from one batch to another.

Located on top of second body plate 29 is a third molding body plate having an interior opening whose lateral internal surface is shown at 34. The interior opening of the third plate 33 is in registration with the interior openings of first and second plates 24 and 29, and the lateral internal surface 34 of plate 33 is shaped to form the exterior lateral surface of the top, cup-shaped portion of the arbor to be formed in cavity 22. Plate 33 has timing slots 35, best shown in Fig 7, for mating with alignment lugs on the toric core pin, to be described.

Adapted for insertion into the interior opening of body plate 33 is a toric core pin 36 having the positive of a toric lens curve on its bottom end 37. The core pin 36 has a diameter at its lower end which is slightly less than

the diameter of the interior opening in body plate 33 at that point, so that the external lateral surface of the core pin 36 is spaced apart from the interior lateral surface 34 of the plate 33 to provide the shape of the upper, cup-shaped portion of cavity 22. The toric core pin 36 has a flange 38 which rests on shoulder 39 of body plate 33, so that the toric lower end 37 of core pin 36 is spaced apart from the upper end 40 of first core pin 31 to provide a cavity having the shape of the partition element separating the upper and lower portions of the arbor to be formed in cavity 22. The toric pin 36 is also provided with timing or alignment lugs or ridges 41 adapted for mating with timing slots 35 in the body plate 33, to provide centering of toric base curve axis to pin axis for location in the injection mold.

The toric core pin 36 is made of metal, such as nickel or nickel alloy, or any other suitable permanent material, and has a concave toric end surface 37. The toric surface may be produced by known manufacturing procedures, including for example lathe machining followed by polishing; electroforming; or electro discharge machining followed by polishing. It is essential in any of such manufacturing procedures that the toric axis of the concave curve produced in the bottom end of the pin be precisely aligned with the timing lugs or ridges 41 of the core pin. As shown in Fig 8, which is a view of the bottom end of the core pin 36, the toric axis C -- C' must be aligned in a permanent relationship to the lugs 41, so that when the toric pin is inserted in the opening of body plate 33, the toric axis on the concave surface 37 is always aligned in the same direction.

As previously mentioned, the injection molding body may be an assembly of plates or cartridges which are inserted into a frame and locked together to form the desired mold cavity 22. As illustrated in the case of body plate 33 in Fig 7, each of the body plates 24, 29 and 33 may be composed of two parts, separated along line 42, and the halves of each plate may be inserted into the frame from opposite directions to provide the desired interior cavity.

The rotatable ring plate 26 forms an essential feature of the invention and provides a means for forming the alignment slots 16 at a predetermined position in the bottom end 17 of the molding arbor. As illustrated in Fig 6, and in more detail in Figs 9 through 11, the ring plate 26 is made up of a tubular body section 43, a flange 27, and a cylindrical shoulder 44. The flange 27 is adapted to seat on the shoulder 28 of the first body plate 24, and the opening in the ring plate 26 is designed to fit around the first core pin 31. The top surface 45 of the cylindrical shoulder 44 forms the bottom end 17 of the casting mold to be formed in the cavity 22. Alignment forming lugs 46 are positioned on the top surface 45 of the cylindrical shoulder 44, and it will be seen that these lugs protrude into the cavity 22 and result in corresponding slots 16 in the bottom edge 17 of the finished form of the casting mold arbor to be produced in cavity 22.

A series of locator holes 47 are positioned around the bottom circumference of flange 27, extending as

much as 180 degrees around the flange. These holes are adapted to mate with a locator pin 48 fixed in body plate 24 at the place indicated. The upper surface of flange 27 carries calibration indicia 49 corresponding to the positions of the locator holes 47 in the bottom of the flange.

When the injection molding body is being assembled, the first mold body plate 24, which serves as a seat for the rotatable ring plate 26, is placed on top of the base plate 23 and over the core pin 31. The mold operator then reads the prescription specifying the number of degrees the toric axis is to be offset from the orientation axis of the prism ballast and drops the rotatable ring 26 into place on mold body plate 24, so that the hole 47 corresponding to the specified number of degrees mates with the locator pin 48. Optionally, the ring plate 26 may be locked in place by use of a set screw 50 and corresponding slot 51. Following this, the second and third body plates 29 and 33 are inserted in the injection molding frame, and finally the toric core pin 36 is placed in position, with the timing lugs 41 mating with timing slots 35. It is a feature of the invention that the timing slots 35 and the locator pin 48 are permanently fixed in the injection molding body, in a precision relationship with each other, so that when the rotatable ring 26 is seated with locator pin 48 engaging a hole 47 corresponding to a desired toric axis offset, the slots 16 in the bottom edge of the mold arbor will always provide the prescribed number of degrees of offset between the toric axis and the prism orientation axis of the lens produced on the mold arbor.

When the injection mold has been assembled as described, a molding grade resinous material such as a polyimide, polycarbonate, polymethylpentene, polyethylene, polypropylene, or other molding material is introduced into the cavity 22 through injection means (not shown), and standard injection molding techniques are used to apply the necessary heat and pressure to produce the desired casting mold arbor. After appropriate cooling and stabilisation, the arbor is ready to be filled with monomer and cured to produce the lens button, in the manner previously described.

The production of toric base curve contact lenses, using casting mold arbors produced by the present invention, provides numerous advantages and efficiencies, as compared to current commercial procedures. The number of manufacturing operations is reduced dramatically. All the lathe operator-dependent determinations involved in the current procedures for making toric base curve lenses are transferred to the injection molding stage, where the base curves and axis offsets are permanently established by the injection molding equipment itself, rather than by operator adjustment. The errors introduced by plastic flow of the lens polymer in the crimped state are avoided. The variations and the resulting high reject rate caused by lathe operator eye strain and fatigue in cutting, polishing, and measuring the back and front surface curves and setting and resetting the lathe tool, are eliminated. The lathe tool remains in a permanent position for making the ballast and other

cuts on successive batches of lenses, even though the toric axis offset may vary from batch to batch, because the offset is built into the casting mold arbor used for each batch. Scrap rates are reduced from the current 90 - 98% to only about 50%.

Although preferred embodiments of the invention have been described in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention. For example, the casting mold arbor may be made in the shape illustrated in Fig 12, wherein the hollow bottom portion 11A is configured with the lathe mounting taper on the outside surface, for mating with a cap 52 on a lathe spud 53.

Claims

1. An injection molding machine for producing a lens casting mold arbor, said arbor having hollow top and bottom portions (10, 11) separated by a partition element (12) having a toric surface (15) formed on its top surface, said method comprising:
 - a) providing an injection molding cavity (22) defining the lateral surfaces, the top edge surface and the toric surface of said arbor;
 - b) providing a rotatable ring plate element (26) defining in said cavity the bottom edge surface (17) of said arbor, said ring plate element having the negative (46) of at least one alignment means in its upper surface for forming the positive (16) of said alignment means in the bottom end surface of said arbor;
 - c) rotating and locking said ring plate element at a point where said alignment means in said ring plate element is offset a predetermined number of degrees from the toric axis of said toric surface; and
 - d) introducing resinous molding material into said cavity and applying heat and pressure to produce a lens casting arbor having an alignment means in its bottom end surface, offset a predetermined number of degrees from the toric axis of its toric surface.
2. The injection molding method of claim 1 wherein the alignment means in the upper surface of said rotatable ring plate is a ridge (46), whereby the alignment means in the bottom end surface of said arbor becomes a slot (16).
3. The method according to claim 1, further including the steps of:
 - e) filling the top portion of said lens casting arbor and covering said toric surface with a liquid monomer lens material and polymerizing said material to form a lens button (13) having one



much as 180 degrees around the flange. These holes are adapted to mate with a locator pin 48 fixed in body plate 24 at the place indicated. The upper surface of flange 27 carries calibration indicia 49 corresponding to the positions of the locator holes 47 in the bottom of the flange.

When the injection molding body is being assembled, the first mold body plate 24, which serves as a seat for the rotatable ring plate 26, is placed on top of the base plate 23 and over the core pin 31. The mold operator then reads the prescription specifying the number of degrees the toric axis is to be offset from the orientation axis of the prism ballast and drops the rotatable ring 26 into place on mold body plate 24, so that the hole 47 corresponding to the specified number of degrees mates with the locator pin 48. Optionally, the ring plate 26 may be locked in place by use of a set screw 50 and corresponding slot 51. Following this, the second and third body plates 29 and 33 are inserted in the injection molding frame, and finally the toric core pin 36 is placed in position, with the timing lugs 41 mating with timing slots 35. It is a feature of the invention that the timing slots 35 and the locator pin 48 are permanently fixed in the injection molding body, in a precision relationship with each other, so that when the rotatable ring 26 is seated with locator pin 48 engaging a hole 47 corresponding to a desired toric axis offset, the slots 16 in the bottom edge of the mold arbor will always provide the prescribed number of degrees of offset between the toric axis and the prism orientation axis of the lens produced on the mold arbor.

When the injection mold has been assembled as described, a molding grade resinous material such as polyimide, polycarbonate, polymethylpentene, polyethylene, polypropylene, or other molding material is introduced into the cavity 22 through injection means (not shown), and standard injection molding techniques are used to apply the necessary heat and pressure to produce the desired casting mold arbor. After appropriate cooling and stabilisation, the arbor is ready to be filled with monomer and cured to produce the lens button, in the manner previously described.

The production of toric base curve contact lenses, using casting mold arbors produced by the present invention, provides numerous advantages and efficiencies, as compared to current commercial procedures. The number of manufacturing operations is reduced dramatically. All the lathe operator-dependent determinations involved in the current procedures for making toric base curve lenses are transferred to the injection molding stage, where the base curves and axis offsets are permanently established by the injection molding equipment itself, rather than by operator adjustment. The errors introduced by plastic flow of the lens polymer in the crimped state are avoided. The variations and the resulting high reject rate caused by lathe operator eye strain and fatigue in cutting, polishing, and measuring the back and front surface curves and setting and resetting the lathe tool, are eliminated. The lathe tool remains in a permanent position for making the ballast and other

cuts on successive batches of lenses, even though the toric axis offset may vary from batch to batch, because the offset is built into the casting mold arbor used for each batch. Scrap rates are reduced from the current 90 - 98% to only about 50%.

Although preferred embodiments of the invention have been described in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention. For example, the casting mold arbor may be made in the shape illustrated in Fig 12, wherein the hollow bottom portion 11A is configured with the lathe mounting taper on the outside surface, for mating with a cap 52 on a lathe spud 53.

Claims

1. An injection molding machine for producing a lens casting mold arbor, said arbor having hollow top and bottom portions (10, 11) separated by a partition element (12) having a toric surface (15) formed on its top surface, said method comprising:
 - a) providing an injection molding cavity (22) defining the lateral surfaces, the top edge surface and the toric surface of said arbor;
 - b) providing a rotatable ring plate element (26) defining in said cavity the bottom edge surface (17) of said arbor, said ring plate element having the negative (46) of at least one alignment means in its upper surface for forming the positive (16) of said alignment means in the bottom end surface of said arbor;
 - c) rotating and locking said ring plate element at a point where said alignment means in said ring plate element is offset a predetermined number of degrees from the toric axis of said toric surface; and
 - d) introducing resinous molding material into said cavity and applying heat and pressure to produce a lens casting arbor having an alignment means in its bottom end surface, offset a predetermined number of degrees from the toric axis of its toric surface.
2. The injection molding method of claim 1 wherein the alignment means in the upper surface of said rotatable ring plate is a ridge (46), whereby the alignment means in the bottom end surface of said arbor becomes a slot (16).
3. The method according to claim 1, further including the steps of:
 - e) filling the top portion of said lens casting arbor and covering said toric surface with a liquid monomer lens material and polymerizing said material to form a lens button (13) having one



finished base curve toric optical surface molded against the toric surface in said arbor;

f) mounting said arbor containing said lens button on a precision lathe, with the alignment means on the bottom edge of said arbor mated with a corresponding alignment means on said lathe; and

g) machining the front surface of said lens button to provide a prism which is offset a predetermined number of degrees from the toric axis of said lens.

4. Injection molding apparatus for producing a lens casting mold arbor, said arbor having hollow top and bottom portions (10,11) separated by a partition element (12), said injection molding apparatus comprising:

a) an injection molding body (24,29,33) having an interior opening shaped to form the exterior lateral surface of said arbor;

b) a first core pin (31) inserted in the bottom portion of said interior opening of said molding body, the external surface (32) of said core pin being spaced apart from the surface of the interior opening of said molding body to provide a cavity (22) having the shape of the lower portion of said arbor;

c) a toric core pin (36) having the positive of the toric lens curve on its bottom end (37), said toric core pin being inserted in the upper portion of said interior opening of said molding body and having its external lateral surface of said molding body to provide a cavity having the shape of the upper portion of said arbor, and the toric lower end of said toric pin being spaced apart from the upper end (40) of said first core pin to provide a cavity having the shape of said partition element separating the upper and lower portions of said arbor;

d) alignment means (41) formed in said toric pin for mating with corresponding alignment means (35) in the upper portion of said molding body, whereby the toric axis of said toric pin is maintained in a stationary position;

e) a rotatable ring plate (26) inserted in said molding body for forming the bottom end surface (17) of said arbor, said rotatable ring plate having the negative (46) of at least one alignment means in its upper surface for forming the positive (16) of said alignment means in the bottom end surface of said arbor;

f) means for rotating and locking (50) said rotatable ring plate at a point where said alignment means in said ring plate is offset a predetermined number of degrees from the toric axis of said toric pin; and

g) means for introducing resinous molding material into said cavities and applying heat and pressure to produce said lens casting arbor.

5. The injection molding apparatus of claim 4 wherein said rotatable ring plate is provided with a series of spaced holes (47) around at least a portion of its circumference, said holes being adapted to mate with a pin (48) fixed in said molding body.

6. The injection molding apparatus of claim 4 or claim 5, wherein the alignment means in the upper surface of said rotatable ring plate is a ridge (46), whereby the alignment means in the bottom end surface of said arbor becomes a slot (16).

7. The injection molding apparatus of claim 4, wherein said injection molding body includes first, second and third plates (24,29,33), said first plate (24) having an interior opening and serving as a ring plate seat, said second plate (29) located above said first plate and having an interior opening in registration with the opening in said first plate, a lateral surface (30) of the opening in said second plate being shaped to form the external lateral surface of the bottom portion of said arbor; said first core pin being inserted into the openings of said first and second plates, the external surface (32) of said first core pin being spaced apart from the lateral surface of the opening in said second plate to provide said cavity (22) with the shape of the lower portion of said arbor, said third plate located above said second plate and having an interior opening in registration with the interior opening of said second plate, a lateral surface (34) of the opening in said third plate being shaped to form the exterior lateral surface of the top portion of said arbor, said toric core pin being inserted in the upper portion of said interior opening of said third plate, said alignment means comprising at least one alignment ridge (41) for mating with a corresponding alignment slot (35) in said third plate, said ring plate being inserted in said first plate, said negative of said at least one alignment means comprising at least one ridge (46) formed in said upper surface of said ring plate.

Patentansprüche

1. Spritzgießverfahren zum Herstellen eines Gießformdornes für eine Linse, wobei der Dorn einen hohlen Oberendabschnitt (10) und einen hohlen Unterendabschnitt (11) aufweist, die von einem Trennelement (12) getrennt sind, das eine an seiner Oberseite ausgebildete Torusfläche (15) aufweist, wobei das Verfahren enthält:

a) Bereitstellen einer Spritzgießkavität (22), die die seitlichen Oberflächen, die obere Randfläche und die Torusfläche des Dornes festlegt;



- b) Bereitstellen eines drehbaren Ringplat-
tenelementes (26), das in der Kavität die untere
Randfläche (17) des Dornes festlegt, wobei das
Ringplattelement das Negativ (46) von
zumindest einem Ausrichtungsmittel in seiner
oberen Oberfläche zum Bilden des Positivs (16)
des Ausrichtungsmittels in der Unterendfläche
des Dornes aufweist; 5
- c) Drehen und Verriegeln des Ringplattele-
mentes in einer Stellung, in der das Ausrich-
tungsmittel in dem Ringplattelement um
einen vorgegebenen Winkel aus der
Torusachse der Torusfläche versetzt ist; und 10
- d) Zuführen von Harzgießmaterial in die Kavität
und Aufbringen von Wärme und Druck, um
einen Linsengießdorn zu schaffen, der ein Aus-
richtungsmittel in seiner Unterendfläche auf-
weist, das um einen vorgegebenen Winkel von
der Torusachse seiner Torusfläche versetzt ist. 15
2. Spritzgießverfahren nach Anspruch 1, dadurch
gekennzeichnet, daß das Ausrichtungsmittel in der
oberen Oberfläche der drehbaren Ringplatte eine
Rippe (46) ist, wodurch das Ausrichtungsmittel in
der Unterendfläche des Dornes ein Schlitz (16) wird. 20
3. Verfahren nach Anspruch 1, dadurch gekennzeich-
net, daß es weiterhin die Schritte enthält:
- e) Füllen des Oberendabschnittes des Linsen-
gießdornes und Bedecken der Torusfläche mit
einem liquiden Monomerlinsenmaterial und
Polymerisieren des Materials, um einen Linsen-
rohling (13) zu bilden, der eine fertiggestellte
Basiskrümmung mit torischer optischer Ober-
fläche aufweist, die an der Torusfläche des
Dornes gegossen ist; 30
- f) Anbringen des den Linsenrohling
enthaltenden Dornes an einer Präzisionsdreh-
maschine, wobei das Ausrichtungsmittel an
dem Unterrand des Dornes an einem
entsprechenden Ausrichtungsmittel an der
Drehmaschine passend montiert ist; und 40
- g) Bearbeiten der Frontoberfläche des Linsen-
rohlings, um ein Prisma zu schaffen, das um
einen vorgegebenen Winkel aus der
Torusachse der Linse versetzt ist. 45
4. Spritzgießvorrichtung zum Herstellen eines Gieß-
formdornes für eine Linse, wobei der Dorn einen
hohlen Oberendabschnitt (10) und einen hohlen
Unterendabschnitt (11) aufweist, die von einem
Trennelement (12) getrennt sind, wobei die
Spritzgießvorrichtung enthält: 50
- a) einen Spritzgußkörper (24, 29, 33) mit einer
Innenöffnung, die zum Bilden der äußeren Sei-
tenoberfläche des Dornes geformt ist;
- b) einen ersten Kernstift (31), der in den Unter-
abschnitt der Innenöffnung des Gußkörpers
eingefügt ist, wobei die Außenoberfläche (32)
des Kernstiftes von der Oberfläche der
Innenöffnung des Gußkörpers beabstandet ist,
um eine Kavität (22) bereitzustellen, die die
Form des Unterendabschnittes des Dornes auf-
weist;
- c) einen torischen Kernstift (36), der das Positiv
der Krümmung der torischen Linse an seinem
Unterende (37) aufweist, wobei der torische
Kernstift in den Oberabschnitt der Innenöffnung
des Gußkörpers eingefügt ist und die äußere
Seitenoberfläche des Gußkörpers dafür
vorgesehen ist, eine Kavität zu schaffen, die die
Form des Oberendabschnittes des Dornes auf-
weist, und wobei das torische Unterende des
torischen Stiftes von dem Oberende (40) des
ersten Kernstiftes beabstandet ist, um eine
Kavität zu schaffen, die die Form des Trennele-
mentes aufweist, das den Oberendabschnitt
und den Unterendabschnitt des Dornes trennt;
- d) ein Ausrichtungsmittel (41), das in dem tor-
ischen Stift zum Zusammenpassen mit
entsprechenden Ausrichtungsmitteln (35) in
dem Oberabschnitt des Gußkörpers ausgebil-
det ist, wodurch die Torusachse des torischen
Stiftes in einer stationären Position gehalten
wird;
- e) eine drehbare Ringplatte (26), die in den
Gußkörper zum Bilden der Unterendfläche (17)
des Dornes eingefügt ist, wobei die drehbare
Ringplatte das Negativ (46) von zumindest
einem Ausrichtungsmittel in seiner oberen
Oberfläche zum Bilden des Positivs (16) des
Ausrichtungsmittels in der Unterendfläche des
Dornes aufweist;
- f) eine Einrichtung zum Drehen und Verriegeln
(50) der drehbaren Ringplatte in einer Stellung,
in der das Ausrichtungsmittel in der Ringplatte
um einen vorgegebenen Winkel aus der
Torusachse des torischen Stiftes versetzt ist;
und
- g) eine Einrichtung zum Zuführen von
Harzgießmaterial in die Kavitäten und Aufbrin-
gen von Wärme und Druck zum Erzeugen des
Linsengießdornes.
5. Spritzgießvorrichtung nach Anspruch 4, dadurch
gekennzeichnet, daß die drehbare Ringplatte mit
einer Reihe von beabstandeten Löchern (47) auf
zumindest einem Abschnitt ihres Umfangs versehen
ist, wobei die Löcher angepaßt sind, um mit einem
in dem Gußkörper befestigten Stift (48) zusammen-
zupassen. 55
6. Spritzgießvorrichtung nach Anspruch 4 oder 5,
dadurch gekennzeichnet, daß das Ausrichtungsmit-
tel in der oberen Oberfläche der drehbaren Ring-



platte eine Rippe (46) ist, wodurch das Ausrichtungsmittel in der Unterendfläche des Dornes ein Schlitz (16) wird.

7. Spritzgießvorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß der Spritzgußkörper eine erste, eine zweite und eine dritte Platte (24, 29, 33) enthält, wobei die erste Platte (24) eine Innenöffnung aufweist und als ein Ringplattensitz dient, die zweite Platte (29) oberhalb der ersten Platte angeordnet ist und eine Innenöffnung in Deckung mit der Öffnung in der ersten Platte aufweist, eine Seitenoberfläche (30) der Öffnung in der zweiten Platte derart geformt ist, daß sie die äußere Seitenoberfläche des Unterendabschnittes des Dornes bildet; der erste Kernstift in die Öffnungen der ersten und der zweiten Platte eingefügt ist, die Außenoberfläche (32) des ersten Kernstiftes von der Seitenoberfläche der Öffnung in der zweiten Platte beabstandet ist, um die Kavität (22) mit der Form des Unterendabschnittes des Dornes bereitzustellen, die dritte Platte oberhalb der zweiten Platte angeordnet ist und eine Innenöffnung in Deckung mit der Innenöffnung der zweiten Platte aufweist, eine Seitenoberfläche (34) der Öffnung in der dritten Platte derart geformt ist, daß sie die äußere Seitenfläche des Oberendabschnittes des Dornes bildet, der torische Kernstift in den Oberabschnitt der Innenöffnung der dritten Platte eingefügt ist, das Ausrichtungsmittel zumindest eine Ausrichtungsrippe (41) zum Zusammenpassen mit einem entsprechenden Ausrichtungsschlitz (35) in der dritten Platte aufweist, die Ringplatte in der ersten Platte eingefügt ist, und das Negativ des zumindest einen Ausrichtungsmittels eine Rippe (46) aufweist, die in der oberen Oberfläche der Ringplatte ausgebildet ist.

Revendications

1. Machine de moulage par injection pour produire un mandrin formant moule de coulée pour une lentille, ledit mandrin comportant des parties supérieure et inférieure creuses (10, 11) séparées par un élément formant cloison (12) ayant une surface torique (15) formée à sa partie supérieure, ledit procédé consistant à:
- a) fournir une cavité de moulage par injection (22) définissant les surfaces latérales, la surface supérieure formant bord et la surface torique dudit mandrin;
 - b) fournir un élément (26) formant plaque annulaire rotative définissant dans ladite cavité la surface inférieure formant bord (17) dudit mandrin, ledit élément formant plaque annulaire por-

tant, dans sa surface supérieure, le négatif (46) d'au moins un moyen d'alignement, ce négatif étant destiné à former le positif (16) dudit moyen d'alignement dans la surface inférieure d'extrémité dudit mandrin;

c) faire tourner ledit élément formant plaque annulaire jusqu'à une position où ledit moyen d'alignement dans ledit élément formant plaque annulaire est décalé d'un nombre prédéterminé de degrés par rapport à l'axe torique de ladite surface torique, et l'y verrouiller; et

d) introduire de la matière résineuse de moulage dans ladite cavité et lui appliquer de la chaleur et de la pression pour produire un mandrin pour le coulage d'une lentille comportant dans sa surface d'extrémité inférieure, un moyen d'alignement, décalé d'un nombre prédéterminé de degrés par rapport à l'axe torique de sa surface torique.

2. Procédé de moulage par injection selon la revendication 1, où le moyen d'alignement dans la surface supérieure de ladite plaque annulaire tournante est une nervure (46), d'où il résulte que le moyen d'alignement dans la surface inférieure d'extrémité dudit mandrin sera une rainure (16).

3. Procédé selon la revendication 1, comprenant en outre les étapes consistant à:

e) remplir la partie supérieure dudit mandrin de coulée pour une lentille, couvrir ladite surface torique avec une matière monomère liquide pour lentille, et polymériser ladite matière afin de former une ébauche de lentille (13) comportant une surface optique de base finie, à courbure torique, moulée contre la surface torique dudit mandrin;

f) monter ledit mandrin contenant ladite ébauche de lentille sur un tour de précision, avec le moyen d'alignement formé sur le bord inférieur dudit mandrin accouplé à un moyen d'alignement correspondant sur ledit tour; et

g) usiner la surface avant de ladite ébauche de lentille pour fournir un prisme qui est décalé d'un nombre prédéterminé de degrés par rapport à l'axe torique de ladite lentille.

4. Appareil de moulage par injection pour produire un mandrin formant moule de coulée pour une lentille, ledit mandrin comportant des parties supérieure et inférieure creuses (10, 11) séparées par un élément formant cloison (12), ledit appareil de moulage par injection comprenant:

a) un corps de moulage par injection (24, 29, 33) comportant une ouverture intérieure modélisée de manière à former la surface latérale extérieure dudit mandrin;



b) une première tige formant noyau (31) insérée dans la partie inférieure de ladite ouverture intérieure dudit corps de moulage, la surface extérieure (32) de ladite tige formant noyau étant espacée de la surface de l'ouverture intérieure dudit corps de moulage pour définir une cavité (22) ayant la forme de la partie inférieure dudit mandrin;

c) une tige torique formant noyau (36) comportant à son extrémité inférieure (37) le positif de la courbe torique de la lentille, ladite tige torique formant noyau étant insérée dans la partie supérieure de ladite ouverture intérieure dudit corps de moulage et définissant avec la surface latérale extérieure dudit corps de moulage une cavité ayant la forme de la partie supérieure dudit mandrin, l'extrémité inférieure torique de ladite tige torique étant espacée de l'extrémité supérieure (40) de ladite première tige formant noyau pour fournir une cavité ayant la forme dudit élément formant cloison qui sépare les parties supérieure et inférieure dudit mandrin;

d) des moyens d'alignement (41) formés dans ladite tige torique et destinés à s'accoupler avec des moyens d'alignement correspondants (35) prévus dans la partie supérieure dudit corps de moulage, grâce à quoi l'axe torique de ladite goupille torique est maintenu dans une position immobile;

e) une plaque annulaire rotative (26) insérée dans ledit corps de moulage, et destinée à former la surface d'extrémité inférieure (17) dudit mandrin, ladite plaque annulaire tournante comportant, dans sa surface supérieure, le négatif (46) d'au moins un moyen d'alignement, ce négatif étant destiné à former le positif (16) dudit moyen d'alignement dans la surface d'extrémité inférieure dudit mandrin;

f) des moyens pour faire tourner ladite plaque annulaire tournante jusqu'en une position où ledit moyen d'alignement dans ladite plaque annulaire est décalé d'un nombre prédéterminé de degrés par rapport à l'axe torique de ladite goupille torique et pour l'y verrouiller (50);

g) des moyens pour introduire une matière résineuse de moulage dans lesdites cavités et lui appliquer de la chaleur et de la pression pour produire ledit mandrin destiné au coulage d'une lentille.

5. Appareil de moulage par injection selon la revendication 4, où ladite plaque annulaire tournante est pourvue d'une série de trous espacés (47) autour d'au moins une partie de sa circonférence, lesdits trous étant prévus pour s'adapter à une goupille (48) fixée dans ledit corps de moulage.

6. Appareil de moulage par injection selon la revendication 4 ou la revendication 5, où le moyen d'alignement

est dans la surface supérieure de ladite plaque annulaire tournante est une nervure (46), d'où il résulte que le moyen d'alignement dans la surface d'extrémité inférieure dudit mandrin sera une fente (16).

7. Appareil de moulage par injection selon la revendication 4, où ledit corps de moulage par injection comprend des première, seconde et troisième plaques (24, 29, 33),

ladite première plaque (24) comportant une ouverture intérieure et servant de siège de plaque annulaire,

ladite seconde plaque (29), placée au-dessus de ladite première plaque et, comportant une ouverture intérieure coïncidant avec l'ouverture prévue dans ladite première plaque, une surface latérale (30) de l'ouverture dans ladite seconde plaque étant modelée pour former la surface latérale extérieure de la partie inférieure dudit mandrin; ladite première tige formant noyau étant insérée dans les ouvertures desdites première et seconde plaques, la surface extérieure (32) de ladite première tige formant noyau étant espacée de la surface latérale de l'ouverture dans ladite seconde plaque pour fournir ladite cavité (22) ayant la forme de la partie inférieure dudit mandrin,

ladite troisième plaque, placée au dessus de ladite seconde plaque comportant une ouverture intérieure coïncidant avec l'ouverture intérieure de ladite seconde plaque, une surface latérale (34) de l'ouverture de ladite troisième plaque étant modelée pour former la surface latérale extérieure de la partie supérieure dudit mandrin, ladite tige torique formant noyau étant insérée dans la partie supérieure de ladite ouverture intérieure de ladite troisième plaque, ledit moyen d'alignement comprenant au moins un ergot d'alignement (41) prévu pour s'accoupler avec une fente d'alignement correspondante (35) de ladite troisième plaque,

ladite plaque annulaire est insérée dans ladite première plaque, et ledit négatif d'au moins un desdits moyens d'alignement comprend au moins une nervure (46) formée dans ladite surface supérieure de ladite plaque annulaire.

50

55