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Bullet cartridge, method for manufacturing a bullet cartridge and plant for
manufacturing bullet cartridges

The invention relates to a method for manufacturing a bullet cartridge, a plant for manufacturing bullet cartridges and a bullet cartridge.

In particular in the case of small and medium calibers, seals are required which are leak-proof over a long period of more than 10 years despite negative or positive pressure and in an intended temperature band. The sealing between the projectile and the case should be as cost-effective as possible. The seal between the projectile and the case should also ensure high pull-out resistance and be as easy as possible to manufacture in series.

Sealants with a highly viscous sealing medium are generally known from the prior art. Usually, a viscous sealing medium with a corresponding thinner is applied to the inside of the case. Joining the projectile into the case forces part of the applied sealing medium into the case. The remaining sealant then creates the seal. When the projectile is fired, the sealing medium is burned off. The connection between the projectile and the case by means of the high-viscosity sealing medium is a force-fit and a material-fit. However, a highly viscous sealing medium is very problematic to handle because of its viscosity.

WO 2017/198328 A1 relates to a bullet cartridge with a projectile and a case and with a seal between the projectile and the case, the seal being formed by two rings of a bituminous mixture. Bituminous sealants show advantageous mechanical and thermal properties in terms of long storage as well as in terms of pull-out resistance and are

appreciated for their low cost. To apply the bituminous sealant, a spraying technique can be used in which a bullet case is held stationary with its opening vertically downward, and then a mirror is inserted into the confluence of the case, against which a bitumen channel is directed, from which bitumen is sprayed under pressure. Such a manufacturing plant is very complex in construction and operation. It has been found that the application of small amounts of paint below a minimum dispensing amount cannot be implemented in a reproducible manner in series production. It has also proved disadvantageous that the application of the spray technique inevitably causes contamination with bitumen, for example at the confluence and outside the bullet case, so that it requires costly cleaning.

In a so-called lubricating nose process, a sealing medium is continuously provided at an output opening. The sealing medium is wiped off along the neck of the cartridge case. Precise process control cannot be achieved. The process requires a very high amount of sealing medium and is therefore disadvantageous for series production. A process in which a sealing medium is applied by means of a needle of the hypodermic needle type and, if necessary, a wiper is additionally used in the wake of the needle to adjust the thickness of the applied layer of sealing medium is described, for example, in US 2005 0 056 183 A1. According to US 2005 0 056 183 A1, a light-curing coating is to be applied because sealing media containing bitumen are considered unsuitable for such manufacturing processes. US 6 367 386 B1 also criticizes the fact that automated application of bituminous sealants is not feasible.

In EP 0 110 862 B2, it is proposed to design the projectile with a circumferential groove in order to achieve a desired sealing effect with the aid of viscous bitumen coating. This process has proved uneconomical and therefore unsuitable for series production.

US 5 256 203 A describes a plant for applying an anaerobic sealing medium to a cartridge case. For this purpose, a mandrel is inserted into the neck of the cartridge case. The mandrel has a circumferential groove on the outside in which the sealing medium is applied to the neck of the cartridge case in an annular manner. Towards the interior of the case, the circumferential groove is bounded by a fully cylindrical plate section. Five mandrels each are fed with the sealing medium through internal channels from a common metering valve. The plant is unsuitable for viscous sealing media, such as bitumen. For stable process control, a high minimum delivery amount of sealing medium

per mandrel is required. As a result of the required amount of sealing medium, series production with such a plant is only economically feasible to a limited extent.

If the process is poorly controlled, for example if too high a amount of the sealing medium is applied to the case, the annular layer produced may become too thick or too wide. A ring that is too thick has the disadvantage that the case is unnecessarily widened, causing the case mouth to fall out of tolerance. A ring that is too wide has the disadvantage that the sealing effect can be impaired.

It is an object of the invention to provide a bullet cartridge and an associated method of manufacturing as well as a corresponding plant for manufacturing which overcome the disadvantages of the prior art, in particular ensuring low-cost and high-quality series production of bullet cartridges with sealing between the bullet case and the projectile. This object is solved by the subject-matter of the independent claims.

Accordingly, the invention relates to a bullet cartridge comprising a bullet case defining a caliber diameter and a projectile inserted into the neck portion of the bullet case. In particular, the bullet cartridge is manufactured using the method described below. The bullet cartridge has an annular gap delimited by the projectile on the inside and the inner circumference of the bullet case on the outside. In the bullet cartridge according to the invention, an annular layer of a sealing medium formed of a sealing medium is provided between the bullet case and the projectile. The annular layer may be applied by means of microdosing. Alternatively, or additionally, the annular layer comprises not more than 1 mg of sealing medium per mm of caliber diameter, in particular not more than 0,5 mg of sealing medium per mm of caliber diameter, preferably not more than 0.3 mg of sealing medium per mm of caliber diameter. It may be preferred that the bullet cartridge comprises an annular layer of sealing medium having a weight of about 2 mg. In particular, the bullet cartridge may be provided with exactly one annular layer of the sealing medium. According to an alternative embodiment, the bullet cartridge may have two annular layers of the sealing medium spaced apart in the axial direction. Preferably, the sealing medium complies with the Technical Purchase Specification TL 8010-025 paragraph 2-2.4.11 (Technical Requirements; in short: TL 0810-025) of the German Federal Office of Defense Technology and Procurement (as of 02/2021). Preferably, the sealing medium is a bitumen-containing sealant mixture, such as a bitumen-containing sealing lacquer, in particular according to TL 0810-025. The bitumen mixture can have

at least one additive, preferably graphite. The at least one annular layer of the sealing medium is preferably formed in a completely circular manner around the projectile.

In a preferred embodiment of a bullet cartridge, the sealing medium of the at least one annular layer is uniformly distributed in the circumferential direction. Preferably, the sealing medium of the annular layer is almost one hundred percent uniformly distributed in the circumferential direction. In particular, the at least one annular layer has circumferential deviations of not more than 50 nL/mm annular circumferential width, in particular not more than 10 nL/mm annular circumferential width, 5 nL/mm annular circumferential width or 1 nL/mm annular circumferential width, preferably not more than 0.5 nL/mm annular circumferential width.

According to one embodiment of a bullet cartridge, the at least one annular layer has a width of at least 1 mm, in particular at least 2 mm. Alternatively or additionally, the layer has a width of not more than 10 mm, in particular not more than 6 mm. The width of the annular layer defines its extension in the axial direction or (parallel to the symmetry axis of the bullet case).

According to one embodiment of a bullet cartridge, the at least one annular layer has a thickness of at least 0,003 mm, in particular at least 0,005 mm. Alternatively or additionally, the layer has a thickness of not more than 0,04 mm, preferably not more than 0,025 mm, in particular not more than 0,015 mm. The thickness of the annular layer defines its extension in radial direction to the symmetry axis of the bullet case.

In one embodiment of the bullet cartridge, the annular layer is formed from multiple drops, in particular microdrops and/or nanodrops. Preferably, the annular layer is formed of at least 3, at least 5, or more drops. In particular, the annular layer is formed of drops, preferably microdrops and/or nanodrops. Preferably, a single droplet has a diameter or width that is substantially smaller than the width of the annular layer. In particular, a droplet is at least 10 times, preferably at least 100 times smaller than the width of the annular layer. Compared to sealing layers of conventional bullet cartridges, an annular layer formed by multiple drops can be realized with much more precise manufacturing tolerances with respect to sealing effect and material consumption.

According to one embodiment, the bullet cartridge comprises not more than one annular layer. Surprisingly, it has been shown that even with a single, thin sealing-medium-layer applied with microdosing, a reliable sealing effect can be achieved with the least amount of material.

In particular, in one embodiment of the bullet cartridge, it is provided that the sealing medium comprises 50 vol-% to 70 vol-% of a preferably bitumen-containing sealant mixture, in particular 54 vol-% to 65 vol-% of a preferably bitumen-containing sealant mixture, as well as 5 vol-% to 20 vol-% thinner, in particular 6.5 vol-% to 16.5 vol-% thinner, and 25 vol-% to 40 vol-% of graphite ($D_{90} < 10\mu\text{m}$), in particular 28.5 vol-% to 32 vol-% graphite ($D_{90} < 10\mu\text{m}$), or consists thereof. For example, the sealant may be provided as a mixture, for which in relation to each other, 100 mL of a preferably bitumen-containing sealant mixture, 10 mL to 30 mL thinner, and 44 mL to 52 mL of graphite are comprised. It is conceivable that one, in particular single or first, annular layer of the bullet cartridge is formed from such a graphite-containing sealant mixture. In a bullet cartridge having a second annular layer, the second layer may be formed from a sealing medium free of graphite. The sealing medium of the second layer may comprise, a preferably bitumen-containing sealant mixture and a thinner, in particular consist thereof. For example, the sealing medium of the second layer may be provided as a mixture, for which in relation to each other, 100 mL of a preferably bitumen-containing sealant mixture and 10 mL to 30 mL thinner are comprised.

A method of manufacturing a bullet cartridge is further provided, wherein a bullet case is first provided having a neck portion for receiving a projectile. The neck portion defines an inner circumference which may correspond to the caliber diameter. In the method, an annular, preferably full circumferential, layer of a sealing medium is applied to a bullet case at an inner circumference in the neck portion of the bullet case. Preferably, a bitumen-based sealing medium is used. The bitumen-based sealing medium may comprise bitumen and at least one thinner. The thinner may be selected from the group comprising ketones, esters, alcohols and hydrocarbons, in particular aromatic hydrocarbons, or a mixture thereof. The sealing medium may comprise an additive in addition to a preferably bitumen-containing sealant mixture. A suitable additive is, for example, graphite powder. Graphite powder is suitable for adjusting the slip properties of the bitumen mixture. According to the invention, it is provided that a predetermined amount of the applied sealing medium is provided by microdosing. For example, the amount of sealing medium can be provided gravimetrically or volumetrically

predetermined by the microdosing. For example, the microdosing can comprise a lifting chamber with a lifting piston movably arranged therein, and the amount of sealing medium can be determined by means of the volume of the lifting chamber, the travel range of the lifting piston, and the number of dosing lifts. In particular, microdosing can be realized by a jet valve or microdosing valve, such as a solenoid valve or a piezo valve.

Surprisingly, it has been shown that, contrary to the general assumption, a cost-effective and easily controllable series production of bullet cartridges with a seal made of a preferably bituminous sealing medium can be realized by using microdosing. Microdosing is known from inkjet printing. With the aid of microdosing, smallest amounts of a sealing medium can be applied in a well-dosed manner to the inner surface in the neck portion of the bullet case. This enables considerable savings to be made in terms of the minimum amount of sealing medium required, which is particularly advantageous in the series production of bullet cartridges.

According to a preferred embodiment, exactly 2 or more than 2 rings are applied as a respective full circumferential layer of the sealing medium to an inner circumference of the bullet case. In a manufacturing method comprising the application of 2 or more annular sealing-medium-layers, it may be preferred that at least 2 different rings are produced from different sealing media. For example, a first, in particular near-edge, ring may be applied a bitumen-based sealing medium with at least one additive, which may preferably comprise graphite, and a second, in particular far-edge, ring may be applied with another, in particular bitumen-based, sealing medium, preferably with a smaller amount of additive, in particular without additive and/or without graphite.

According to an alternative preferred embodiment of the method, it can be provided that only a single ring is applied as a fully circumferential annular layer of the sealing medium on the inner circumference of the bullet case. The in particular single annular sealing-medium-layer is preferably applied to the outer edge of the bullet case. By providing two annular layers of the sealing medium to be applied one after another and separately from each other in the axial direction of the cartridge case, the amount of sealing medium required can be reduced. It has been shown that this can be done for at least some types of bullet cartridges without impairing the sealing effect.

In one embodiment of a method for manufacturing a bullet cartridge, following the application of at least one annular layer of a sealing medium, a bullet is inserted into the

neck portion of the bullet case. The sealing medium layer seals an annular gap between the inner circumference of the bullet case neck portion and the cylinder outer surface of the projectile inserted therein.

According to one embodiment of the method, a bullet cartridge is manufactured with a certain caliber diameter. The caliber diameter is defined according to the inner diameter of the inner circumference in the neck portion of the bullet cartridge. For forming the annular layer, a predetermined amount of not more than 1 mg of sealing medium per mm of caliber diameter is applied in relation to the caliber diameter of the bullet cartridge. In particular, not more than 0,5 mg of sealing medium is applied per mm of caliber diameter. Preferably, not more than 0,3 mg of sealing medium per mm of caliber diameter is applied. By applying a small amount of sealing medium per caliber diameter by means of microdosing, it can be ensured that the applied layer of sealing medium does not form a ring that is too wide or too thick on the inner circumference of the bullet case.

According to a further development of the method, a predetermined amount of not less than 0,01 mg of sealing medium per mm of caliber diameter is applied for forming the annular layer in relation to the caliber diameter of the bullet cartridge. In particular, not less than 0,03 mg of sealing medium per mm of caliber diameter, preferably not less than 0,05 mg of sealing medium per mm of caliber diameter, is applied.

It may be preferred that the sealing medium is applied with a layer thickness of not more than 0,1 mm, in particular not more than 0,05 mm. This can ensure that the bullet cartridge remains loadable. Alternatively, or additionally, it may be preferred that the sealing medium is applied with a layer thickness of at least 0,005 mm, preferably at least 0,007 mm. It has been shown that a reliable seal can be achieved with good reproducibility from such a layer thickness. In particular, the sealing medium can be applied with a layer thickness in the range from 0,007 to 0,02 mm, preferably in the range from 0,01 mm to 0,015 mm.

In one embodiment of a method combinable with the foregoing, a bitumen-containing sealant mixture is provided as the sealant medium. Preferably, the bitumen-containing mixture comprises bitumen and a thinner. In addition, the bitumen-containing mixture may comprise an additive, such as graphite, in particular graphite powder, for adjusting the sliding properties of the annular layer of sealing medium. The bullet cartridge can be manufactured particularly inexpensively if the sealing medium is a bitumen mixture.

Preferably, the sealing medium is guided in the microdosing, for example a jet valve, in particular a piezo valve or a solenoid valve, at a temperature of at least 25 °C, in particular at least 30 °C, preferably at least 35 °C, and/or at most 60 °C, in particular at most 55 °C, preferably at most 50 °C, particularly preferably at most 45 °C. The temperature control in the microdosing can be realized, for example, by equipping the microdosing with a heater and/or cooler for the sealing medium. Preferably, the temperature control can be used to ensure that the sealing medium, in particular the bitumen-containing mixture, is continuously kept within a predetermined temperature band during conveyance through the microdosing. For some sealing media, such as bitumen-based sealing media, it has proven advantageous to use precise temperature control to influence the material properties of the dispensed sealing medium, such as its phase composition and/or viscosity.

Alternatively, or additionally, during the method, an ambient temperature range can be set, in particular in a controlled manner, at least temporarily and/or sectionally, in particular in the spatial environment of the microdosing. For example, during the method, at least temporarily and/or sectionally, in particular in the spatial environment of the microdosing, the temperature of the bullet case and/or the temperature of a holder which receives the bullet case, can be set in a predetermined ambient temperature range. The ambient temperature range may, for example, be determined as at least 10°C, in particular at least 15°C, preferably at least 20°C, and/or at most 50°C, in particular at most 45°C, preferably at most 40°C. Setting a defined ambient temperature range can be advantageous for a temperature-sensitive sealing medium.

According to one embodiment of the process, the sealing medium, in particular in the microdosing, is adjusted to a viscosity in the range from about 5 s to 100 s, in particular 10 s to 70 s, preferably in a range from 30 s to 70 s or in a range from 10 s to 20 s. The viscosity of the sealing medium, in particular of the bitumen-containing sealing medium, can be adjusted in particular in accordance with a viscosity measurement method according to DIN 52211, preferably with an ISO-4mm-flow cup. DIN 52211-1987-06 can be authoritative. To adjust the viscosity, on the one hand, the composition of the sealing medium can be adjusted from a sealant, for example bitumen, and other components, for example thinner and/or additive. Additionally, or alternatively, in combination with the temperature control operated above, the viscosity can sometimes be influenced.

According to a further development of the method, the sealing medium is dispensed from the microdosing in mist form. In particular, the microdosing can be used to dispense mist in the form of nanodrops, preferably nanodrops with a volume in the nanolitre range, in particular with a nanodrop-volume in the range 1 nL to 500 nL. In particular, for dispensing the sealing medium in mist form, the viscosity of the sealing medium in the microdosing is set to at most 30 s, in particular at most 25 s, preferably at most 20 s. Fogging of the sealing medium makes it possible to produce a particularly thin annular sealing-medium-layer and thus save a particularly large amount of bitumen material.

In an alternative further development of the process, the sealing medium is dispensed from the microdosing in droplet form. Dispensing the droplet-shaped sealing medium from the microdosing preferably occurs by a droplet dispensing from the microdosing, which is implemented, for example, as a jet valve, moving away from the microdosing and, after the respective droplet has been detached from the microdosing, hitting the bullet case. With the aid of microdosing, precisely defined sealing medium drops are secreted, which, after being applied to the inner circumference, converge with each other to form a full circumferential, annular layer of sealing medium. When the sealing medium is dispensed in droplet form from the microdosing, the viscosity is preferably adjusted in the microdosing to at least 10 s, in particular at least 15 s, preferably at least 30 s.

According to a further development of the manufacturing method, in which the sealing medium is dispensed from the microdosing droplet, for forming the annular layer for a single bullet case, at least one droplet is dispensed. Preferably, multiple drops are dispensed. Microdosing can be used to dispense in particular drops in the form of microdrops, preferably microdrops with a volume in the microliter range, in particular with a microdroplet volume in the range 10 nL to 50 μ L, in particular 100 nL to 5 μ L. Five successively dispensed drops, in particular at least partially overlapping one another, preferably have a cumulative standard deviation of not more than $\pm 10\%$, in particular not more than $\pm 5\%$, preferably not more than 4%, relative to the dispensed volume. In particular, the bullet cartridge is manufactured with a certain caliber diameter and 1 to 5 drops per mm caliber diameter are dispensed for forming the annular layer in relation to the caliber diameter of the bullet cartridge. Alternatively, or additionally, in one embodiment, an annular layer having a width of at least 1 mm, in particular at least 2 mm, and/or not more than 10 mm, in particular not more than 6 mm, and/or having a thickness of at least 0,003 mm, in particular at least 0,005 mm,

and/or not more than 0,04, preferably not more than 0,025 mm, in particular not more than 0,015 mm, may be formed. It has been shown that even with thin and narrow rings of, for example, not more than one drop per mm of caliber diameter, a sufficient sealing effect can be achieved by the ring- or band-shaped layer on the bullet case produced with the aid of the sealing medium. In some cases, the sealing effect may be improved by using more than one drop per mm caliber diameter.

According to a further development of the method, which can be combined with the previous one, the drops are dispensed at a rate in the range from 100 Hz to 3000 Hz, in particular in the range from 250 Hz to 2000 Hz, preferably in the range from 300 Hz to 1000 Hz. The pressure medium is provided to the microdosing at a pressure of preferably about 1 bar. It is conceivable that a microdosing is implemented as a pump valve, for example a piezo valve, and the droplet-dispensing-rate is composed of a suction time and a lifting time. Preferably, the suction time corresponds approximately to the lifting time. The suction time can be in the range 150 μ s to 400 μ s or 800 μ s. Alternatively, or additionally, the lifting time may be in the range 150 μ s to 400 μ s or 800 μ s. Alternatively, the microdosing can be implemented as an, in particular a pressurized, opening valve, for example as a solenoid valve, and the droplet-dispensing-rate can be composed of a valve opening time and a valve closing time. It may be preferred that the valve opening time is at most as long as or shorter than the valve closing time. The valve opening time can be in the range of 350 μ s to 1000 μ s. In the microdosing, in particular in a pressurized opening valve, the sealing medium can be provided at a pressure in the range from 1 bar to 10 bar, preferably 2 bar to 5 bar.

In one embodiment of the method, which can be combined with the previous ones, it is provided that at least the neck portion of the bullet case is radially widened, in particular in the region of an edge of the confluence, which may be referred to as the case mouth edge, before insertion of the projectile. The neck portion, in particular the confluence, of the bullet case can be widened, in particular after the sealing medium has been applied. In particular, the neck portion is widened by a few μ m, in particular less than 30 μ m, preferably less than 20 μ m, particularly preferably less than 10 μ m. By pre-expansion of the case mouth, a scratch deformation of the neck portion by the projectile can be counter-acted, which could impair the sealing effect.

In one embodiment of a manufacturing method that can be combined with the previous ones, the sealing medium is dispensed from the microdosing through a nozzle.

Preferably, the nozzle for dispensing the sealing medium is held at an inclined angle, in particular orthogonally, to the inner circumference. This can minimize the risk of a drop ricochet (statellite). It may be preferred to keep the nozzle aligned in a direction that deviates from a direction of movement of an actuator, such as a piezostack or a magnetic armature, of the microdosing. Alternatively, or additionally, it may be preferred that the nozzle is held at a predetermined distance from the inner circumference. The nozzle may be held at a distance of at least 0,5 mm, in particular at least 1 mm, and/or at a distance of not more than 20 mm, in particular not more than 10 mm, preferably not more than 5 mm or not more than 7 mm. The distance between the nozzle and the inner circumference can be determined in particular on the basis of the path to be covered from the nozzle to the inner circumference through the, in particular in droplet- or sprayshaped, sealing medium. It has been shown that with such an arrangement of the nozzle in relation to the inner circumference, a homogeneous, annular sealing-medium-layer can be produced in the neck portion of the bullet case.

In one embodiment of the method, a movement for inserting the nozzle into the neck portion of the bullet case is performed before dispensing the sealing medium. In particular, a linear movement is performed, wherein the linear movement is preferably parallel or coaxial to the symmetry axis of the bullet case. Preferably, the nozzle is moved into the bullet case, which is in particular held stationary, in order to insert the nozzle into the bullet case. Alternatively, or additionally, the bullet case can be moved relative to the, in particular stationary, nozzle, wherein in particular the bullet case is slipped over the nozzle when the valve is stationary.

In particular, the process time for coating a bullet case with at least one annular layer of sealing medium can be set to a rate in the range from 0,1 Hz to 10 Hz, in particular in the range from 0,2 Hz to 5 Hz, preferably in the range from 0,3 Hz to 3 Hz. For example, 3 bullet casings can be internally coated per second.

In a further development of the manufacturing method, a nozzle is used which has an initial diameter in the range from 0,05 mm to 0,5 mm, in particular in the range from 0,1 mm to 3 mm, preferably with an initial diameter of about 0,15 mm.

According to one embodiment of the method, it may be provided that the bullet case is rotated in relation to the microdosing, in particular the nozzle, about a symmetry axis of the bullet case. Preferably, the relative rotation of the bullet case with respect to the

microdosing, in particular the nozzle, occurs during the dispensing of the sealing medium from the microdosing. In particular, the relative rotation of the bullet case with respect to the microdosing may occur during the dispensing of the at least one droplet or spray mist. It may be preferred that the bullet case may be continuously rotated while the sealing medium for forming the annular layer is applied. Preferably, the relative position of the bullet case with respect to the microdosage occurs by holding the microdosage on a stationary frame while the bullet case is held by a support that is movable with respect to the frame.

In particular, in one embodiment of the method, it is provided that the sealing medium is formed as a mixture comprising or consisting of 50 vol-% to 70 vol-% of a preferably bitumen-containing sealant mixture, such as a sealing lacquer, in particular 54 vol-% to 65 vol-% of a preferably bitumen-containing sealant mixture, as well as 5 vol-% to 20 vol-% thinner, in particular 6.5 vol-% to 16.5 vol-% thinner, and 25 vol-% to 40 vol-% graphite ($D_{90} < 10\mu\text{m}$), particularly 28.5 vol-% to 32 vol-% graphite ($D_{90} < 10\mu\text{m}$). For example, the sealing medium may be provided as a mixture, for which in relation to each other, 100 mL of sealant mixture, 10 mL to 30 mL thinner, and 44 mL to 52 mL of graphite are comprised. It is conceivable that one, in particular single or first, annular layer of the bullet cartridge is formed from such a graphite-containing sealant mixture. When manufacturing a bullet cartridge with a second annular layer, the second layer may be formed from a sealing medium free of graphite. The sealing medium of the second layer may be formed from a mixture comprising or consisting of a preferably bitumen-containing sealant mixture and a thinner. For example, the sealing medium of the second layer may be provided as a mixture, for which in relation to each other, 100 mL of preferably bitumen-containing sealant mixture and 10 mL to 30 mL thinner are comprised.

According to the invention, there is further provided a plant for manufacturing bullet cartridges. The plant for manufacturing bullet cartridges comprises a bearing for holding a bullet case having a neck portion for receiving a projectile defining an inner circumference. In accordance with the invention, the plant comprises a microdosing for providing a predetermined amount of a sealing medium for application to the inner circumference. Alternatively, or additionally, the plant is adapted and arranged to perform a method as described above. The plant may include a plurality of microdosings with which sealing medium may be simultaneously applied to a plurality of different bullet casings. In the plant of the invention, the ratio of the number of microdosages to

bullet cartridges within the plant may be at least 1:1. The ratio of microdosing and bullet cartridges within the plant may be greater than 1:1.

In one embodiment, the plant comprises a temperature control for guiding the sealing medium, in particular in the microdosing, preferably with a temperature of at least 25 °C and/or at most 60 °C. The temperature control comprises at least one heater and/or cooler and optionally a temperature sensor.

According to another embodiment, the plant has one, in particular exactly one, nozzle fluidically connected to the microdosing with an outlet diameter in the range of 0.05 mm to 0.5 mm, in particular in the range of 0.1 mm to 3 mm, for dispensing the sealing medium. Such a nozzle, in conjunction with a microdosing, in particular a jet valve or microdosing valve, such as a solenoid valve or a piezo valve, has proven to be particularly suitable for providing sealing, fully circumferential, annular layers of the sealing medium onto the bullet case.

According to a further development, the nozzle and the bearing are matched to one another in such a way that the nozzle is aligned orthogonally to the inner circumference when the sealing medium is dispensed. In this way, a particularly clean layer of sealing medium can be applied.

According to another further development, the nozzle and the bearing are matched to one another in such a way that the nozzle is kept at a predetermined distance of at least 0.5 mm, in particular at least 1 mm, and/or not more than 20 mm, in particular not more than 10 mm, preferably not more than 5 mm, from the inner circumference when dispensing the sealing medium. In this distance range, clean application can be ensured without the fear, even with a highly viscous sealing medium, that the nozzle will smear with the sealing medium along the inner circumference.

In a further development of the plant that can be combined with the previous ones, the nozzle and the bearing for moving the nozzle relative to the inner circumference, in particular for inserting the nozzle into the neck portion of the bullet case, are movable relative to each other, in particular linearly. The linear mobility can be useful for applying multiple annular layers side-by-side to the inner circumference.

According to one embodiment of the plant, the bearing is adapted to the microdosing and/or the nozzle in such a way that the bullet case can be rotated about a symmetry axis of the bullet case, preferably continuously. By rotating the inner circumference around

the output opening of the microdosing, in particular of the nozzle, a reliable full circumferential seal can be realized.

In one embodiment, the plant comprises a conveyor for feeding and/or discharging at least one bullet case per second, in particular at least two bullet cases per second, preferably at least three bullet cases per second, to or from the microdosing. A conveyor can guide bullet casings, in particular in the or into the bearing, to the microdosing so that the sealing medium can subsequently be applied. The same or a second conveyor can convey bullet casings, in particular in the or out of the bearing, away from the microdosing after at least one annular layer of sealing medium has been applied to the inner circumference.

Further features, advantages and characteristics of the invention will become apparent from the following description of preferred embodiments of the invention with reference to the accompanying drawings, in which show:

- Figure 1a a schematic sectional view of a bullet cartridge;
- Figure 2a a schematic representation of a method in which a first annular layer of sealing medium is applied to a bullet case;
- Figure 2 a schematic representation of a method in which a second annular sealing medium layer is applied;
- Figure 3a a schematic representation of another method in which a first annular sealing-medium-layer is applied to a bullet case;
- Figure 3b a schematic representation of the application of a second sealing-medium-layer according to the other method; and
- Figure 4a a schematic sectional view of a bullet case with two annular sealing-medium-layers arranged in the neck portion and a separate projectile.

For ease of reading, the same or similar reference signs are used for the same or similar components in the following description of the invention based on the illustrated preferred embodiments.

A bullet cartridge is generally designated by the reference sign 1. The bullet cartridge 1 comprises as essential components a bullet case 3, a projectile 4 and a sealing medium 5 provided between the projectile 4 and the bullet case 3.

Figure 1 shows a schematic cross-sectional view of a bullet cartridge 1. The sealing medium 5 creates a seal between the projectile 4 and the case 3. The bullet case 3 is a rotational body with a symmetry axis S. The bullet cartridge 1 has a certain caliber diameter D, which can be determined on the basis of the inner diameter at the inner circumference 33 in the neck portion 31 of the case 3. Typical caliber diameters D are, for example, 5,56 mm, 7,62 mm or 8,6 mm. The neck portion 31 designates the section of the case 3 into which the projectile 4 is inserted to form the bullet cartridge 1. In the case of the bullet case 3 shown in Figures 1 and 4, the neck portion 31 has a narrower diameter than a region 39, located behind it with respect to the confluence 30 of the case 3, for receiving the propellant charge.

Two annular layers 51, 52 of the sealing medium are applied to the inner circumference 33 of the case 3 in its neck portion 31. A first layer 51, arranged closer to the free edge of the case 3, contains a bitumen-containing sealing lacquer mixed with an additive as sealing medium 5. The sealing medium for forming the first layer 51 may, for example, comprise 42wt.-% of a bitumen-containing sealing lacquer, 42wt.-% of thinner and 16wt.-% of graphite. An optional second layer 52, arranged deeper in the case, contains a bitumen-containing sealing lacquer without additive. The second layer 52 contains 66 wt% of a bituminous sealing lacquer and 34 wt% of thinner. The same or a different mixture may be used for an embodiment with only one annular layer 51. Alternatively, in particular for an embodiment with only one annular layer 51, the sealing medium may comprise 50 vol-% to 70 vol-% of a bitumen-containing sealing lacquer, especially 54 vol-% to 65 vol-% of a bitumen-containing sealing lacquer, and 5 vol-% to 20 vol-% thinner, in particular 6.5 vol-% to 16.5 vol-% thinner, and 25 vol-% to 40 vol-% of graphite ($D_{90} < 10\mu\text{m}$), in particular 28.5 vol-% to 32 vol-% graphite ($D_{90} < 10\mu\text{m}$). The width of the first and/or second layer 51, 52 parallel to the direction of the symmetry axis S of the bullet case 3 is in the range of 0.5 mm to 6 mm each, in particular in the range of 1 mm to 3 mm each. The thickness of the first and/or second layer 51, 52 radial to the direction of the symmetry axis S of the bullet case 3 is in the range of 0.003 mm to 0.04 mm, in particular in the range of 0.005 mm to 0.015 mm. The distance between two layers 51, 52 can be less than 2 mm, in particular less than 1.5 mm.

Figures 2a and 2b schematically show a first method for applying annular layers 51 and 52 of sealing medium 5 to the inner circumference 33 of the bullet case 3. The sealing medium 5 is applied to the inner circumference 33 of the bullet case 3 in the neck portion 31 of the bullet case 3 by means of microdosing 7. With the aid of the microdosing 7, the sealing medium 5 is applied particularly uniformly to the inner circumference. The microdosing 7 is held completely outside the bullet case 3, in front of its confluence 30. The bullet case 3 is rotated about its symmetry axis S in relation to the microdosing 7.

In the embodiment shown in Figure 2a, the sealing medium 5 is applied to the inner circumference 33 in the form of drops 55 from the microdosing 7. By means of microdosing 7, multiple defined individual spots of sealing medium 5 are applied along the inner circumference 33 of the case 3, which together form a circumferential and homogeneous coating ring. In relation to the caliber diameter D of the bullet case 3, the microdosing 7 dispenses one to five drops, which may also be referred to as shots, per mm of caliber diameter D. For example, with a 5,56 mm caliber diameter, 6 to 28 shots can be dispensed. With a 7,62 mm caliber diameter, 8 to 38 shots can be dispensed. With an 8,6 mm caliber diameter, 9 to 42 shots can be fired.

The microdosing 7 has a nozzle 71 with an opening diameter in the range from 0,1 mm to 0,3 mm at its discharge end directed towards the bullet case 3. The nozzle 71 is adapted and arranged to dispense the sealing medium 5 in a certain firing direction or dispensing direction A. The dispensing direction A is oriented at an inclined angle with respect to the symmetry axis S. The dispensing direction A may cross the symmetry axis S. The inclined angle between the dispensing direction A and the symmetry axis S can be in the range of 30° to 90°, for example. Preferably, the oblique angle is at least 45°, in particular at least 60°. The nozzle 71 of the microdosing 7 is kept at a distance from the inner circumference 33 of the bullet case 3 in the dispensing direction A. The individual drops 55 of the sealing medium 5 are then not simultaneously in contact with both the nozzle 71 and the inner circumference 33.

As shown in Figure 2b, the annular sealing-medium-layer 51, which is closer to the confluence 30, is produced first, followed by the second layer 52 of sealing medium 5, which is more distant with respect to the confluence 30. Alternatively, in reverse order, the second layer 52 can be produced first and then the first layer 51.

For example, a bitumen-containing mixture can be used as the sealing medium 5. The sealing medium 5 may comprise a bitumen-containing sealant mixture, such as a sealing lacquer, and a thinner, and optionally an additive, such as graphite. For application by means of microdosing 7, the viscosity of the bitumen-containing mixture can be adjusted in a range from 10 s to 70 s. The viscosity of the sealing medium 5 can be determined by the viscosity measurement method according to DIN 52211 using a 4mm-ISO-dip-flow cup.

It has been found to be advantageous if the microdosing 7 is provided with a heater and/or cooler 73 for controlled adjustment of the temperature of the sealing medium 5. With a heater and/or cooler 73, the temperature of the sealing medium 5, while it is conveyed through the microdosing 7, can be guided in a temperature range between, for example, 30 °C and 55 °C. The heater and/or cooler 73 may be adapted and arranged to impose a controlled temperature on the complete microdosing 7. Alternatively, the heater and/or cooler 73 can be adapted and arranged to regulate the temperature of different portions of the microdosing 7 independently of one another.

For example, a microdosing valve in the form of a solenoid valve from Fritz-Gyger AG can be used as microdosing 7, in particular valve type: SMLD 300G (sub-micro liquid dispenser). The microdosing valve can, for example, be an electromagnetically actuated, so-called solenoid valve. The sealing medium 5 flows directly through the microdosing valve. In the de-energized state, the microdosing valve is closed. A closing spring of the microdosing valve acts on a mobile armature with a valve ball. When the valve coil is energized, the mobile armature with the valve ball is magnetically attracted by the magnetic field of a stationary armature, so that the microvalve opens and the sealing medium, which is under a pressure of, for example, 1 to 5 bar dispenses from the valve nozzle 71. The microdosing valve comprises a built-in heater 73 for adjusting the temperature of the sealing medium 5. The microdosing valve preferably comprises a hard-sealing valve, which is preferably adapted and arranged to ensure an opening lift of a few hundredths of a mm in a precisely reproducible manner. The microdosing valve can be arranged for a cycle rate of up to 4000 Hz. Hard materials, such as sapphire and/or ruby, may be provided for the valve seat and/or the valve ball. The microdosing valve is preferably adapted and arranged to reproducibly dispense individual shots or drops in the nanoliter range.

Alternatively, a microdosing valve in the form of a piezo valve from the company VERMES Microdispensing, in particular valve type MDV 3280, can be used as microdosing 7. The microdosing valve is preferably adapted and arranged for reproducibly dispensing individual shots or drops in the nanoliter range. The piezo valve can be adapted and arranged to be placed under voltage by a control unit for dosage of a sealing medium 5. The voltage pulses applied to the piezo valve by the control unit open and/or close the piezo valve. The piezo valve may comprise a plunger for closing the nozzle 71. The plunger may be connected to a piezostack of the piezo valve by means of a lever device. By moving the piezo stack up and down, drops or shots can be precisely dispensed at a frequency of several 100 Hz.

Figures 3a and 3b show a second method for producing layers 51, 52 from sealing medium 5 on the inner circumference 33 of a bullet case 3. The method differs substantially only from that previously described in that the nozzle 71 of the microdosing 7 is oriented in a substantially orthogonal dispensing direction A with respect to the inner circumference 33. The nozzle 71 is inserted into the bullet case 3 through the confluence 30 for application of the sealing medium 5. For this purpose, the nozzle 71 can be moved linearly into the bullet case parallel to the direction of the symmetry axis S. The nozzle 71 has a curvature 72 in the area just before its dispensing opening, which defines the dispensing direction A. After the sealing medium has been applied, the nozzle 71 is removed again from the neck portion 31 of the bullet case 3, for example, with a reverse movement.

As shown in Figure 3b, the annular sealing medium layer 52, which is further away from the confluence 30, is produced first, followed by the sealing medium layer 51, which is closer to the confluence 30.

In the two methods illustrated in Figures 2a and 3a, respectively, the sealing medium 5 may be dispensed in the form of drops 55 or in the form of a spray mist 57. In order to dispense a spray mist 57, it may be preferred to set the viscosity of the sealing medium 5 to not more than 20 s. This allows a spray mist 57 to be applied to the case 3 from the microdosing 7. The spray mist 57 can be used to apply a particularly thin sealing medium layer 51, 52.

After the application of the single layer or, optionally, the two layers 51 as well as 52, as indicated in Figure 3, the projectile 4 is inserted into the neck portion 31 of the case 3 to form the bullet cartridge 1 shown in Figure 1.

The features disclosed in the foregoing description, figures, and claims may be significant to the various embodiments of the invention both individually and in any combination.

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RUAG Ammotec AG

List of reference signs

1	bullet cartridge
3	bullet case
4	projectile
5	sealing medium
7	microdosing
30	confluence
31	neck portion
33	inner circumference
39	range
51, 52	annular layer
55, 57	drop or spray mist
71	Nozzle
72	Curvature
73	Heater and/or cooler
A	dispensing direction
D	caliber diameter
S	symmetry axis

Claims

1. A bullet cartridge (1) comprising a bullet case (3) defining a caliber diameter (D), a projectile (4) inserted into the neck portion (31) of the bullet case (3), and at least one annular layer (51, 52) of a sealing medium (5) formed from a sealing medium (5) between the bullet case (3) and the projectile (4), characterized in that the annular layer (51, 52) is applied by means of microdosing and/or comprises not more than 1 mg of sealing medium (5) per mm of caliber diameter (D), in particular not more than 0,5 mg of sealing medium (5) per mm of caliber diameter (D), preferably not more than 0,3 mg of sealing medium (5) per mm of caliber diameter (D).
2. Bullet cartridge (1) according to claim 1, characterized in that the sealing medium (5) of the at least one annular layer (51, 52) is uniformly distributed in the circumferential direction, in particular the at least one annular layer (51, 52) having deviations of not more than 50 nL/mm annular circumferential width, in particular not more than 5 nL/mm annular circumferential width, preferably not more than 5 nL/mm annular circumferential width.
3. Bullet cartridge (1) according to claim 1 or 2, characterized in that the at least one annular layer (51, 52) has a width of at least 1 mm, in particular at least 2 mm, and/or not more than 10 mm, in particular not more than 6 mm.
4. Bullet cartridge (1) according to one of the preceding claims, characterized in that the at least one annular layer (51, 52) has a thickness of at least 0,003 mm, in particular at least 0,005 mm, and/or not more than 0,04 mm, in particular not more than 0,015 mm.
5. Bullet cartridge (1) according to one of the preceding claims, characterized in that the at least one annular layer (51, 52) is formed from multiple drops.
6. Bullet cartridge (1) according to any one of the preceding claims, characterized in that the bullet cartridge (1) comprises not more than one annular layer (51) of the sealing medium.
7. Bullet cartridge (1) according to one of the preceding claims, wherein the sealing medium (5) comprises 50 vol-% to 70 vol-% of a sealant mixture, in particular containing bitumen, in particular 54 vol-% to 65 vol-% of a sealant mixture, in

particular containing bitumen, and 5 vol-% to 20 vol-% thinner, in particular 6.5 vol-% to 16.5 vol-% thinner, and 25 vol-% to 40 vol-% graphite ($D_{90} < 10\mu\text{m}$), in particular 28.5 vol-% to 32 vol-% graphite ($D_{90} < 10\mu\text{m}$), in particular consists thereof.

8. Method of manufacturing a bullet cartridge (1), wherein a bullet case is provided which has a neck portion for receiving a projectile, which neck portion defines an inner circumference, wherein an annular, preferably full circumferential, layer (51, 52) of a sealing medium (5), in particular a bitumen-containing sealant mixture, is applied to the bullet case (3) at an inner circumference (33) in the neck portion (31) of the bullet case (3), characterized in that a predetermined amount of the applied sealing medium (5) is provided by microdosing (7).
9. Method according to claim 8, characterized in that the bullet cartridge (1) is manufactured with a certain caliber diameter (D) and that for forming the annular layer (51, 52) in relation to the caliber diameter (D) of the bullet cartridge (1) a predetermined amount of not more than 1 mg of sealing medium (5) per mm of caliber diameter (D), in particular not more than 0,5 mg of sealing medium (5) per mm of caliber diameter (D), preferably not more than 0,3 mg of sealing medium (5) per mm of caliber diameter (D) is applied.
10. Method according to claim 8 or 9, characterized in that for forming the annular layer (51, 52) in relation to the caliber diameter (D) of the bullet cartridge (1) a predetermined amount of not less than 0,01 mg sealing medium (5) per mm caliber diameter (D), in particular not less than 0,03 mg sealing medium (5) per mm caliber diameter (D), preferably not less than 0,05 mg sealing medium (5) per mm caliber diameter (D) is applied.
11. Method according to one of claims 8 to 10, characterized in that a bitumen-containing sealant mixture is provided as the sealing medium (5), wherein the sealing medium, in particular in the microdosing, is guided at a temperature of at least 25°C, in particular at least 30°C, preferably at least 35°C, and/or at most 60°C, in particular at most 55°C, preferably at most 50°C, particularly preferably at most 45°C.
12. Method according to one of claims 8 to 11, characterized in that the sealing medium, in particular in the microdosing, is adjusted to a viscosity in the range from about 5 s to 100 s, in particular 10 s to 70 s, preferably in a range from 30 s to 70 s or in a range from 10 s to 20 s, wherein in particular the viscosity is adjusted according to a

- viscosity measurement method according to DIN 53211 using an ISO-4mm-dip-flow cup.
13. Method according to claim 12, characterized in that the sealing medium (5) is dispensed from the microdosing (7) in mist form (57), wherein in particular the viscosity of the sealing medium in the microdosing (7) is set to at most 30 s, in particular at most 25 s, preferably at most 20 s.
 14. Method according to claim 12, characterized in that the sealing medium (5) is dispensed from the microdosing (7) in droplet form, wherein in particular the viscosity of the sealing medium (5) in the microdosing unit (7) is set to at least 10 s, in particular at least 15 s, preferably at least 30 s.
 15. Method according to one of the claims 8 to 14, characterized in that for forming the annular layer (51, 52) the sealing medium (5) is dispensed from the microdosing (7) in at least one, preferably multiple, drops (55), wherein in particular the bullet cartridge (1) is produced with a certain caliber diameter (D) and that for forming the annular layer (51, 52) in relation to the caliber diameter (D) of the projectile cartridge (1), 1 to 5 drops (55) are dispensed per mm of caliber diameter (D) and/or in that an annular layer (51, 52) is formed with a width of at least 1 mm, in particular at least 2 mm, and/or not more than 10 mm, in particular not more than 6 mm, and/or with a thickness of at least 0,003 mm, in particular at least 0,005 mm, and/or not more than 0,025 mm, in particular not more than 0,015 mm.
 16. Method according to claim 14 or 15, characterized in that the drops (55) are dispensed at a rate in the range from 100 Hz to 3000 Hz, in particular in the range from 250 Hz to 2000 Hz, preferably in the range from 300 Hz to 1000 Hz.
 17. Method according to any one of claims 8 to 16, characterized in that the neck portion (31) of the bullet case (3) is radially widened before insertion of the projectile (4), in particular along an edge of a confluence 30.
 18. Method according to any one of claims 8 to 17, characterized in that the sealing medium (5) is dispensed from the microdosing (7) through a nozzle (71) which is preferably held orthogonally to the inner circumference (33) and/or at a predetermined distance of at least 0,5 mm, in particular at least 1 mm, and/or not more than 20 mm, in particular not more than 10 mm, preferably not more than 5 mm.

19. Method according to claim 18, characterized in that, before the sealing medium (5) is dispensed, a movement, in particular a linear movement, is performed for inserting the nozzle (71) into the neck portion (31) of the bullet case (3).
20. Method according to claim 17 or 19, characterized in that a nozzle (71) with an initial diameter in the range from 0,05 mm to 0,5 mm, in particular in the range from 0.1 mm to 0,3 mm, preferably with an initial diameter of 0,15 mm, is used.
21. Method according to any one of claims 8 to 20, characterized in that the bullet case (3) is rotated in relation to the microdosing (7), in particular the nozzle (71), about a symmetry axis (S) of the bullet case (3), preferably continuously.
22. Method according to any one of claims 8 to 21, characterized in that the sealing medium (5) comprising 50 vol-% to 70 vol-% of a sealant mixture, in particular containing bitumen, in particular 54 vol-% to 65 vol-% of a sealant mixture, in particular containing bitumen, and 5 vol-% to 20 vol-% thinner, in particular 6.5 vol-% to 16.5 vol-% thinner, and 25 vol-% to 40 vol-% graphite ($D_{90} < 10\mu\text{m}$), in particular 28.5 vol-% to 32 vol-% graphite ($D_{90} < 10\mu\text{m}$), in particular consisting thereof, is provided.
23. A plant for manufacturing bullet cartridges (1), particularly adapted and arranged to perform a method according to any one of the preceding claims, comprising a bearing for holding a bullet case having a neck portion for receiving a projectile defining an inner circumference, characterized by a microdosing for providing a predetermined amount of a sealing medium (5) for application to the inner circumference.
24. Plant according to claim 23, characterized by at least one heater and/or cooler and, optionally, a temperature control comprising a temperature sensor for guiding the sealing medium, in particular in the microdosing, preferably at a temperature of at least 25 °C and/or at most 60 °C.
25. Plant according to claim 23 or 24, characterized by at least one, in particular exactly one, nozzle (71) fluidically connected to the microdosing and having an outlet diameter in the range from 0,05 mm to 0,5 mm, in particular in the range from 0.1 mm to 3 mm, for dispensing the sealing medium (5).

26. Plant according to claim 25, characterized in that the nozzle (71) and the bearing are matched to one another in such a way that the nozzle is aligned orthogonally to the inner circumference (33) when the sealing medium (5) is dispensed.
27. Plant according to claim 25 or 26, characterized in that the nozzle (71) and the bearing are matched to one another in such a way that the nozzle (71) is kept at a predetermined distance of at least 0,5 mm, in particular at least 1 mm, and/or not more than 20 mm, in particular not more than 10 mm, preferably not more than 5 mm, from the inner circumference (33) when dispensing the sealing medium.
28. Plant according to any one of claims 25 to 27, characterized in that the nozzle (71) and the bearing of the nozzle for moving the nozzle (71) relative to the inner circumference, in particular for inserting the nozzle (71) into the neck portion (31) of the bullet case (3), are linearly movable relative to one another.
29. Plant according to one of claims 23 to 28, characterized in that the bearing is matched to the microdosing and/or the nozzle in such a way that the bullet case (3) can be rotated about a symmetry axis (S) of the bullet case (3), preferably continuously.
30. Plant according to any one of claims 23 to 29, characterized by at least one conveyor for feeding and/or discharging at least one bullet case per second, in particular at least two bullet cases per second, preferably at least three bullet cases per second, to and from the microdosing.