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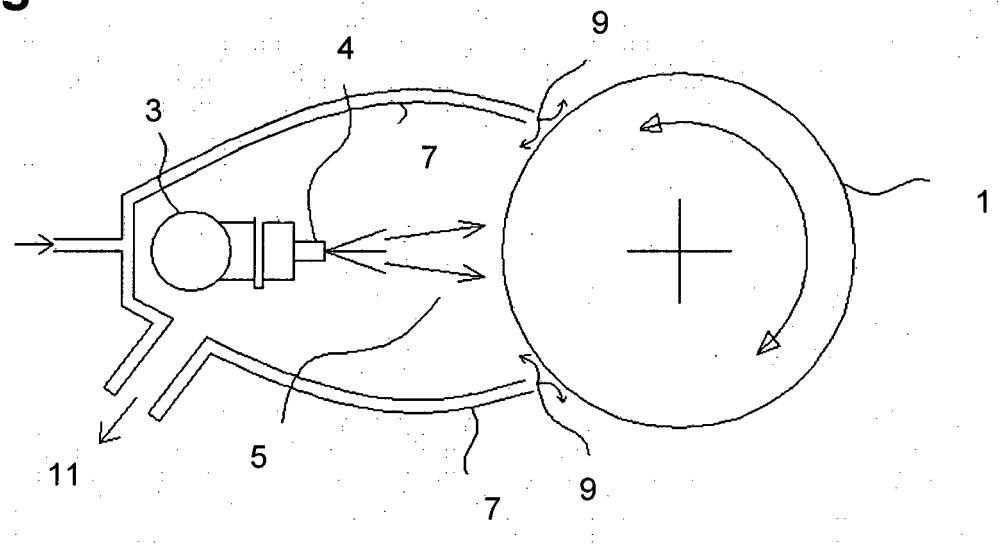
(54) **Method and apparatus to isolate the cold in cryogenic equipment**

(57) The invention relates to an apparatus and a method for spraying a cryogenic fluid to a work piece (1) comprising a cryogen feed line (3), at least one delivery nozzle (4) for delivering the cryogenic fluid (2), a shroud which surrounds at least part of said delivery nozzle (4) and which has a front face with an opening which is directed to the workpiece. The shroud and the work piece (1) are movable relative to each other between a working configuration and a maintenance configuration. In the maintenance configuration the shroud comprises a barrier which prevents or minimizes ambient air from entering the shroud.

Fig. 1



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Description

[0001] The invention relates to an apparatus for spraying a cryogenic fluid to a work piece comprising a cryogen feed line, at least one delivery nozzle for delivering the cryogenic fluid, a shroud which surrounds at least part of said delivery nozzle and which has an opening which is directed to the workpiece, said shroud and said work piece being movable relative to each other between a working configuration and a maintenance configuration, said shroud being arranged to form an essentially closed space together with the work piece in said working configuration.

[0002] The invention further relates to a method for spraying a cryogenic fluid to a work piece wherein said cryogenic fluid is sprayed by means of at least one delivery nozzle, and wherein a shroud is provided which surrounds at least part of said delivery nozzle and which has an opening which is directed to the workpiece, and wherein said shroud and said workpiece can be arranged in a working configuration wherein said shroud forms an essentially closed space together with said work piece, and wherein said shroud and said workpiece can be arranged in a maintenance configuration wherein said opening of said shroud is not sealed by the work piece.

[0003] It is well known that metal rolling processes produce a lot of heat and that the most common method for removing this heat is to spray a coolant onto the rolls. The most common coolants are water and kerosene but recently the use of cryogenic fluids has been suggested in WO 2012/110241 A1.

[0004] A major problem with the use of cryogenic fluids for cooling in some metal rolling processes such as the cold rolling of aluminium is that moisture from the surrounding atmosphere can condense onto the equipment and form water, ice or snow which can then fall or be carried onto the strip and damage it.

[0005] WO 2012/110241 A1 proposes to provide a shroud which surrounds at least part of the delivery nozzle for spraying the cryogenic fluid. The shroud is arranged to form an essentially closed space together with the work piece and it comprises means for keeping the outside of said shielding means at a temperature above the dew point. When the spraying system according to WO 2012/110241 A1 is in operation, i.e. when cryogenic fluid is sprayed onto the work piece, the shroud and the work piece are arranged close to each other and an essentially closed space is formed which prevents atmospheric air from entering the area within the shroud.

[0006] From time to time it is necessary to stop the spraying process and to retract the delivery nozzle and the shroud from the work piece for maintenance operations. When the delivery nozzle with the shroud is retracted from the work piece, the interior of the shroud is no longer closed to the surrounding atmosphere and ambient air will enter the shroud. Since the interior of the shroud is still very cold, there is a certain risk that moisture from the ambient air will condense on the shroud.

[0007] An object of this invention is to avoid getting any water into the shroud when it has been retracted from the work piece.

[0008] Another object of the invention is to avoid getting moisture into the shroud while the shroud is being retracted from the work piece.

[0009] Another object of the invention is to prevent water droplets from staining the work piece.

[0010] At least some of these objects are achieved by an apparatus for spraying a cryogenic fluid to a work piece comprising

- a cryogen feed line,
- at least one delivery nozzle for delivering the cryogenic fluid,
- a shroud which surrounds at least part of said delivery nozzle and which has a front face with an opening which is directed to the workpiece,
- said shroud and said work piece being movable relative to each other between a working configuration and a maintenance configuration,
- said shroud being arranged to form an essentially closed space together with the work piece in said working configuration,

and which is characterized in that
in said maintenance configuration said shroud comprises a barrier which prevents or minimizes ambient air from entering the shroud.

[0011] The inventive method for spraying a cryogenic fluid to a work piece wherein said cryogenic fluid is sprayed by means of at least one delivery nozzle, and wherein a shroud is provided which surrounds at least part of said delivery nozzle and which has an opening which is directed to the workpiece, wherein said shroud and said workpiece can be arranged in a working configuration wherein said shroud forms an essentially closed space together with said work piece, and wherein said shroud and said workpiece can be arranged in a maintenance configuration wherein said opening of said shroud is not sealed by the work piece, is characterized in that in said maintenance configuration said opening is sealed by means of a barrier which prevents or minimizes ambient air from entering the shroud.

[0012] When a cryogenic fluid, such as liquid nitrogen, is sprayed, the cryogenic fluid will evaporate and displace the air from the volume confined by the shroud and the work piece. The shroud will be filled with liquid and gaseous cryogen.

[0013] The shroud is preferably provided with an opening aligned with the orifice of the delivery nozzle(s). The term "aligned" shall mean that the nozzle orifice and the opening in the front face of the shroud are arranged in such a way that the cryogenic fluid leaving the delivery nozzle passes part of the interior of the shroud, that is the essentially closed space, and then leaves the shroud through said opening in the front face of the shroud in order to be sprayed to or onto the work piece.

[0014] The shroud might surround only one delivery nozzle or more than one delivery nozzle, that is two or more delivery nozzles. Preferably all delivery nozzles for supplying the cryogenic fluid are located within one shroud.

[0015] According to the invention the open front face of the shroud is closed by the work piece when the delivery nozzle for spraying the cryogenic fluid and the work piece are in working configuration. The term "working configuration" shall mean that the delivery nozzle and the work piece are arranged in such a way that cryogenic fluid can be sprayed onto the work piece without causing condensation of atmospheric water vapour / moisture on the work piece or within the shroud. In particular, in the working configuration the shroud and the work piece form an essentially closed space.

[0016] The outer surface of the shroud is preferably kept at a temperature above the dew point temperature. The dew point is defined as the temperature at which at a given pressure water vapour will condense into water. According to the invention, the temperature of the outer walls of the shroud shall be above the dew point of the surrounding ambient air. In particular, the outside of the shroud shall be kept at a temperature of at least a few degrees centigrade above the dew point temperature of the ambient air. In a preferred embodiment the outer surface of the shroud is kept at least at the temperature of the surrounding atmosphere. Thereby, condensation of water vapour at the outer surface of the shroud is avoided.

[0017] The shroud preferably comprises an enclosure, a shell or a box-like element with an opening arranged to be turned towards the workpiece. The edge of the shroud which is directed towards the work piece is preferably designed to form a seal with the work piece.

[0018] For maintenance or for other operations it is possible to retract the delivery nozzle with the shroud and the work piece from each other. That configuration when the delivery nozzle with the shroud and the work piece are not positioned close to each other, do not abut each other and'when the opening in the front face of the shroud is not completely closed or covered by the work piece shall be called the "maintenance configuration".

[0019] According to the invention in the maintenance configuration a barrier is provided which seals the opening in the front face of the shroud to avoid the intrusion of ambient air into the shroud. Thus the barrier prevents water vapour entering the shroud and water droplets from staining the work piece. The barrier prevents condensation or icing from occurring inside the closed space, on the nozzles or on the workpiece because the ambient atmosphere is excluded and the inner space of the shroud only contains cold dry gas.

[0020] According to a preferred embodiment of the invention the barrier comprises one or more physical covers which can be arranged to cover the opening in the front face of the shroud. Preferably, the covers are movably connected to the shroud. For example, the covers can be rotated, slided and/or pivoted or swung relative to the shroud in order to close the opening in the front face. Examples of such covers are cover sheets, doors or door-like means, sliding doors, shields, lids, louvres or partition elements, such as partition walls.

[0021] According to one embodiment the shroud has a cylindrical shape with a sectoral aperture or opening which is directed to the work piece. One or more, especially two, covers are rotatably connected to the shroud and are able to move in an essentially circular motion. The circular motion of the covers is preferably around the axis of the cylindrical shroud.

[0022] According to another embodiment the covers can be moved into the shroud in order to uncover the opening in the front face of the shroud. The covers can for example slide or rotate into the shroud. The shroud could be provided with a guide rail, guide groove, guide bar or guide plate along which the cover is allowed to move.

[0023] The position and/or motion of the cover(s) is preferably linked to the relative position of the delivery nozzle and the shroud with respect to the work piece. When the shroud is positioned close to the work piece as in the working configuration, the cover or the covers are moved into the shroud and the opening in the shroud is uncovered by the cover(s) but sealed by the work piece. With increasing distance of the shroud from the work piece the cover(s) cover more and more of the opening in the front face of the shroud.

[0024] The covers could be linked to the retraction mechanism by guide grooves or other means so that as the shroud and the delivery nozzle are retracted, the retractive motion will cause the cover(s) to close. It is also possible to move the cover(s) by other means such as a motor or hydraulics. By such motion of the covers the opening in the front face of the shroud is always covered: In the working configuration the opening is covered by the work piece. When the shroud is far removed from the work piece the opening is closed by the cover and at a distance inbetween the opening is partly covered by the cover and partly by the work piece.

[0025] As described above the cover can preferably be moved into the shroud in the working configuration. Therefore, it is preferred that the shroud comprises a space or pocket for the cover(s) where they fit in. It is further possible to continuously heat and/or purge the space or pocket with an inert gas or another dry gas. The inert gas, for example gaseous nitrogen, has preferably ambient temperature.

[0026] By heating and/or purging the covers are kept at a sufficient high temperature such that when they leave the shroud in order to close or seal the opening, the outside of the cover(s) is at a sufficient high temperature to prevent condensation or icing on their outer surfaces. Preferably the temperature of the cover(s) is kept at or above the dew point of the surrounding ambient atmosphere.

[0027] According to another embodiment the opening

in the front face of the shroud is not mechanically or physically closed or covered but an inert gas curtain prevents ambient air from entering the shroud. Gas is blown parallel to the plane of the opening and/or in a direction from inside the shroud to the outside of the shroud forming a gas flow out of the shroud. Thereby, ambient air is pushed away from the opening and the ingress of humid air into the shroud is prevented.

[0028] The pressure of the gas blown into the vicinity of the gap between the shroud and the work piece is preferably controlled to be above the atmospheric pressure of the surrounding ambient air and above the pressure inside the essentially closed space. This ensures that air is not sucked into the essentially closed space and that no cold gaseous coolant leaves the essentially closed space through said gap.

[0029] The flow of gas forming the gas curtain preferably consists of dry gas. The term 'dry gas' shall mean a gas which contains essentially no water vapour or such a low level of water vapour that no condensation or ice is formed when this gas comes into contact with the cryogenic fluid or with equipment such as the edge of the interior part of the shielding which has been cooled by the cryogenic fluid. The dry gas will prevent formation of ice on the shielding means, especially on the edge of the opening. Preferably, the content of H_2O in the dry gas is less than 10 ppm or less than 10 vpm (parts per million by volume).

[0030] According to another preferred embodiment gaseous nitrogen is used as dry gas. The gas outlet or gas outlets for supplying the dry gas to the opening of the shroud and to the gap between the shroud and the work piece are preferably in fluid communication with a source of gaseous nitrogen. It is possible to use other dry gases, in particular inert gases, as dry gas but gaseous nitrogen is preferred.

[0031] It is also possible to have both: a physical barrier and a gas curtain.

[0032] The invention is in particular used for cooling in a metal rolling process of rolling a metal strip. In that case the essentially closed space is defined by the shroud and the part of the outside surface of the work roll which shall be cooled. The work roll is the work piece which is sprayed with the cryogenic fluid. In the working configuration the opening of the shroud is closed by the work roll thereby forming an essentially closed space inside. The essentially closed space does preferably not include the whole of the workpiece, in this case not the whole of the work roll. The invention prevents condensation outside the essentially closed space and thus no water, ice or snow is formed which could fall onto the metal strip and damage it.

[0033] In the maintenance configuration, for example when a roll shall be changed, the opening in the front face of the shroud is covered by the barrier. The barrier could be a physical barrier such as one or more doors or other covers and/or a gas curtain which due to the direction of the gas flow prevents ambient air from entering the shroud.

[0034] The shroud might comprise a sealing member arranged to sealingly close the gap between the shroud and the work piece. Preferably, the cover(s) are also provided with a sealing member in order to seal the gap between the cover(s) and the work piece and/or between the covers themselves and/or between the cover(s) and the shroud. The sealing member can comprise an elastic material, for example a plastic material. The sealing member could also be realised by a pressure barrier or a gas flow which prevents any gas below the dew point from escaping from the essentially closed space into the area local to the work piece.

[0035] According to the invention the outside of the shroud shall be kept at a temperature above the dew point of the surrounding ambient air, preferably above the temperature of the surrounding ambient air. In the maintenance configuration the same applies to the cover(s). The means to keep the temperature of the outside of the shroud and/or of the cover(s) in the desired range may include passive elements, such as thermal insulation, which reduce the rate of heat transfer between the inside of the closed space and the outside walls of the shroud and/or of the cover(s). These means preferably comprise material with a low heat transfer coefficient, for example one or more layers of a solid material with a low thermal conductivity. Further, the means for keeping the outside of said shroud and/or of the cover(s) at a temperature above the dew point may also include active elements which keep the wall temperature above the dew point by heat supply, for example by provision of heating means, in particular electric heating means.

[0036] According to another preferred embodiment the shroud and/or the cover(s) are at least partly double-walled and a source of a gas is connected to the gap between said walls. The shroud and/or the cover(s) comprise an inner and an outer wall and a gas is introduced into the gap between these walls in order to act as an insulator and to provide a source of heat to keep the outer wall above the dew point. Preferably a gas is used which is at ambient temperature or even above ambient temperature or which has been warmed up to a temperature above ambient temperature.

[0037] It is further preferred that the gap between the walls of the shroud and/or between the walls of the cover(s) comprises a gas outlet at or close to the gap between the shroud and/or the cover(s) and the work piece. At least part of the gas which is introduced into the gap between the walls of the shroud and/or of the cover(s) flows out of the gas outlet near the work piece. The gas acts as a gas seal or pressure barrier and prevents atmospheric air from entering through this gap into the essentially closed space and cold gas from escaping from the closed space into the vicinity of the workpiece. Therefore, any condensation is kept away from the essentially closed space and the cold inner parts of the system.

[0038] Instead of or in addition to the gas outlet(s) mentioned above it is also possible to have a separate gas

feed line for feeding a gas, preferably a warm gas, close to the gap between the shroud and/or the cover(s) and the work piece which then acts as a shroud or gas barrier to prevent cold gas getting out and ambient air getting into the essentially closed space.

[0039] The present invention will now be more particularly described by way of example with reference to the accompanying drawings, in which:

figure 1 schematically shows a first embodiment of the invention in the working configuration and
figure 2 shows the same embodiment in the maintenance configuration,
figure 3 shows another embodiment of the invention,
figure 4 schematically shows a cross section of another embodiment in the working configuration which is very similar to the embodiment of figure 3, and
figure 5 schematically shows a cross section of the embodiment of figure 4 in the maintenance configuration.

[0040] Figure 1 schematically shows a device for spraying liquid nitrogen onto a work roll 1 which is used for cold rolling a metal strip or metal foil, for example an aluminium foil. Liquid nitrogen 2 is supplied via a supply line 3 to a plurality of delivery nozzles 4. The liquid nitrogen leaves the delivery nozzles 4 in the form of nitrogen jets 5 directed to the surface of the roll 1. During and after the spraying process the liquid nitrogen evaporates and forms gaseous nitrogen.

[0041] The delivery nozzles 4 are surrounded by an enclosure 6 which serves as a shroud. The enclosure or shroud 6 has in its front face an opening towards the work roll 1. The shroud 6 is at least partly designed with double walls 7. Gaseous nitrogen 8 with room temperature is provided to the gap between the two walls 7 of the shroud 6. The nitrogen gas 8 flows between the two walls 7 and thereby thermally insulates the shroud 6. The outer surface of the shroud 6 remains warm although liquid nitrogen is evaporated inside the essentially closed space confined by the shroud 6 and the work roll 1. The warm gas does not only insulate the outer wall but also provides heat. The dry gaseous nitrogen leaves the annular gap 7 between the double walls close to the edge of the opening of the shroud 6, i.e. in operation close to the work roll 1.

[0042] In addition to or alternatively to the double wall insulation described above, it is possible to use a cartridge heater in the shroud 6 to heat up the outer walls or part of the outer walls of the shroud 6. It is further possible to provide the walls of the shroud 6 with insulation material and/or to contruct the shroud walls of different layers. As an example, the shroud walls or a part of the shroud walls comprise an outer layer of stainless steel coated on its inner surface and a second layer of a porous insulation material, such as an aerogel, which is bonded to an innermost layer made of polystyrene or another thermoplastic polymer.

[0043] The warm nitrogen gas 9 leaving the gap 7 acts as a gas barrier and blocks the small gap between the shroud 6 and the roll 1 and thus prevents air from entering into the interior of the shroud 6 and cold gas from escaping. The pressure of the gas flow 9 is above the atmospheric pressure and above the pressure inside the essentially closed space confined by the shroud 6.

[0044] The shroud 6 further comprises a duct 11 which allows to withdraw gas from the essentially closed space confined by the shroud 6. The gas flow through duct 11 is controlled in such a way that surplus nitrogen gas is extracted from the shroud 6 and from the surface of the roll 1. That gas would otherwise create a turbulence which may affect the efficiency of the liquid nitrogen spraying. Furthermore, potentially asphyxiating inert nitrogen gas is removed from the work environment. On the other hand, the gas flow through duct 11 should not suck in air from the surroundings into the enclosure 6 via the gap between the enclosure 6 and the roll 1. That means the gas flow through duct 11 is preferably controlled to achieve an optimum of the above described effects. The gas flow through duct 11 is preferably controlled depending on the design of the enclosure 6, the pressure and flow of the liquid nitrogen 2, 5 and/or the pressure and flow of the dry gas 8 passed through the double-walls 7.

[0045] Preferably, the back of the enclosure 6 - behind or upstream the nozzles 4 - and the supply line 3 are insulated to ensure that those parts as well as the double walled part 7 are above the dew point. It is further preferred to also insulate the exhaust duct 11, at least within the critical region where any condensation on the exhaust duct 11 could get onto the strip 10.

[0046] Figure 1 shows the inventive apparatus in the operation configuration, that means roll 1, nozzles 4 and shroud 6 are arranged in such a way that nitrogen can be sprayed onto the roll surface without getting any water or condensation onto the roll 1 and into the shroud 6. The shroud 6 forms together with the roll 1 an essentially closed space.

[0047] From time to time it is necessary to change the roll 1 or to carry out some maintenance operations at the roll 1. In that case the liquid nitrogen supply to the delivery nozzles 4 is stopped and the roll 1 is retracted from the nozzles 4 with the shroud 6 or the nozzles 4 with shroud 6 are retracted from the roll 1. This configuration when roll 1 on one hand and nozzles 4 and shroud 6 on the other hand are retracted from each other shall be called the maintenance configuration. In the maintenance configuration the shroud 6 is no more in direct contact with the roll1 or in general with the work piece. Figure 2 shows the maintenance configuration when the opening of the shroud 6 is not covered and sealed by the roll 1.

[0048] At least in the first phase after the shroud 6 and the roll 1 have been retracted from each other, the shroud 6 still contains cold and moisture in the atmospheric air entering the shroud 6 or contacting the delivering nozzles 4 would condense.

[0049] Therefore, the invention proposes to control the nitrogen gas 9 leaving the gap 7 such that it forms a gas curtain or gas barrier 12 which prevents the ingress of air into the interior of the shroud 6 and thereby prevents condensation. Normally it is necessary to increase the gas flow 9 and / or the pressure of gas flow 9 compared to the gas flow 9 in the working configuration.

[0050] Preferably the gas flow 9 is redirected to flow parallel to the plane of the opening of the shroud 6 or in a direction from inside the shroud to outside the shroud. It is also possible to have a separate gas supply system for forming the gas barrier. Such a separate gas supply system may comprise a tube around the opening of the shroud 6 connected to a gas supply line and provided with a number of apertures for gas to pass through and form a gas curtain. The gas flow through duct 11 is stopped or at least reduced in order to avoid that ambient air from the surroundings is sucked into the shroud 6. The pressure inside the shroud 6 should preferably be close to the pressure of the ambient air. If the pressure is too high the cold gas from inside the shroud will escape, if it is too low then air will get sucked in.

[0051] Figures 3 shows another embodiment of the invention to avoid condensation of atmospheric air inside the shroud 6 when the shroud 6 and the roll 1 are moved apart from each other. Figures 4 and 5 show a cross section of another inventive embodiment which is very similar to the embodiment of figure 3. In the following figures 3 to 5 will be explained together and same reference numbers will be used for the same features.

[0052] The shroud 6 has the shape of a cylinder with a recess 20 for the roll 1 in its front face. In the working configuration, as shown in figure 3, the roll 1 fits into the recess 20. Thereby, the work roll 1 covers and seals the opening of the shroud 6 so that the inner space of the shroud 6 is closed to the surrounding atmosphere. Ambient air and in particular moisture cannot enter the shroud 6.

[0053] The shroud 6 comprises a fixed outer part 21 of cylindrical shape with the recess 20 for the roll 1 and two movable inner shields 22a, 22b of sectoral shape. The two inner shields 22a, 22b are rotatable with respect to the symmetry axis 23 of the cylindrical shroud 6. The shields 22a, 22b can either be moved or rotated to a closed position wherein the shields 22a, 22b cover the recess 20 and close the shroud 6 (figures 3 and 5). Or the shields 22a, 22b can be moved to an open position wherein the shields 22a, 22b are moved into the shroud 6 such that the recess 20 is open (figure 4). The side walls 43 of the fixed outer part 21 are profiled to match the curvature of the work roll 1 so that they seal against the work roll 1, i.e. the fixed part 21 is sealed against the work roll 1 all the way around the opening, at the top, at the bottom and at the sides.

[0054] It is also possible to profile the side walls of the shields 22a, 22b such that they match the curvature of the work roll 1 in the working configuration. In that case it is preferred to make the side walls of the shields 22a, 22b overlap in the maintenance configuration.

[0055] According to the embodiment of figure 3 both shields 22a, 22b are provided with contact rolls 38. In the working configuration the contact rolls 38 are in contact with the work roll 1 and ensure that the same gap is maintained between the shields 22a, 22b and the work roll 1. The movable shields 22a, 22b allow the shroud 6 to fit many different sizes of work rolls 1 by varying the degree of opening the recess 20 in the shroud 6. As long as the contact rolls 38 are in contact with the roll 1 there is always the same gap between the shroud 6 or the shields 21, 22 and the roll 1.

[0056] In the working configuration the contact rolls 38 are in contact with the work roll 1. Both sectoral shields 22a, 22b are moved backwards into the shroud 6 so that the recess 20 can be covered by the roll 1. There could also be an adjusting mechanism which controls the position of the sectoral shields 22a, 22b. That means, when moving the shroud 6 a short distance away from the work roll 1 the shields 22a, 22b will be closed to such an extent that the contact rolls 38 remain in contact with the work roll 1. With increasing distance between shroud 6 and work roll 1 the shields 22a, 22b will close more and more until they completely cover the opening or recess 20 of the shroud 6.

[0057] The adjusting mechanism guarantees that the inner space of the shroud 6 is always sealed to the surrounding atmosphere:

- In the working configuration the opening in the shroud 6 is covered by the work roll 1.
- In the maintenance configuration when shroud 6 and roll 1 are spaced apart from each other the opening in the shroud 6 is closed by the sectoral shaped shields 22a, 22b.
- And during the retraction process when the shroud 6 is moving away from the work roll 1 the shields 22a, 22b are closed depending on the distance between shroud 6 and roll 1.

[0058] The adjusting mechanism can be realised by rolls, sensors and controllers in combination with means to move the shields 22a, 22b. Such means to move the shields 22a, 22b can, for example, be a motor, hydraulics, an elastic element or a spring element.

[0059] In figures 3 to 5 the fixed outer part 21 is double-walled forming an outer pocket 26. The outer pocket 26 is purged with a gas, preferably a warm gas and/or an inert gas, which is supplied via feed port 28. The outer pocket 26 insulates the shroud 6 and keeps the outer surface of the shroud 6 warm such that no condensation of humid air will occur. The purge gas 31 flows through the outer pocket 26 and exits the outer pocket 26 at the edge 27. In the working configuration the purge gas 31 seals the joint between the outer part 21 and the work roll 1. A portion 30 of the purge gas will leave the outer pocket to the ambient atmosphere outside the shroud 6, another portion 29 of the purge gas will leave the outer

pocket 26 and enter the interior of the shroud 6.

[0060] The purge gas flowing through the outer pocket 26 has a double function: First, it insulates the shroud 6 and keeps the outer wall of the outer part 21 warm to avoid condensation on the outer part 21. Second, in the working configuration the purge gas leaving the outer pocket 26 at the edge 27 works as a gas seal between the shroud 6 and the work roll 1.

[0061] The rotatable inner shields 22a, 22b are also double-walled. Between the double walls a passage 32 is formed. As shown in figures 4 and 5 the passage 32 is preferably closed by a bar 33 at its inner end which is moved into the outer part 21. The outer wall of the passage 22 comprises an opening 34 close to the bar 33. The fixed outer part 21 has an aperture 35 with a gas port 36.

[0062] In the maintenance configuration as shown in figure 5 a purge gas 37 is supplied to gas port 36 and flows through aperture 35 and opening 34 into the passage 32. The purge gas 37 continues to flow through the passage 32 and leaves it at the end where the two shields 22a, 22b abut. The purge gas 37 keeps the outer surface of the shields 22a, 22b warm and works as a gas seal between the two shields 22a, 22b.

[0063] In the working configuration (figure 4) the double wall structure of the shields 22a, 22b can also be used to gas seal the gap between the shroud 6 and the work roll 1. Purge gas 37 supplied via gas port 36 flows through aperture 35 into the gap between the outer part 21 and the shield 22a, 22b and then through opening 34 into passage 32. The purge gas 37 leaves the passage 32 close to the contact area between the outer part 21 and the work roll 1 and forms an additional gas seal.

[0064] In the embodiment according to figure 3 the shields 22a, 22b are also double-walled forming a passage for a purge gas between the walls of the double-wall structure. In this case the gas port 39 for the purge gas is directly connected to the shields 22a, 22b.

[0065] In the embodiments according to figures 3 to 5 the shroud is essentially formed as a right circular cylinder. In that case the shroud might also comprise additional feed ports 40, 41, 42 for feeding purge gas to the side walls 43 of the fixed outer part 21 and to the gaps between the side walls 44 of the shields and the side walls 43 fixed outer part 21. The term "side wall of the fixed outer part" shall mean the base area(s) of the right circular cylinder forming the shroud 6.

Claims

1. Apparatus for spraying a cryogenic fluid (2) to a work piece (1) comprising

- a cryogen feed line (3),
- at least one delivery nozzle (4) for delivering the cryogenic fluid (2),
- a shroud (6) which surrounds at least part of said delivery nozzle (4) and which has a front face with an opening which is directed to the workpiece,
- said shroud and said work piece being movable relative to each other between a working configuration and a maintenance configuration,
- said shroud (6) being arranged to form an essentially closed space together with the work piece (1) in said working configuration,

characterized in that
in said maintenance configuration said shroud comprises a barrier which prevents or minimizes ambient air from entering the shroud.

2. Apparatus according to claim 1 **characterized in that** said barrier comprises one or more physical covers which can be arranged to cover said opening.

3. Apparatus according to claim 2 **characterized in that** said covers are rotatably or slidably engaged with said shroud.

4. Apparatus according to any of the preceding claims **characterized in that** the position of the cover(s) relative to the shroud is controlled with respect to the position of the shroud relative to the work piece.

5. Apparatus according to any of the preceding claims **characterized in that** said cover(s) can be moved into the shroud.

6. Apparatus according to any of the preceding claims **characterized in that** said shroud comprises a gas blowing means positioned close to the opening of the shroud for blowing an inert gas in a direction parallel to said opening and/or in a direction from the inside of the shroud to the outside of the shroud so as to suppress intrusion of ambient air into the shroud.

7. Apparatus according to any of the preceding claims **characterized in that** said shroud comprises an adjusting mechanism which maintains the gap between the cover(s) and the work piece during retraction of the shroud from the work piece.

8. Method for spraying a cryogenic fluid to a work piece

- wherein said cryogenic fluid is sprayed by means of at least one delivery nozzle,
- and wherein a shroud is provided which surrounds at least part of said delivery nozzle and which has an opening which is directed to the workpiece,
- and wherein said shroud and said workpiece can be arranged in a working configuration wherein said shroud forms an essentially closed

space together with said work piece,
- and wherein said shroud and said workpiece can be arranged in a maintenance configuration wherein said opening of said shroud is not sealed by the work piece,

characterized in that
in said maintenance configuration said opening is sealed by means of a barrier which prevents or minimizes ambient air from entering the shroud.

9. Method according to claim 8 **characterized in that** said barrier comprises one or more covers which are arranged to cover said opening in said maintenance configuration.

10. Method according to claim 8 or 9 **characterized in that** the position of the cover(s) relative to the shroud is controlled with respect to the position of the shroud relative to the work piece.

11. Method according to any of claims 8 to 10 **characterized in that** said cover(s) are at least partly moved into the shroud in said maintenance configuration.

12. Method according to any of claims 8 to 11 **characterized in that** the cover(s) or portions of the cover(s) are purged with an inert gas.

13. Method according to any of the claims 8 to 12 **characterized in that** an inert gas is blown in a direction parallel to said opening and/or in a direction from the inside of the shroud to the outside of the shroud so as to suppress intrusion of ambient air into the shroud.

Fig. 1

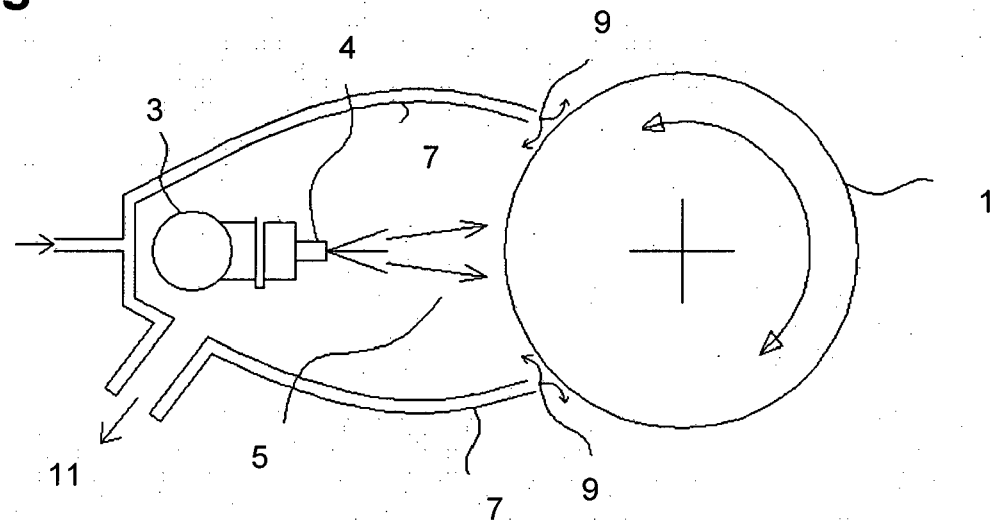
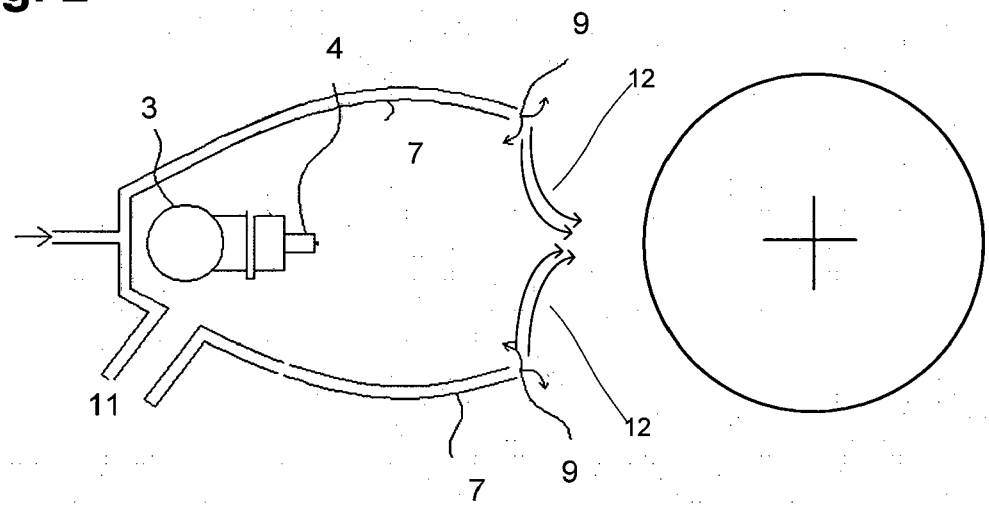
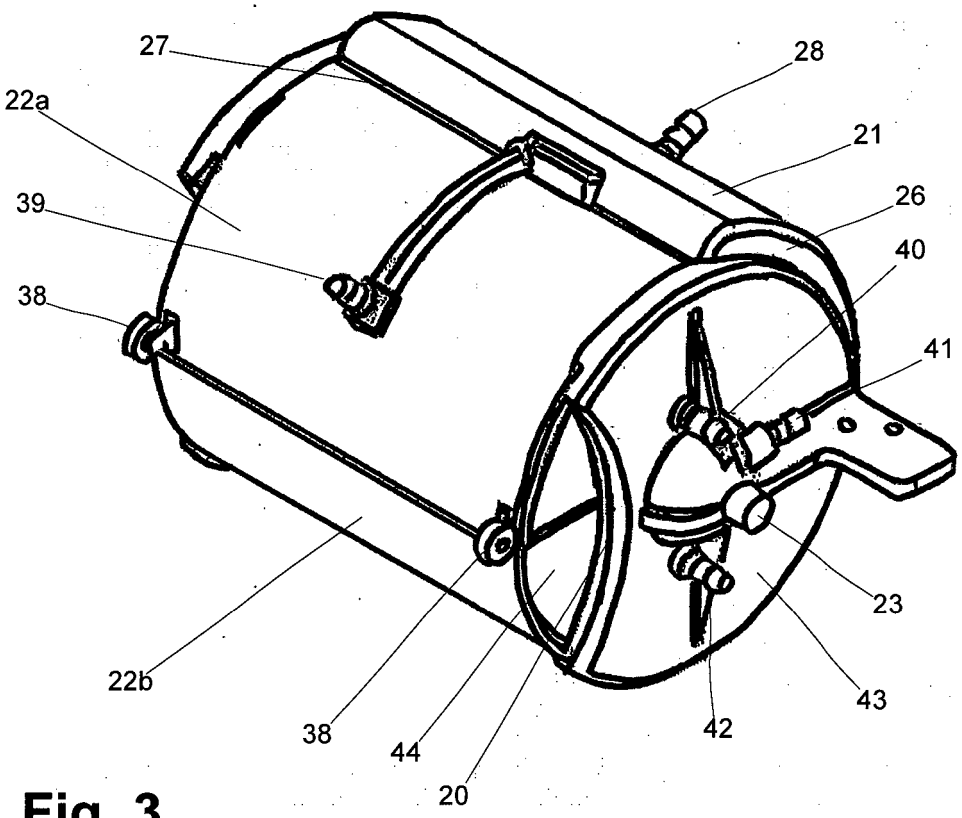


Fig. 2




27
28
22a
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22b
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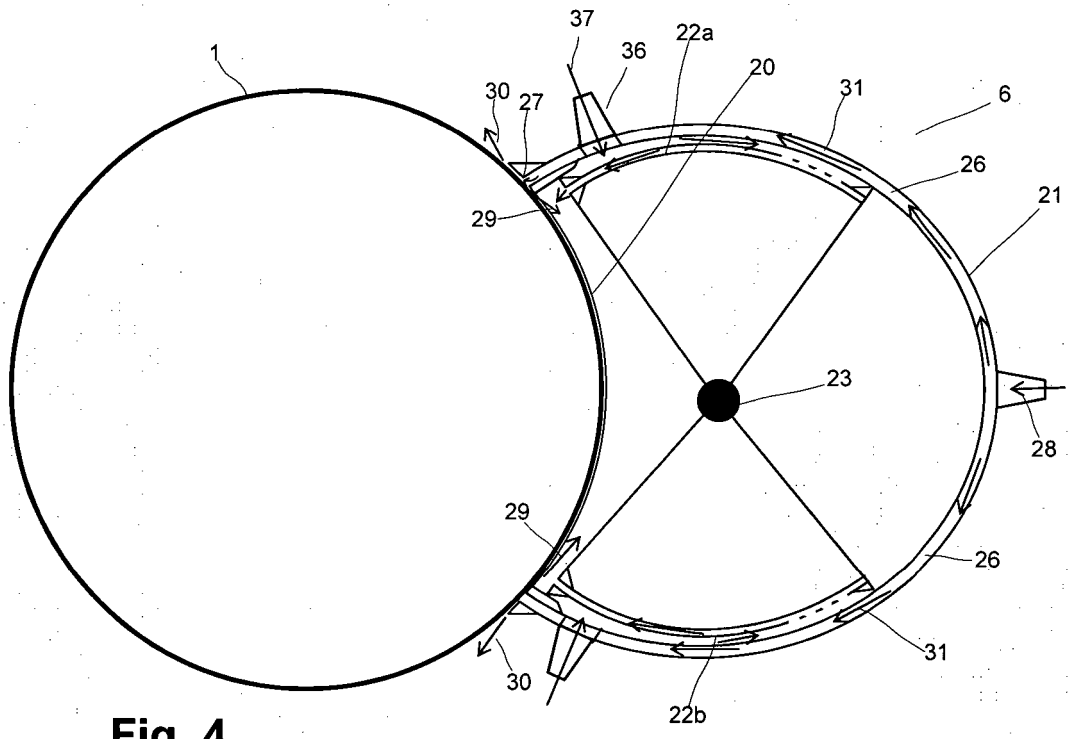
Fig. 3


37
22a
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30
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26
29
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31
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22b

Fig. 4

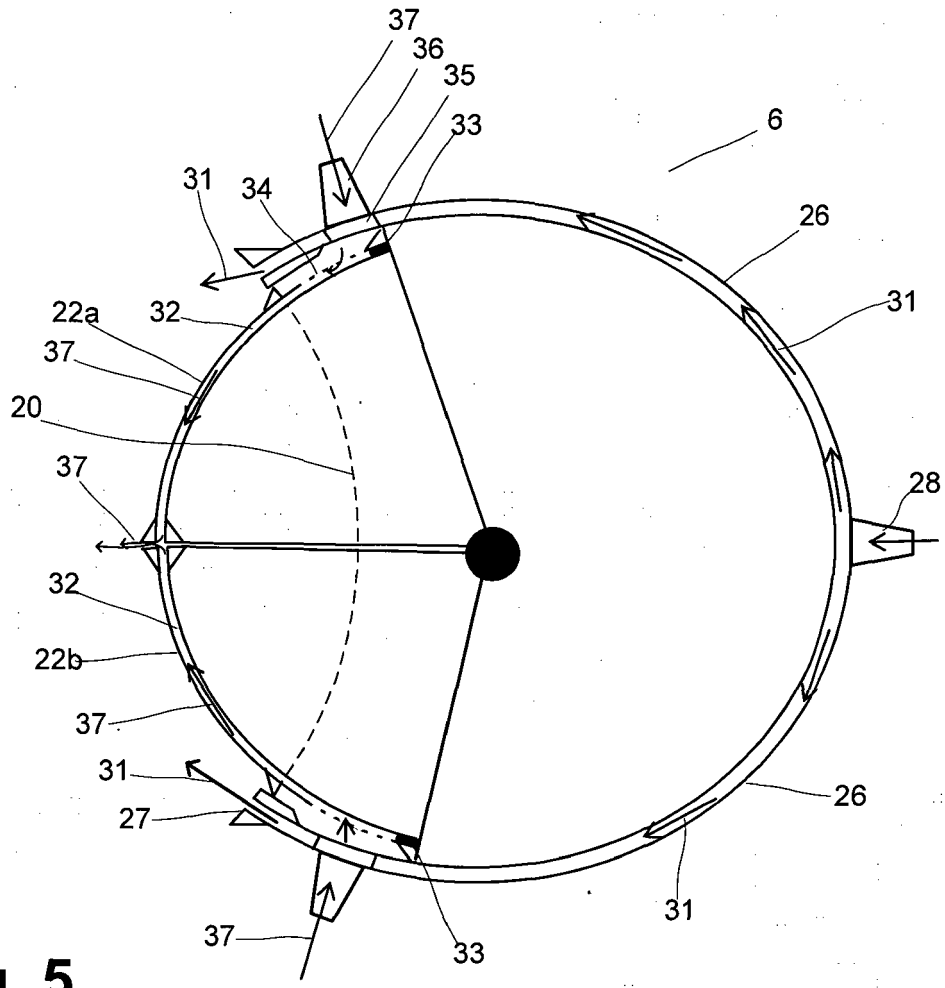

Fig. 5

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EUROPEAN SEARCH REPORT

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EP 13 00 5710

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Place of search	Date of completion of the search	Examiner
Munich	31 March 2014	Forciniti, Marco

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