MOLD AND METHOD FOR MAKING AN INSULATOR FOR HIGH-VOLTAGE GAS INSULATED SWITCH GEAR

Fig. 8

Abstract: The invention is directed to an insulator (1) for a gas insulated device, an injection mold (15) and a method for making the same. The insulator (1) comprises an injection molded insulator disc (2) and a conductor (3). The insulator disc (2) comprises a center opening (4) encompassed by an inner bead (5) inside which the conductor (3) is arranged. The insulator disc (2) consists out of a first material, which is injection molded onto the conductor (3).

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MOLD AND METHOD FOR MAKING AN INSULATOR FOR HIGH-VOLTAGE
GAS INSULATED SWITCH GEAR

FIELD OF THE INVENTION

Aspects of the invention relate to an insulator for a gas insulated device, in particular to an insulator comprising an insulator disc surrounding a high voltage conductor. Further aspects relate to a gas insulated device comprising such an insulator and to methods of producing such an insulator.

BACKGROUND OF THE INVENTION

A gas-insulated device accommodates high-voltage conductors such as lead conductors to which a high voltage is applied. In order to shield and insulate the high-voltage conductor from other components and from the outside, such an apparatus comprises a grounded metal enclosure filled with an insulating gas, a dielectric gas such as SF6, for example.

In order to hold a high-voltage conductor firmly inside the device volume, in a position sufficiently far away from the grounded enclosure such as to avoid dielectric breakdowns, an insulator is provided inside the gas enclosure. The insulator is secured at its outer edge to the enclosure, and has a central opening for accommodating the high-voltage conductor. The main portion of the spacer is an insulator disc, with the opening at its center. Some spacers may have a metallic armature ring attached to the outer circumference of the insulator disc. The armature ring may have attachment means such as thread holes, which allow the insulator disc to be firmly attached to the GIS enclosure.
For a long time, alumina filled epoxy has been used as basic material for the manufacturing of insulators in GIS. Epoxy is a material, which has good electrical insulating properties and mechanical strength but has also disadvantages. Epoxy is not environment friendly and the manufacturing process (moulding) is complicated, time consuming and therefore also relatively costly. An additional disadvantage of the epoxy insulators is the material inherit brittleness. This brittleness may lead to an unwanted sudden failure if loaded too high and therefore needs to be controlled closely to ensure proper part function. The manufacturing process is complex but a stable production critical for good part quality.

**EP2273641** was filed in the name of ABB Technology AG and published in January 2011. It discloses a spacer for a gas insulated device. The spacer comprises an insulator disc and an armature extending around an outer perimeter of the insulator disc and foreseen to hold the insulator disc. For producing the spacer, an armature is positioned in a first molding cavity of a molding machine such that a second molding cavity is formed. An insulation material is brought into the second cavity and then cured such that the armature holds the insulator disc therein thus forming the insulator. The armature ring of an insulator may have a through channel (see [0056] and Fig. 13) extending across the ring in a radial direction and used for casting the mold.

**JP2004104897A** was filed in the name of Fuji Electronic Holding Ltd. and is directed to the production of a spacer for a gas-insulated electrical apparatus using thermoplastic resin, which can be easily recycled. An insulation body of the spacer is divided into a plurality of layers in the axial direction of a conductor. Each of the layers is formed using a thermoplastic resin and the divided bodies are integrally combined. By dividing an insulation body, the thickness of each of the divided bodies can be made reduced, thus enabling injection molding by the
thermoplastic resin of each of the divided bodies. The layers are combined so as to be in a hollow shell condition, and partially or totally jointed by adhesion, fitting, or fusing, thus obtaining required mechanical strength and insulation strength. One drawback of this solution is that the insulator tends to comprise inclusions which are taking influence on the electrical field. A further drawback are the difficulty in the production of the product.

US4263476 was assigned to Electric Power Research Institute and published in 1979. It is directed to an injection molded insulator with a single insulator structure, which is used in an elongated flexible gas-insulated cable. The insulator is made of two halves, which are latched together and are made of any suitable plastic material by an injection molding process. It is described that the insulator would preferably be used in a flexible gas-insulated cable for a high voltage transmission system having a relatively low frequency (60 Hertz) at high voltage (345 kV at 600 volts). The central conductor of the cable is supported by the insulator within an outer corrugated housing. The housing is filled with an electronegative gas, such as SF6 at a positive pressure, for example, two to three atmospheres.

EP2062268 was filed in the name of Areva SA. and was published in March 2008. It is directed to an insulating support for a high-voltage or medium-voltage device. The insulating support is based on an insulating polymeric material comprising at least at one of its ends a zone comprising a composite material comprising a matrix made of an insulating polymeric material with an electrically conducting filler, which is a polymeric filler possibly encapsulating a mineral filler.

US7795541 B was assigned to Areva AG. It was first published in 2006 and relates to an insulating device for medium or high voltage electrical equipment in the shape of a disc inside an enclosure acting as a support for an electrical
conductor. The disc is made of thermoplastic polyester. The disc can be worked starting from a thick board using conventional machining tools and it can be provided with particular arrangements, for example to facilitate its assembly or connection of conductors supported on it.

From the prior art, the process of injection molding of thermoplastic material is known since a long time. A more special kind of process of injection molding of thermoplastic material is known as injection compression molding. This process is often used for making of thin walled products.

DE437337 of Aeriola GmbH was published in 1925 and is directed to a procedure for making of parts made out of isolating material (isolators) for electro-technical applications. It is an object to make isolators with a shiny surface in a single step procedure by combining an injection and a compression method simultaneously. Liquefied material is filled into a mold cavity. After the mold cavity is sufficiently filled, a plunger is used to apply sufficient pressure onto the soft material in the cavity such that the material completely fills the mold cavity and achieves a shiny surface.

US4836960A assigned to Plinkington Vision Care Inc. was first published on 15.1.0.1 988. It is directed to a method and an apparatus for the fabrication of optical lenses by injection/compression molding of thermoplastic material. A selected pair of mold inserts is placed in the bore of a sleeve with front and back surface forming optical surfaces in confronting relationship to define a mold cavity. The assembly is heated to a temperature above the glass transition temperature of the thermoplastic to be molded. An injection port extends through the sleeve to the bore and is positioned to inject fluid thermoplastic material into the cavity. After injection of the thermoplastic material, the mold in-
serts are compressed together and excess thermoplastic is forced out of the mold cavity. The mold inserts are then translated together relative to the sleeve to uncouple the injection port from the cavity. Compressive pressure is then maintained on the mold inserts while the mold assembly is cooled below the glass transition temperature. The mold inserts are pulled from the sleeve, and the finished lens is removed.

US4008031A assigned to Techsight Holding Corp. was first published on 15.02.1977. It describes an apparatus for injection molding thermoplastic lenses in a single injection molding operation. Movable optical inserts (dies) are forced apart by injected polycarbonate. Then, the inserts are urged together forcing a portion of the injected polycarbonate into a pocket.

CH354939A of Ankerwerk Gebr Goller was published in 1961. It is directed to a process for producing articles from thermoplastic materials. Thermoplastic material is injected into a not yet completely closed injection mold. A closing mechanism starts to close the mold before the total amount of thermoplastic material required for filling of the cavity of the closed mold is injected. During closing of the mold further thermoplastic material is constantly injected such that solidification of the thermoplastic material in the nozzle is prevented.

DE2914076A of Mannesmann Demag Kunststofftechnik GmbH was first published on 16.01.1980. It is directed to a procedure for injection compression molding of plastic parts on an injection moulding machine. A mold closing mechanism, which comprises an elbow lever mechanism and a hydraulic pressure cushion is used to drive a form plate into a position nearby closing position. Afterwards, plastic material is injected and then the form plate is fully closed by increasing the pressure in the pressure cushion.
WO9635569A of Mobius and Ruppert KG was first published on 13.06.1996. It relates to a device for the production of a plastic object with a large area and thin walls. The device has a lower and an upper mould section, which can be pivoted against each other about a connecting shaft. Through the connecting shaft extends an inlet opening into the moulding chamber which can be altered between a wedge-shaped widened position and a position corresponding to the plastic object. In order to be able easily to withstand the counter-forces occurring when the lower and upper sections of the mould are pressed together, even at high pressures, the upper mould section has a holding-down device in the region of the connecting shaft, which presses the upper mould section temporarily against the lower mould section.

WO07096144 of Demag Ergotech GmbH was first published on 30.08.2007. It is directed to a process for production of thin-walled plastics mouldings via injection of melted plastic into a mould, which has at least one fixed and at least one movable mould half. An aperture gap is formed between the two mould halves in the opened condition of the mould. The aperture gap between the mould halves is continuously reduced while melted plastics is injected into the mould during the movement of the movable mould half onto the fixed mould half.

JP2001-67962 was first published on 16.02.2001. It is directed to an insulating spacer for insulating and supporting a high voltage conductor in a grounded metal container filled with an insulating gas. A high-tension side shield, which is arranged next to a high voltage conductor, is formed integrally with the conductor section. An outer low-tension side shield is integrally formed out of filled metal. Casting is carried out integrally with the epoxy resin of the insulating part.
JP2010-161065 of Nissin Electric Co. Ltd. was first published on 22.07.2010. It is directed to an insulating spacer having high air tightness by a simple shape of a joint surface between an insulation part and an embedded conductor. The insulating spacer comprises an insulation part and a conductor which is embedded inside the insulation part.

SUMMARY OF THE INVENTION

The present invention is directed to a method for making of an insulator for a gas insulated device, in particular for a high voltage device, and an injection mold suitable to execute the method and an injection molded insulator made according to the method.

Hereinafter the term high voltage is understood as a nominal voltage in an electric device, e.g. a gas insulated device, which has a nominal voltage of more than a 1000 Volts in general and of more than about a 50000 Volts in particular.

The insulator normally has a disc like shape and is made out of a thermoplastic material, which overcomes the disadvantages inherent to the prior art. The thermoplastic material preferably used is of ductile nature and therefore more fail safe. The insulator disc is produced by the injection molding process as described subsequent. Advantages are: reduced cycle time, increased degree of automation, less complicated material preparation, less residual stress in the final part, precise geometry, less shrinkage.

In a preferred embodiment the insulator according to the invention comprises an injection molded insulator disc and a conductor. The insulator disc comprises a center opening encompassed by an inner bead inside which the conductor is
arranged. The insulator disc further comprises an outer bead encompassing the insulator disc. The outer bead is suitable to mount the insulator disc in a gas insulated device. In a preferred embodiment the insulator disc is at least partially injection molded onto the conductor, e.g. in that the insulator disc is injection molded onto an outer surface of the conductor.

Alternatively or in addition, an intermediate layer is arranged between the conductor and the insulator disc. The intermediate layer is e.g. a primer to promote adhesion between the conductor and the polymer. In addition the primer might aid to control the electric field close to the metal polymer interface.

The conductor may comprise teeth, which are directly or indirectly engaged with the insulator disc for form fit. The inner bead can at least partially be distanced by a gap from the conductor. If appropriate, a transition means is arranged in the gap interconnecting the inner bead and the conductor. A holding means may be arranged inside the gap positioning the conductor with respect to the insulator disc. The holding means may be at least one circumferential holding rib and/or at least one holding rib arranged in axial direction (axial holding rib). The holding means may be integrally connected to the insulator disc.

In an embodiment the invention is directed to an injection mold for making of an insulator, said insulator comprising: an insulator disc having a center opening and an inner bead and an outer bead, a conductor arranged in the center opening of the insulator disc. The mold in general comprises: a first mold half, a second mold half interacting with the first mold half along a parting plane, at least one cavity corresponding to an insulator disc encompassed by the first and the second mold half. The mold may further comprise at least one adapter suitable to receive and temporarily hold a conductor during injection molding of the insu-
lato disc, at least one injection nozzle arranged at the first mold half discharging directly or indirectly into the at least one cavity. Depending on the field of application and the design of the insulator it is possible to use at least two different injection nozzles to inject the material. The injection mold may comprise at least one adapter which may form part of one of the mold halves. The at least one adapter may have an in general cylindrical shape. The at least one adapter may comprise clamping means to temporarily receive and hold the conductor. The at least one adapter may be arranged displaceable independent of a movement of the mold halves. The at least one adapter may be arranged displaceable against the force of a spring. If the insulator disc shall be produced independent of the conductor it is possible to use a dummy which is later replaced by the conductor. The dummy is placed in the mold instead of the adapter. If required the area forming the inside of the insulator disc can be completely integrated in the mold. The injection mold may comprise at least one ejector. The ejector is preferably arranged at the second mold half to eject the insulator from the injection mold. The at least one ejector may be arranged in the region of and acting upon the outer rim of the insulator disc. Alternatively or in addition the at least one ejector may be arranged in the region of and acting upon conductor of the insulator disc. Further ejectors may be arranged in-between.

The at least one injection nozzle may discharge into the cavity in the area of the outer rim of insulator disc. Furthermore, alternatively or in addition the at least one injection nozzle may discharge into the cavity through at least one channel arranged in the conductor and/or another mold part. Alternatively or in addition the at least one injection nozzle may discharge into the cavity through at least one gap designed to act as a film gate. The at least one gap may be interconnected to a chamber into which the material is discharged first. The at least one
gap may have a variable geometry in circumferential direction and/or have several segments.

In a preferred embodiment, the material is injected by at least one first distribution channel arranged at a circumferential position with respect to the insulator disc. The distribution channel at least partially encompasses the insulator disc. If appropriate, the distribution channel may be separated in segments.

A method for making of an insulator disc as described above in general comprises the following method steps:

a. providing an injection mold having:

i. a first mold half;

ii. a second mold half interacting with the first mold half along a parting plane;

iii. a cavity corresponding to the insulator encompassed by the first and the second mold half;

iv. at least one injection nozzle arranged at the first mold half suitable to discharge liquefied material into the cavity directly or indirectly;

b. closing the mold by relative movement of the first with respect to the second mold half until the cavity is closed;

c. injecting liquefied material through the at least one injection nozzle;
d. opening the mold by relative movement of the first with respect to the second mold half (16, 17); and

e. removing the insulator from the mold cavity (17).

If required it is possible to provide in the mold at least one adapter suitable to receive and temporarily hold a conductor during injection molding of the insulator disc. In this case, before injecting the liquefied material into the cavity, the mold is opened by relative movement of the first mold half with respect to the second mold half in a first direction. Then a conductor is attached to the at least one adapter and the mold is subsequently closed.

At least one part of the mold may be arranged movable to reduce the volume of the cavity and thereby compressing the material in the cavity after and/or during injection of the liquefied material. By this compression step the quality of the surface of the insulator disc can be improved. The compression step can be performed by relative movement of the mold halves from a first into a second closing position. Alternatively or in addition at least one segment of at least one of the mold halves can be designed movable independent of the movement of the mold halves. E.g. a ring like segment in the area of the outer bead can be arranged movable for the compression step. Thereby it is possible to avoid parting lines in the functional critical area of the insulator disc.

If appropriate the at least one ejector is activated to eject the insulator from the injection mold. The several injection nozzles may be arranged in at least one concentric row or at least one group around the center of the mold. The several injection nozzles may be activated simultaneously or in a sequence, e.g. in that at least two injection nozzles are activated at different times to obtain uniform
material distribution. An outer surface of the conductor may be treated by a surface treatment and/or coated by a coating material to increase bonding of the material injection molded onto the outer surface.

In an embodiment, the material injected into the at least one cavity is at least one out of the group of the following materials: polyesters (e.g. polyethylene terephthalate, polybutylene terephthalate), polyamide (PA), polysulfone (e.g. PES), polyetherimide (PEI), polyphenylene sulfide (PPS), polyether ether ketone (PEEK), polyphthalamide (PPA), polypropylene (PP), polyoxymethylene (POM), phenol formaldehyde (PF), unsaturated polyester (UP), polyurethane (PUR and PU). The first material may comprise at least one filler material out of the group of the following filler materials: Polyamide, polyimide, polyester, polyvinyl alcohol, polyvinylidene chloride, polyacrylonitrile, polyurethane, polyalkylene paraoxybenzoate, phenol type, wool, silk, cotton, rayon, cellulose acetate, flax, ramie, jute, aramide fibres, glass, sepiolite, potassium titanate, ceramic, alumina, calcium silicate, rock wool. The second material may be at least one out of the following material groups: thermoplastic elastomers (TPE), thermoplastic polyurethanes (TPU), epoxies or polyurethane (PUR or PU). A third material may be filled in a space delimited by at least two ribs. Alternatively or in addition, the third material can be used to coat the side surface (wall) of the insulator disc and/or the ribs. Said third material may be at least one out of the group of: thermoplastic elastomers (TPE), thermoplastic polyurethanes (TPU), polyurethane (PUR or PU) or Silicones. For economic manufacturing of the insulator, the first material is preferably at least one out of the group of the following materials: a polyester (e.g. PET, PBT), a polyamide (PA), a polyphthalamide (PPA), a polypropylene (PP), a polyoxymethylene (POM), phenol formaldehyde (PF), unsaturated polyester (UP) or polyurethane (PUR and PU). For high thermal stability at least one out of the group of the following polymers is preferred: polysulfone
(e.g. PES), polyetherimide (PEI), polyphenylene sulfide (PPS) or a polyether ether ketone (PEEK).

If appropriate, the material is injected through at least one channel arranged outside of the conductor. The second material may be injected through a channel arranged inside the conductor and/or by direct injection into the gap. The conductor may be preheated to a defined temperature before injection of the material. For this reason, the mold may comprise appropriate means, e.g. in the form of appropriate connection channels, to interconnect to at least one of the channels arranged in the conductor. Alternatively or in addition, the mold can be designed such that the conductor is directly accessible from the outside, i.e. the mold comprises an opening through which the conductor, respectively the channels arranged in the conductor, are accessible from the outside when the conductor is arranged inside of the closed mold. The mold may comprise an adapter to receive and temporarily hold the conductor during the injection molding process. The adapter may be designed exchangeable such that different conductors can be processed with the same mold. If appropriate, the adapter can be part of the cavity of the mold thereby being at least partially in contact with the injection molded material.

The advantages pertaining to the inventive insulator disclosed in this application and producible by a method disclosed in this application are conferred on a medium voltage or high voltage switchgear where at least one such insulator disc is buildt in.
BRIEF DESCRIPTION OF THE DRAWINGS

The herein described invention will be more fully understood from the detailed description given herein below and the accompanying drawings, which should not be considered limiting to the invention described in the appended claims.

The drawings are showing:

Fig. 1 an insulator disc according to the present invention in a perspective view;

Fig. 2 the insulator disc according to Figure 1 in a top view;

Fig. 3 a section view along section line AA;

Fig. 4 a second embodiment of an insulator in a partially cut and exploded view;

Fig. 5 a third embodiment of an insulator in a partially cut manner;

Fig. 6 a first embodiment of an injection mold for making of a insulator disc in a top view;

Fig. 7 a section view along section line BB of Figure 6;

Fig. 8 the mold according to Figure 6 in a partially cut manner in an open position;

Fig. 9 a second embodiment of an injection mold for making of an insulator disc in a top view;
DESCRIPTION OF THE EMBODIMENTS

The foregoing summary as well as the following detailed description of the preferred embodiments is better understood when read in conjunction with the appended drawings. For the purposes of illustrating the invention, several embodiments are shown in the drawings, in which like numerals represent similar parts throughout the several views of the drawings, it being understood, however, that the invention is not limited to the specific methods and instrumentalities disclosed.
Figure 1 shows a first embodiment of an insulator 1 according to the present invention in a perspective view. Figure 2 shows the insulator according to Figure 1 in a front view and Figure 3 shows the insulator 1 in section view along section line AA according to Figure 2.

Figure 4 shows a second embodiment of an insulator 1 in a perspective, partially cut and exploded view. The hidden lines are shown dashed.

Figure 5 shows a third embodiment of an insulator 1 in a perspective, partially cut view.

The insulator 1 comprises a conductor 3, which in a mounted position is arranged in a center opening 4 of an insulator disc 2. As shown, the insulator disc 2 may comprise an inner bead 5 and an outer bead 6, which delimit the insulator disc 2 with respect to the inside and to the outside. By the outer bead 6, which may have a specific design (e.g. several radial indentations and radial protrusions), the insulator 1 is mounted e.g. inside a gas insulated device (not shown in detail). As shown in the embodiment according to Figure 5 the outer bead may be encompassed or replaced by an outer ring 37 made out of another material, such as metal or another appropriate material. At least one field guide electrode 38 may be arranged inside the insulator disc 2. The at least one field guide electrode may be interconnected to the inner conductor 3 or to the outer ring 37.

If appropriate, at least an outer surface 11 of the conductor 3 may be coated by a primer to promote adhesion between the conductor and the polymer. In addition the primer may be foreseen to aid to control the electric field close to the metal polymer interface. The conductor might be exposed to a surface treat-
ment to increase the bonding process i.e. sandblasting or any other treatment that increases bonding forces between the bonding surfaces. As it can be seen in the section view according to Figure 3 the conductor 3 of the shown embodiment comprises teeth 13, which form fit with the insulator disc 2. The insulator disc 2 is injection molded onto the conductor 3.

As shown in Figure 4 and 5 the conductor 3 and the insulator disc 2 are at least partially spaced apart by a distance gap 40, which may be at least partially filled with a second material 10 as shown in Figure 5. The insulator 3 can be held in the center by at least one distance rib 12 arranged in radial (see Figure 4) and/or circumferential (see Figure 5) direction. The distance rib 12 is acting as holding means. As shown in Figure 4 the insulator disc 2 may be made independent and the conductor 3 is then inserted at a later stage as schematically indicated by arrow b from a position above the insulator disc (see conductor 3 position 3.1) to the position inside the insulator disc 2 (see conductor 3 position 3.2).

As mentioned above, the insulator disc 2 is made by injection molding of a first material. The injection molding process can be performed in one or several steps. The conductor 3 is preferably placed inside of a single or several molds. If required the material injected to form the disc can be compressed by a special mold movement (injection compression).

The injection compression molding process can increase the advantages of the injection molding process further, especially help to reduce residual stress in the part through the evenly distributed pressure throughout the mold cavity during the compression step. This favorable pressure distribution will also lead to an superior surface quality - when used in combination with a mirror polished mold
cavity surface. A further advantage of an insulator surface having a surface roughness that is as low as possible resides in that the electric field is locally less intensified at the insulator surface compared to an insulator surface having a higher roughness. Hereinafter, the term surface roughness is to be understood as the surface quality, i.e. the amount of the vertical deviations of a real surface from its ideal form. These deviations relate to the size and the number of peaks/valleys on the surface of a body in general. If these deviations are large, the surface is rough; if they are small the surface is smooth. The lower the surface roughness value is, the lower locally intensified the electric fields are once the insulator disc is in an operating state of the high voltage gas insulated device. This explanations relating to the effects and advantages arising of the injection compression molding is not limited to this particular embodiment and applies likewise to all remaining embodiments disclosed in the present application.

As can be seen in the shown embodiment, the inner and/or the outer bead 5, 6 may be strut by reinforcement ribs 7, e.g. to increase the mechanical stability of the insulator disc 2. If not required the ribs 7 may be avoided. Alternatively or in addition, the ribs 7 may be foreseen to distribute and guide the liquefied material during injecting of it. Therefore the ribs 7 can be aligned with at least one injection opening. The ribs 7 may have different arrangement/pattern, e.g. at least partially in circumferential direction. Between some of the radial reinforcement ribs 7 a wall 8 is arranged in circumferential direction. If required, the wall 8 can be omitted and being replaced by an opening (cross port) 9. The cross port 9 prevent that the two adjacent sections of the gas insulated device are hermetically sealed with respect to each other. If required, the space between two reinforcement ribs can be at least partially filled with filler 14 made out of a third material (schematically indicated by hatched area) as mentioned above. If required,
the complete side surface or only specific parts of it can be covered by the third and/or a fourth material.

Figs. 6-17 are showing in a schematic and simplified manner several embodiments of injection molds (molds) 15 for injection molding of an insulator 1.

The injection molds 15 in general comprise a first mold half 16 and a second mold half 17, which are interacting with each other along a parting plane 18. The first and the second mold half 16, 17 are encompassing, respectively forming, in a closed position a cavity 19 into which appropriate material can be injected through one or several injection nozzles 20 in a liquefied state to form the insulator disc 2. According to the invention, the injection nozzles 20 are preferably arranged directly discharging into the cavity 19. It is furthermore advantageous when the injection nozzles are arranged in the area of the outer rim 6 of the isolator disc 2. The injection nozzles 20 can e.g. be arranged in one or several rows around the center of the mold 15 (position of the conductor 3). For best results and if required, at least two nozzles 20 may be activated at different point of times (sequentially with respect to each other). If required the mold flow of each nozzle can be adjusted independent. In the shown embodiment, the injection nozzles 20 are arranged in the first mold half 16. The injection nozzles 20 are being for example of a needle type each comprising a needle 21 to the mold flow of the plasticized material. A plasticizing unit and channels for distribution of the plasticized material to the nozzles 20 are not shown in detail. Other types of nozzles and distribution channels may be chosen depending on the injection material, flow requirements, for example.

Furthermore, the injection molds 15 comprise one or several rows or groups of ejectors 22, which here are arranged in the second mold half 17. The injectors
22 are e.g. arranged such that they interact directly or indirectly upon the inner conductor 3 and/or the inner rim 5 and/or the outer rim 6 and/or ribs 7 and/or the wall.

The mold may further comprise a first adapter 23, which is foreseen to receive and temporarily hold the conductor 3 during the injection molding process. The conductor 3 forms part of the mold 15, i.e. provides part of the mold cavity through an outer surface 11. The first adapter 23 can be designed exchangeable such that different conductors can be processed with the same mold or the same adapter can be used in different molds for the production of different insulator discs 2. The mold may comprise a second adapter 24, which is normally arranged opposite to the first adapter 23. The first and/or the second adapter 23, 24 may be arrange deflectable, e.g. against the force of a spring 26 to compensate mold movement.

Subsequent, the embodiments of injection molds are described more specifically. The injection mold 15, according to Figures 6-8, is shown in closed position. The second mold half 17 here comprises pin-shaped first ejectors 22, which are arranged movable in vertical direction (z-axis). They are positioned in the area of the outer bead 6 of insulator disc 2. Second ejectors 23 are integrated in the second adapter 25. They are suitable to temporarily hold the conductor 3 in that they are suitable to engage with corresponding holes 27 of the conductor 3. In the shown embodiment, the insulator disc 2 and/or the conductor 3 are shaped such that when opening of the mold 15 the insulator 1 remains attached at the second mold half. After the injected material is sufficiently cured, the insulator 1 can be ejected from the second mold half by simultaneously activating the first and the second ejectors 23. One advantage of the specific arrangement and
cooperation of the first outer and the second inner ejectors 22, 23 is that damaging of the side surface of the insulator disc 2 can be avoided.

In Figure 8 the insulator 1 is shown between the first and the second mold half 16, 17 which are all shown in a partially cut manner. The design of the insulator 1 in general corresponds to the design of the insulator as shown in the Figures 1-3. In difference to the embodiment shown in Figures 1-3 the embodiment shown in Figures 6-8 has a conductor with an in general spherical-shaped outer surface 11 which after manufacturing bonds to the corresponding inner surface of the insulator disc 2. The shape is preferably designed such that due to shrinkage of the material of the insulator disc during curing bonding effect is increased. By the special design of the shape the maximum peak stress can be adjusted. Other shapes are possible. Furthermore the outer surface 11 can be coated by an appropriate material, e.g. a polyurethane coating or rubber like material to protect the surface from scratches or improve impact behavior. Furthermore the coating may be applied for achieving a surface roughness value that is much smaller than the surface roughness value of the molded insulator body. The lower the surface roughness value is, the lower locally intensified the electric fields are once the insulator disc is in an operating state of the high voltage gas insulated device.

If an outer surface 41 of the insulator disc 2 shall be coated, it is possible to apply one or several layers of the same or different coating material to a corresponding inner surface 42 of the cavity. Said layers of coating are then bonded to the material injected into the cavity 17 forming the insulator disc. If required the mold halves may charged electrically to increase temporary holding of the at least one layer of coating material.
Venting of the mold may e.g. be foreseen in the area of the appropriately placed ejectors 22, 23 and/or the at least one adapter 24, 25. The ejector 22, 23 and/or the at least one adapter 24, 25 may comprise one or several venting channels (not shown in detail) along their outer surface or corresponding elements.

The injection mold 15 according to Figures 9-11 is shown in partially opened position. The material for forming the insulator disc 2 is injected through the nozzles 20 directly into the cavity 19. The mold 15 is shown partially open along the parting plane 18 by relative movement of the first mold half 16 away from the second mold half 17. As it can be seen, the insulator 2 has already been made by injecting of plasticized material through the nozzles 20 into the cavity 19, while the mold 15 was closed. The insulator disc 2 is firmly bond to the conductor 3, which is separated from the first adapter 24 arranged on the side of the first mold half 16. As it is schematically shown, a second adapter 25 is arranged behind the conductor 3. The second adapter 25 is displaceable against the force of a spring 26 independent of the movement of the second mold half. The mold shown here allows injection and compression of the material injected into the cavity 19. The mold 15 is designed that after the mold halves 16, 17 are closed and the material is at least partially injected, the mold halves 16, 17 can be further closed by a movement relative to each other the volume of the cavity can be reduced and as a result thereof the material in the cavity 19 is compressed additionally. During the compression process, the second adapter 25 is pressed upward and thereby the spring 26 is compressed. To avoid leakage of the injected material out of the cavity 19, the mold halves 16, 17 comprise a first and a second wall section 28, 29 (see Figure 11), which are arranged opposite to each other extending in vertical direction (z) and which sealingly interact during closing of the mold halves 16, 17. At least one of the walls 28, 29 may have a lead-in surface which improves closing of the mold 15. As it can be seen, the
ejectors 22 are arranged in the region of the outer bead 6 of the insulator disc 2. Alternatively or in addition, further ejectors may be arranged further radially inwardly in the direction of the mold center, e.g. in the area of the ribs 17. The second adapter 25 may be used to support ejection of the insulator disc from the second mold half 16. To safely hold the injector 1 on the second mold half 17 during opening of the injector may comprise a wall section which forms a slight undercut in vertical direction and thereby provides a defined attaching force.

To provide a compression stage it is possible to only move a segment of the mold instead of a complete mold half 16, 17. The segment (not shown) can e.g. have a ring like shape which e.g. is arranged along the outer bead 6. Thereby it is possible to avoid parting lines in critical areas. The segment can be driven independently of the mold halves 16, 17.

The injection mold 15 according to Figures 12-14 is shown in a closed position. Figure 13 is showing a section view along section line EE according to Figure 12. Figure 14 is showing detail F from Figure 13. As it can be best seen in Figure 14, an annular chamber 31 is encompassing the outer bead 6 of the insulator disc 2. The nozzles 20 are discharging into the annular chamber 31. The annular chamber 21 is interconnected to the outer bead 6 by a gap 32 formed between the first and the second mold half 16, 17. The gap 32 is acting as a film gate. The annular gap 32 may have in circumferential direction a variable geometry which is adapted to the design of the outer bead 6, especially when the outer bead 6 has a variable design, e.g. comprising several radial indentations and radial protrusions. During injection of the material, the annular chamber 31 is filled by liquefied material. Then, the material enters through the gap 32 into the cavity 19. In the shown embodiment, the expansion (thickness) of the gap
32 and the size of the volume of the annular chamber 31 is depending on the relative position of the first and the second mold half 16, 17. If required, it is possible to design the annular chamber such that it does instead of a variable a constant volume, e.g. by incorporating it into one of the mold halves 16, 17. By this embodiment, it becomes possible to compress the material injected through the nozzles 20 during curing of the material to obtain very good results. Alternatively or in addition it is possible to design the mold in a way that by a mold movement the ring 31, 32 formed by the annular outer chamber 31 and (if present) the outer gap 32 is (automatically) sheared-off. The insulator disc 2 is ejected from the second mold half by the ejectors 22 which here are arranged acting upon the outer rim 6.

The injection mold 15 according to Figures 15-17 is shown in a closed position. Figure 16 is showing a staggered section view along section line GG of Figure 15. Figure 17 is showing detail H of Figure 16. The mold 15 is shown in closed position. The conductor is clamped between the first and the second mold half 16, 17 and fixed by the first and the second adapters 24, 25. The conductor 3 comprises an inlet opening 33 suitable to connect to an injection nozzle 20. The inlet opening 33 is interconnected to a here star-like arranged channels 34 which in radial direction connects to an annular chamber 35. The annular chamber 35 is interconnected by a circumferential gap 36. Alternatively or in addition the channels 34 may connect directly to the cavity 19 which results in a less complicated shape of the conductor 3.

In the shown embodiment the insulator disc 2 is encompassed by an outer ring 37, e.g. made out of metal or another suitable material. The conductor 3 and the outer ring 37 are inserted into cavity 19 when the mold 15 is in an open position. While the conductor 3 is held between the first and the second adapter 24, 25 in
a spring loaded manner, the outer ring 37 is clamped between first and the second mold half 16, 17. The conductor 3 as well as the outer ring 37 is a part of the inner wall of the cavity 19. Furthermore the outer ring is interconnected to a field guide electrode 38 through bridges 39. As it can be seen, the mold is designed such that the conductor 3 is directly accessible from the outside, i.e. the mold comprises an opening 39 through which the conductor 3, respectively the channels 34 arranged in the conductor 3, are accessible from the outside when the conductor 3 is arranged inside of the closed mold 15.
**LIST OF DESIGNATIONS**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Center axis</td>
<td>22. First Ejector</td>
</tr>
<tr>
<td>b. Vertical movement</td>
<td>23. Second Ejector</td>
</tr>
<tr>
<td>1. Insulator</td>
<td>24. First adapter</td>
</tr>
<tr>
<td>2. Insulator disc</td>
<td>25. Second adapter</td>
</tr>
<tr>
<td>3. Conductor</td>
<td>26. Spring</td>
</tr>
<tr>
<td>4. Center opening</td>
<td>27. Hole (for fixation of conductor)</td>
</tr>
<tr>
<td>5. Inner bead</td>
<td>28. First wall section</td>
</tr>
<tr>
<td>6. Outer bead</td>
<td>29. Second wall section</td>
</tr>
<tr>
<td>7. Reinforcement rib</td>
<td>30. Lead-in surface</td>
</tr>
<tr>
<td>8. Wall</td>
<td>31. Chamber (outer annular)</td>
</tr>
<tr>
<td>9. Cross port</td>
<td>32. Gap (outer)</td>
</tr>
<tr>
<td>10. Second material (gap)</td>
<td>33. Inlet opening</td>
</tr>
<tr>
<td>11. Outer surface (conductor)</td>
<td>34. Channel</td>
</tr>
<tr>
<td>12. Distance rib</td>
<td>35. Annular chamber (inner annular chamber)</td>
</tr>
<tr>
<td>13. Teeth</td>
<td>36. Gap (inner)</td>
</tr>
<tr>
<td>14. Filler (filler material)</td>
<td>37. Outer ring</td>
</tr>
<tr>
<td>15. Injection mold</td>
<td>38. Field guide electrode</td>
</tr>
<tr>
<td>16. First mold half</td>
<td>39. Opening (in first adapter)</td>
</tr>
<tr>
<td>17. Second mold half</td>
<td>40. Distance gap</td>
</tr>
<tr>
<td>18. Parting plane</td>
<td>41. Outer surface (insulator disc 2)</td>
</tr>
<tr>
<td>19. Cavity</td>
<td>42. Inner surface of cavity</td>
</tr>
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PATENT CLAIMS

1. Injection mold (15) for making of an insulator (1), said insulator (1) comprising:

   a. an insulator disc (2) having a center opening (4) and an inner bead (5) and an outer bead (6);

   b. a conductor (3) arranged in the center opening (4) of the insulator disc;

said mold comprising:

   c. a first mold half (16);

   d. a second mold half (17) interacting with the first mold half (16) along a parting plane (18);

   e. a cavity (19) corresponding to the insulator disc (2) encompassed by the first and the second mold half (16,17);

   f. at least one injection nozzle (20) arranged at the first mold half (16) discharging into the cavity (19).
2. The injection mold (15) according to claim 1, characterized in that the injection mold (15) comprises at least one adapter (24, 25) suitable to receive and temporarily hold a conductor (3) during injection molding of the insulator disc;

3. The injection mold (15) according to claim 2, characterized in that the at least one adapter (24, 25) is part of one of the mold halves (16, 17).

4. The injection mold (15) according to claim 2 or 3, characterized in that the at least one adapter (24, 25) has in general a cylindrical shape.

5. The injection mold (15) according to one of the claims 2 to 4, characterized in that the at least one adapter (24, 25) has clamping means (23) to temporarily hold the conductor (3).

6. The injection mold (15) according to one of the claims 2 to 5, characterized in that at least one adapter (24, 25) is arranged displaceable independent of a movement of the mold halves (16, 17).

7. The injection mold (15) according to claim 6, characterized in that the at least one adapter (24, 25) is arranged displaceable against the force of a spring (26).

8. The injection mold (15) according to one of the previous claims, characterized in that at least one area of the mold is arranged displaceable to compress the material after injection.
9. The injection mold (15) according to claim 8, characterized in that the at least one area is a mold half.

10. The injection mold (15) according to claim 8, characterized in that the at least one area is a segment or a ring which is arranged movable independent of the mold halves (16, 17).

11. The injection mold (15) according to one of the previous claims, characterized in that at least one ejector (22) is arranged at the second mold half to eject the insulator (1) from the injection mold (15).

12. The injection mold (15) according to claim 11, characterized in that the at least one ejector (22) is arranged in the region of the outer rim (6) of the insulator disc (2).

13. The injection mold (15) according to claim 11 or 12, characterized in that the at least one ejector (22) is arranged in the region of conductor (3) of the insulator disc (2).

14. The injection mold (15) according to one of the previous claims, characterized in that at least one injection nozzle (20) is discharging into the cavity (19) in the outer rim (6) of insulator disc (2).

15. The injection mold (15) according to one of the previous claims, characterized in that at least one injection nozzle (20) is discharging into the cavity (19) through at least one channel (34) arranged in the conductor (3).
16. The injection mold (15) according to one of the previous claims, characterized in that at least one injection nozzle (20) is discharging into the cavity (19) through at least one gap (32, 36).

17. The injection mold (15) according to claim 16, characterized in that the at least one gap (32, 36) is designed as a film gate interconnected to a chamber (31, 35) into which the material is discharged.

18. The injection mold (15) according to one of the previous claims, characterized in that the insulator (1) is an electric insulator.

19. The injection mold (15) according to one of the previous claims, characterized in that the insulator (1) is an electric insulator for a high voltage use with a nominal voltage of more than about 1000 Volt.

20. The injection mold (15) according to one of the previous claims, characterized in that the insulator (1) is an electric insulator designed for use in gas insulated device.

21. Method for making of an insulator disc (1), said insulator disc comprising:

   a. an insulator disc (2) having a center opening (4) and an inner bead (5) and an outer bead (6);

   b. a conductor (3) arranged in the center opening (4) of the insulator disc;

said method comprising the following method steps:
c. providing an injection mold having:

i. a first mold half (16);

ii. a second mold half (17) interacting with the first mold half (16) along a parting plane (18);

iii. a cavity (19) corresponding to the insulator (1) encompassed by the first and the second mold half (16, 17);

iv. at least one injection nozzle (20) arranged at the first mold half (16) suitable to discharge liquefied material into the cavity (19) directly or indirectly;

d. closing the mold (1) by relative movement of the first with respect to the second mold half (16, 17) until the cavity (17) is closed;

e. injecting liquefied material through the at least one injection nozzle;

f. opening the mold (15) by relative movement of the first with respect to the second mold half (16, 17); and

g. removing the insulator (1) from the mold cavity (17).

22. The method according to claim 21, characterized in that providing in the mold (15) at least one adapter (24, 25) suitable to receive and temporarily hold a conductor (3) during injection molding of the insulator disc and, before injecting liquefied material into the cavity (17), opening the mold (15)
by relative movement of the first mold half with respect to the second mold half (16, 17) in a first direction (z) and attaching a conductor (3) to the at least one adapter (23, 24).

23. The method according to one of the claims 21 or 22, characterized in that at least one part of the mold (15) is arranged movable to reduce the volume of the cavity (17) and thereby compressing the material in the cavity after and/or during injection of the liquefied material.

24. The method according to one of the claims 21 to 23, characterized in that the at least one ejector (22), which is arranged at the second mold half (17), is activated to eject the insulator (1) from the injection mold (15).

25. The method according to one of one of the claims 21 to 24, characterized in that several injection nozzles (20) are provided, which are arranged in at least one concentric row or group around the center of the mold (15).

26. The method according to claim 25, characterized in that several injection nozzles (20) having a different design are present.

27. The method according to claim 25 or 26, characterized in that the several injection nozzles (20) are activated simultaneously.

28. The method according to one of the claims 25 to 27, characterized in that at least two injection nozzles (20) are activated at different times.
29. The method according to one of the claims 21 to 28, characterized in that an outer surface of the conductor is treated by a surface treatment and/or is coated by a coating material to increase bonding of the material injection molded onto the outer surface.

30. The method according to one of the claims 21 to 29, characterized in that an outer surface of the insulator is treated by a surface treatment and/or is coated by a coating material to protect the surface from abrasion and to prevent surface charges.

31. Use of an insulator (1) produced by the method according to any one of claims 21 to 30 in a medium voltage or high voltage switchgear.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. H02G5/06 B29C45/26 B29C45/56

According to International Patent Classification (IPC) and both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H02G H02B H01B B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<tr>
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<td>J P 2010 176969 A (TOSHIBA CORP; UNIV NAGOYA) 12 August 2010 (2010-08-12) abstract; figures 3, 7</td>
<td>1, 14-21, 26-31</td>
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<td>Y</td>
<td>CN 201 707 981 U (MOTIC XIAMEN ELECTRIC GROUP CO LTD) 12 January 2011 (2011-01-12) figures 1-4</td>
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<td>Y</td>
<td>Wo 2007/096144 A2 (DEMAG ERGOTECH GMBH [DE]; LUECK ANDRE [DE]) 30 August 2007 (2007-08-30) cited in the application on page 1; figure</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:

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**O** document relating to an oral disclosure, use, exhibition or other means

**P** document published prior to the international filing date but later than the priority date claimed

**T** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

**X** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

**Y** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

**S** document member of the same patent family

**Date of the actual completion of the international search**

30 November 2012

**Date of mailing of the international search report**

10/12/2012

**Name and mailing address of the ISA**

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Starck, Thierry
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<td>WO 2008/031872 Al (AREVA T &amp; D SA [FR]; KI EFFEL YANNICK [FR]; GI RODET ALAIN [FR]; PONCHON) 20 March 2008 (2008-03-20) page 8, line 19 - line 29 page 12, line 11 - line 17; figures 1-3</td>
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<td>EP 1 294 064 A2 (ALSTOM [FR]) 19 March 2003 (2003-03-19) paragraph [0014]; figure</td>
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