The invention is directed to an insulator (1) for a gas insulated device. 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 in a form-fit manner.
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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. Further aspects relate to methods of producing such an insulator.

BACKGROUND OF THE INVENTION

A gas-insulated switchgear (GIS) 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, generally a dielectric gas such as SF6.

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 GIS 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 metal 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 for the manufacturing of insulators in GIS alumina filled epoxy has been used as basic material. 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 periphery 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.

JP2006340557A was filed in the name of Mitsubishi Electric Corp. and published in December 2006. It is directed to a disc-like member composed of an injection molded insulator. The leakage of insulating gas is blocked by an O-ring fitted in an annular groove. The O-ring can be prevented from falling when the instrument is assembled in that it is fitted in an annular groove formed around the central axis of the disc-like member.
JP2004104897A was filed in the name of Fuji Electronic Holding Ltd. 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 is the difficulty in the production of the product.

US4458100 was assigned to Westinghouse Electric Corp. and published in 1984. It is directed to a gas insulated transmission line having an insulator for supporting an inner conductor concentrically within an outer sheath. A common insulator used for supporting the inner high voltage conductor within the outer conductor. A material, such as epoxy, is selected which has a coefficient of expansion similar to the metal selected for the inner conductor so as to minimize the possibility of voids being formed at the critical interface where the insulator meets the conductor.

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 (345000 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.

US7795541B was assigned 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.

SUMMARY OF THE INVENTION

The present invention is directed to an insulator for electrical insulation, e.g. in switchgear such as a gas insulated device, wherein the insulator 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 in a form-fit manner, respectively in a press-fit manner.

The insulator 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. At least the insulator disc is produced by injection molding, which provides the following advantages: reduced cycle time, increased degree of automation and less complicated material preparation. However, the wall thickness may be limited, e.g. less than 10mm.

The insulator disc may comprise structural components, such as ribs or other reinforcement means to increase stiffness and durability. If required the insulator disc may be built-up by a multi-stage injection molding process where structural parts and/or different materials are integrally combined to form the insulator disc or part of it.

A preferred embodiment of the insulator comprises an insulator disc which is made out of a first material by injection molding and a conductor. The term 'first material' shall not be understood narrow in that it consists of one single material such as PET, for example, but broad in that it may be a material composition. However, a more detailed explanation will follow in this disclosure. The insulator disc comprises a center opening encompassed by an inner bead and if appropriate an outer bead encompassing the insulator disc. The conductor is arranged inside the inner bead in a form-fit (press-fit) manner. The conductor may be positioned with respect to the insulator disc by at least one holding means into which the conductor is arranged in a form-fit, respectively press-fit manner. The holding means may be at least one out of the group of the following holding means: a circumferential holding rib, at least three axial holding ribs, a shoulder providing a mechanical stop for delimiting axial movement of the
conductor with respect to the insulator body in one direction, a thread. The holding means may be integrally connected to the insulator disc or applied as a separate element. The conductor may be at least partially distanced by a gap from the inner bead of the insulator disc. The gap may be at least partially filled with a second material forming a transition means. The conductor may comprise at least one distribution channel arranged within the conductor by which a second material for forming of the transition means can be injected after the conductor is mounted inside the opening of the insulator disc. The transition means may form fit to the insulator disc and/or the conductor. The inner and/or the outer bead may be strut by a plurality of ribs arranged on at least one of a first and a second side surface forming a rib structure. The thickness of the ribs may vary with respect to the thickness of the wall by a maximum of 20%. At least one cross-port may extend between two ribs in an axial direction of the insulator disc for exchange of insulation gas. The ribs may interconnect the inner and the outer bead. The ribs may be arranged alternatively with respect to the wall of the insulator disc for improvement of the mechanical stiffness and local reduction of the wall thickness. At least one field control element may be embedded in the insulator disc. At least one seal may be joint to the insulator disc e.g. by injection molding of the at least one seal onto the insulator disc. The transition means may comprise a conductive material for acting as a field control element.

A mold for making of an insulator disc 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 insulator 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 re-
placed 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 act-
ing 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 intercon-
ected 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 sev-
eral 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 moveable for the compression step. Thereby it is possible to avoid parting lines in the functional critical area of the insulator disc.

The injection compression molding process can further increase the advantages of the injection molding process, 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 a 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.

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 first material 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 formaldehyd (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, polycrylonitrile, polyurethane, polyalkylene paraoxybenzoate, phenol type, wool, silk, cotton, rayon, cellulose acetate, flax, ramie, jute, aramid 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 following material groups: 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 formaldehyd (PF), unsatured 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).

Where required, the conductor of the insulator may be coated with an electrically conductive coating made of a fifth material for acting as a further field control element in an operating state of the insulator. A suitable fifth material may be a polymer with a carbonaceous content.

**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 a first embodiment of an insulator in a perspective view;
Fig. 2 the first embodiment in a front view;

Fig. 3 a section view of the first embodiment along section line 3-3 according to Fig. 2;

Fig. 4 a second embodiment of the insulator in a perspective view partially cut;

Fig. 5 the second embodiment according to Fig. 4 with a second material component;

Fig. 6 a third embodiment of the insulator in a perspective view;

Fig. 7 the third embodiment in a front view;

Fig. 8 a section view of the third embodiment along section line 8-8 according to Fig. 7;

Fig. 9 a fourth embodiment of the insulator in a perspective view;

Fig. 10 the fourth embodiment in a front view;

Fig. 11 a section view of the fourth embodiment along section line 11-11 according to Fig. 10;

Fig. 12 a fifth embodiment of the insulator in a perspective view;

Fig. 13 the fifth embodiment in a front view;

Fig. 14 a section view of the fifth embodiment along section line 14-14 according to Fig. 13;

Fig. 15 an sixth embodiment of the insulator in a perspective view;

Fig. 16 the sixth embodiment in a front view;
Fig. 17 a section view of the sixth embodiment along section line 17-17 according to Fig. 16;

Fig. 18 a seventh embodiment of the insulator in a perspective view;

Fig. 19 the seventh embodiment in a front view;

Fig. 20 a section view of the seventh embodiment along section line 20-20 according to Fig. 19.

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, there are shown in the drawings several embodiments 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 3-3 according to Figure 2.

Figure 4 shows a second embodiment of an insulator 1 according to the present invention in a perspective view and in partially cut manner such that the inside of the insulator 1 becomes visible. Figure 5 shows the insulator according to Figure 4 and comprising a second material component as will be described in more detail subsequent.
Figure 6 shows a third embodiment of an insulator 1 according to the present invention in a perspective view. Figure 7 shows the insulator according to Figure 6 in a front view and Figure 8 shows the insulator 1 in section view along section line 8-8 according to Figure 7.

Figure 9 shows a fourth embodiment of an insulator disc 2 according to the present invention in a perspective view. Figure 10 shows the insulator disc 2 according to Figure 9 in a front view and Figure 11 shows the insulator disc 2 in section view along section line 11-11 according to Figure 10.

Figure 12 shows a fifth embodiment of an insulator disc 2 according to the present invention in a perspective view. Figure 13 shows the insulator disc 2 according to Figure 12 in a front view and Figure 14 shows the insulator disc 2 in section view along section line 14-14 according to Figure 13.

Figure 15 shows a sixth embodiment of an insulator disc 2 according to the present invention in a perspective view. Figure 16 shows the insulator disc 2 according to Figure 15 in a front view and Figure 17 shows the insulator disc 2 in section view along section line 17-17 according to Figure 16.

Figure 18 shows a seventh embodiment of an insulator 1 according to the present invention in a perspective view. Figure 19 shows the insulator 1 according to Figure 18 in a front view and Figure 20 shows the insulator 1 in section view along section line 20-20 according to Figure 19.

The insulator 1 according to the present invention in general comprises a conductor 3 which is arranged in a center opening 4 of an insulator disc 2 in a form-fit or press-fit manner. If appropriate the insulator disc 2 comprises an inner bead 5 and an outer bead 6 which delimit the insulator disc 2 with respect to the inside and to the outside. The inner and/or the outer bead 5, 6 may be
strut by radial reinforcement ribs 7 to increase the mechanical stability of the insulator disc 2. The radial reinforcement ribs 7 can be arranged protruding on at least one side above a wall 14.

The insulator discs 2 of the shown embodiments are made by injection molding of a first material. The injection molding process can be performed in one or several steps. The insulator disc 2 is injection molded first and then the conductor 3 is interconnected to the insulator disc 2 e.g. by pressing or screwing the conductor into the center opening 4 or holding means 16, 17 arranged in the center opening. In certain embodiments the conductor 3 and the insulator disc 2 are at least partially spaced apart by a gap 18 which is at least partially filled with a second material to form a transition means 19.

The first embodiment of the insulator 1 as shown in the Figures 1 through 3 comprises an insulator disc 2 with an inner bead 5 and an outer bead 6. The inner bead 5 surrounds a center opening 4 in which a conductor 3 is arranged in a coaxial manner. The insulator disc 2 is injection molded first and the conductor is then pressed into the insulator disc 2. If appropriate the interacting surface of the conductor 3 can be coated by an appropriate material and/or undertaken a surface treatment to increase the bonding process. As it can be seen in the section view according to Figure 3 the conductor 3 comprises teeth 26 or a thread which form fit appropriate counter means (second teeth or second thread) of the insulator disc 2. The term "teeth" shall not be understood as a jagged structure in a narrow sense since sharp edges shall be avoided for dielectric reasons. The term "teeth" shall be rather understood in a broad sense as a representative term for any suitable locking means for establishing a form fit by a variation in diameter relative to the center axis of the insulator. That engaging means blocks the insulator body from being stripped off the conductor in an axial direction easily, i.e. in the direction of the center axis of the insulator. The person skilled in
the art recognizes immediately that the size of the teeth 26 shown in figure 3 is displayed in a magnified manner allowing a reader to recognize the form-fit locking geometry. In reality, the size of the locking means 26 must be balanced well against the flexibility of the inner bead 5 such that the conductor 3 can be introduced into the opening 4 of the insulator disc 2 in a snap-fit manner.

Alternatively or in addition the conductor can be secured by other means. E.g. it is possible to secure the conductor 3 by a thread (not shown in detail) with respect to the insulator disc 2. In this case the conductor 3 is screwed into the insulator disc 2.

In this embodiment the inner and the outer bead 5, 6 are strut by radial reinforcement ribs 7 which are evenly distributed in circumferential direction. As it can be seen in Figure 3 the radial reinforcement ribs 7 have a conical shape with a thickness which is decreasing in radial direction. The radial reinforcement ribs 7 are arranged perpendicular to a center axis a. If appropriate the ribs 7 can be arranged at an angle (i.e. in a skew manner) with respect to the center axis a.

Between the radial reinforcement ribs 7 a wall 14 is arranged in circumferential direction. If required the wall 14 can be omitted and being replaced by an opening (cross port) 15. The cross port 15 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 25 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.

In the center opening 4 of the second embodiment according to Figures 4 and 5 a holding means in the form of a circumferential holding rib 17 is visible which on the inner end merges into a thickening 11 inside which the conductor 3 can
be positioned and held as shown in Figure 4. In axial direction above and below the circumferential holding rib 17 a gap 18 extends which is filled by a second material as shown in Figure 5 to form a transition means 19. The holding means may comprise at least one lateral opening 20 through which the second material extends.

In the second embodiment according to Figures 4 and 5 the insulator disc 2 is encompassed by an outer ring 22 made out of a conductive material. Examples for suitable materials are a ferromagnetic alloy or a polymer with a carbonaceous content. Two field control elements 21.1, 21.2 are embedded in the insulator disc 2. The inner field control element 21.1 is electrically interconnected by an inner connecting element 23.1 to the conductor 3. The outer field control element 21.2 is electrically interconnected by an outer connecting element 23.2 with the outer ring 22.

The third embodiment according to Figures 6 through 8 in general corresponds to the other embodiments mentioned above. As it can be seen in the section view according to Figure 8 the insulator disc 2 comprises a seal 24 which penetrates the insulator disc 2 through axial openings 28 (see Figure 7) in the insulator disc 2. The seal 24 is preferably made by an injection molding process. Therefore the insulator disc 2 is placed in an injection mold and a third or a fourth material is injected to form the seal 24. In the shown embodiment the material for the seal may be injected through a radial opening 29 in the outer bead 6. The person skilled in the art recognizes immediately that the size of the bulge 26 extending circumferentially and radially on the shell surface of the conductor for forming a form-it or locking means with the negative shape of the insulator disc 2 is displayed in a magnified manner allowing a reader to recognize the form-fit locking geometry. In reality, the size of the bulge must be bal-
anced well against the flexibility of the inner bead 5 such that the conductor 3 can be introduced into the opening 4 of the insulator disc 2 in a snap-fit manner.

**Figures 9 through 11** are showing a fourth embodiment of an insulator disc 2 suitable to be used in an insulator 1 according to the herein described invention. The insulator disc 2 has in general the same design as the foregoing insulator discs 2. Regarding to the general explanations it is therefore referred to those. The insulator disc 2 is made by injection molding of a first material. It comprises radial and circumferential reinforcement ribs 7, 30. The circumferential reinforcement ribs 30 are arranged coaxial between the inner and the outer bead forming closed circles. Some of the radial reinforcement ribs 7 interconnect the inner and the outer bead 5, 6. Other radial reinforcement ribs 7 have a shorter design and extend in the outer region of the insulator disc 2 between the outer bead 6 and a circumferential reinforcement rib 30. The shown insulator disc 2 is preferable for insulators having a relatively large diameter. As it can be seen the radial and the circumferential reinforcement ribs 7, 30 all have the same thickness in axial direction which is only reduced in the region of the outer bead 6. Between the reinforcement ribs 7, 30 a wall 14 extends which prevents leaking. If required at least one cross port (not shown in detail) can be foreseen for exchange of insulator gas as mentioned above.

**Figures 12 through 14** are showing a fifth embodiment of an insulator disc 2 suitable to be used in an insulator 1 according to the herein described invention. The insulator disc 2 has in general the same design as the foregoing insulator discs 2. Regarding to the general explanations it is therefore referred to those. The insulator disc 2 is made by injection molding of a first material. As it can be seen the section view shown in **Figure 14** the axial reinforcement ribs 7 have a wave-like cross-section. This offers the advantage that the side surfaces 8.1, 8.2 can easily be cleaned especially during assembly of the device. Furthermore the
reinforcement ribs 7 offer a high mechanical durability and a low material consumption. A further advantage is that the material during injection molding is equally distributed.

Figures 15 through 17 are showing a sixth embodiment of an insulator disc 2 suitable to be used in an insulator 1 according to the herein described invention. The insulator disc 2 has in general the same design as the foregoing insulator discs 2. Regarding to the general explanations it is therefore referred to those. The insulator disc 2 is made by injection molding of a first material. The reinforcement ribs 7 have a comb-like design which supports the distribution of the occurring forces. Again, the person skilled in the art recognizes immediately that the size of the concave bulge extending circumferentially and radially on the interior shell surface of the opening 4 for forming a form-fit or locking means with a corresponding convex shape of the insulator disc 2 shell surface is displayed in a magnified manner allowing a reader to recognize the form-fit locking geometry. In reality, the size of the bulge must be balanced well against the flexibility of the inner bead 5 such that the conductor 3 can be introduced into the opening 4 of the insulator disc 2 in a snap-fit manner.

The conductor 3 of the seventh embodiment according to Figures 18 through 20 is pressed into axial holding ribs 16 up to a shoulder 27 which acts as a stop (see Figure 20). In the shown embodiment the conductor 3 comprises two injection openings 9 which are interconnected to distribution channels 10 through which a second material for forming of the transition means 19 (as shown in Figures 4 through 5) can be applied into the gap 18. The distribution channels 10 have a star-like arrangement each having an appropriate length with respect to the injection opening 9. The distribution channels 10 can be avoided and the transition means 19 can be made by adding the material in a different way, e.g. by a robot or manually into the gap 18.
In a non-illustrated embodiment, the conductor 3 features a knuckle thread on its shell surface. The nominal diameter of said knuckle thread is smaller than the corresponding valley portions of the inner thread provided in the shoulder portion 16 of the insulator disc 2 such that a helix-shaped cavity is formed although both the inner and the outer thread have the same pitch diameter. Such an embodiment may be advantageous if the transition means 19 is applied into the upper gap 18. Provided that the upper circumferential gap 18 is closed during the manufacturing step of inserting the transition means, e.g. by insertion molding, the pressure in the upper circumferential gap will rise as soon as the second material filled the empty upper circumferential gap 18 that is connected to the distribution channels 10. If the pressure exceeds a given threshold, the second material is squeezed from the upper circumferential gap 18 that is connected to the distribution channels 10 via the helical cavity in the shoulder 16 to the lower circumferential gap. If said lower gap 18 is structurally delimited axially except of at least one tiny air outlet, the pressure in the distribution channels 10 maybe upheld until the lower gap 18 is filled with the second material.
### LIST OF DESIGNATIONS

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<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>a</td>
<td>Center axis</td>
<td></td>
<td>17</td>
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<tr>
<td>1</td>
<td>Insulator</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Insulator disc</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Conductor</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Center opening</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>Inner bead</td>
<td></td>
<td>21.2: Outer field control element / flange</td>
</tr>
<tr>
<td>6</td>
<td>Outer bead</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>Reinforcement rib</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>8</td>
<td>8.1: First Side surface (insulator disc)</td>
<td>10</td>
<td>23.2: Connecting element (field control element / flange)</td>
</tr>
<tr>
<td></td>
<td>8.2: Second Side surface (insulator disc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Injection opening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Distribution channel</td>
<td>15</td>
<td></td>
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<td>11</td>
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<td></td>
</tr>
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<td>12</td>
<td>Outer surface (conductor)</td>
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<td>13</td>
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<td>14</td>
<td>Wall (between ribs)</td>
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<td>15</td>
<td>Cross port (opening)</td>
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<tr>
<td>16</td>
<td>Axial rib (holding means)</td>
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<tr>
<td>27</td>
<td>Axial opening (insulator disc)</td>
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<td>28</td>
<td>Radial opening (insulator disc)</td>
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<tr>
<td>29</td>
<td>Circumferential reinforcement rib</td>
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PATENT CLAIMS

1. Insulator (1) for a gas insulated device, comprising an injection molded insulator disc (2) made out of a first material by injection molding and a conductor (3), whereby the insulator disc (2) comprises a center opening (4) encompassed by an inner bead (5) and an outer bead (6) encompassing the insulator disc (2), whereby the conductor (3) is arranged inside the inner bead (5) in a form-fit manner.

2. The insulator (1) according to claim 1, characterized in that the conductor (3) is positioned with respect to the insulator disc (2) by at least one holding means (17) into which the conductor (3) is arranged in a press-fit manner.

3. The insulator (1) according to one of the previous claims, characterized in that the holding means is at least one out of the group of the following holding means: a circumferential rib (17), at least three axial ribs (16), a shoulder providing a mechanical stop in axial direction, a thread.

4. The insulator (1) according to claim 2 or 3, characterized in that the holding means (17) is integrally connected to the insulator disc (2).
5. The insulator (1) according to one of the previous claims, characterized in that a gap (18) is arranged between the conductor (3) and the inner bead (5) of the insulator disc (2), said gap (18) is at least partially filled with a second material forming a transition means (19).

6. The insulator (1) according to claim 5, characterized in that the conductor (3) comprises at least one distribution channel (10.2) arranged within the conductor (3) by which a second material for forming of the transition means (19) is injected.

7. The insulator (1) according to one of the previous claims, characterized in that the transition means (19) is form fit to the insulator disc (2) and/or the conductor (3).

8. The insulator (1) according to one of the previous claims, characterized in that the inner and/or the outer bead (5, 6) is strut by a plurality of ribs (7) arranged on at least one of a first and a second side surface (8.1, 8.2) forming a rib structure (7).

9. The insulator (1) according to claim 8, characterized in that a thickness of the ribs (7) differs from a thickness of the wall (14) by a maximum of 20%.
10. The insulator (1) according to claim 8 or 9, **characterized in that** at least one cross-port (15) extends between two ribs (7) in an axial direction (2) of the insulator disc (2).

11. The insulator (1) according to claim 8, **characterized in that** the inner bead (5) and/or the outer bead (6) is strut by a plurality of ribs (7) arranged on at least one of a first side surface (8.01) and a second side surface (8.2) such that a rib structure (7) is formed, in particular wherein the ribs (7) interconnect the inner bead (5) and the outer bead (6).

12. The insulator (1) according to claim 8 or 11, **characterized in that** the ribs (7) on a first side surface (8.01) and on a second side surface (8.2) of the insulator disc (2) are arranged circumferentially displaced from one another such that the ribs (7) are arranged alternatively with respect to the wall (14) of the insulator disc (2) in a circumferential direction.

13. The insulator (1) according to one of the previous claims, **characterized in that** at least one field control element (21) is embedded in the insulator disc (2).

14. The insulator (1) according to claim to one of the previous claims, **characterized in that** at the at least one seal (24) is joint to the insulator disc (2) by injection molding of the at least one seal (24) onto the insulator disc (2).
15. The insulator (1) according to one of the previous claims, characterized in that the transition means (19) comprises an electrically conductive material for acting as a further field control element in an operating state of the insulator (1).

16. The insulator (1) according to one of the previous claims, characterized in that the first material comprises at least one material selected from the group of the following materials: PET, PBT, PA, PES, PEI, PPS, PEEK, PPA, PP, POM, PF (phenol formaldehyde resin), UP (unsaturated Polyester), PUR.

17. The insulator (1) according to one of the previous claims, characterized in that the first material comprises at least one filler material selected from 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, aramid fibres, glass, sepiolite, potassium titanate, ceramic, alumina, calcium silicate, rock wool.

18. The insulator (1) according to one of the claims 5 through 17, characterized in that the second material is at least one selected from the group of the following materials: TPE, TPU, Epoxy, PUR.
19. The insulator (1) according to one of the previous claims, characterized in that a space delimited by at least two ribs is at least partially filled with a third material.

20. The insulator (1) according to one of the previous claims, characterized in that the insulator disc (2) is at least partially coated by a fourth material.

21. The insulator (1) according to one of the previous claims, characterized in that the conductor (3) comprises a coating that is at least partially arranged on a shell surface of the conductor (3), wherein the coating comprises a fifth material.

22. The insulator (1) according to claim 21, characterized in that the coating is electrically conductive for acting as a further field control element in an operating state of the insulator (1).

23. A medium voltage or high voltage switchgear comprising at least one insulator (1) according to any one of the previous claims.

24. The medium voltage or high voltage switchgear according to claim 23, characterized in that the medium voltage or high voltage switchgear is gas insulated such that an insulation gas is contacting the insulator disc (2) at least partially.
25. Use of the insulator (1) according to any one of claims 1 to 22 in a medium voltage or high voltage switchgear.

26. Use according to claim 25, characterized in that the medium voltage or high voltage switchgear is gas insulated such that an insulation gas is contacting the insulator disc (2) at least partially.

27. 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;

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

iii. a cavity corresponding to the insulator (1) 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;

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

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

f. opening the mold by relative movement of the first with respect to the second mold half; and

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

28. The method according to claim 27, characterized in that providing in the mold at least one adapter suitable to receive and temporarily hold a conductor (3) during injection molding of the insulator disc and, before injecting liquefied material into the cavity, opening the mold by relative movement of the first mold half with respect to the second mold half in a first direction (2) and attaching a conductor (3) to the at least one adapter.
29. The method according to one of the claims 27 or 28, characterized in that at least one part of the mold is 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.

30. The method according to one of the claims 27 to 29, characterized in that it is a method for the production of an insulator (1) according to one of claims 1 to 22.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02G5/06

According to International Patent Classification (IPC) or to 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 data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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   *A* document member of the same patent family

Date of the actual completion of the international search

29 November 2012

Date of mailing of the international search report

11/12/2012

Authorized officer

Starck, Thierry

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