

LESS LETHAL WEAPON PROJECTILE

This invention relates to less lethal weapon projectiles, able to impact a target such as would a violent stroke of the fist while limiting the damage and or the traumas induced by this impact, in particular on the sensitive and unprotected zones of an individual (in particular the head).

LLW projectiles (for Less Lethal Weapon) are conventionally used by law enforcement and the armed forces in exterior operations, with the purpose of neutralizing or to cause to flee certain individuals, avoiding injuring them or minimizing the injuries or lesions incurred.

These projectiles are shot using rifled launch tubes of which the most common are of a caliber of 40 mm (NATO designation: 40 mm X 46).

Very generally, these LLW projectiles have an overall cylindrical shape of which the length is of a magnitude of 50 to 70 mm and of which the diameter, as specified previously, is of a magnitude of 40 mm, with a front end in the shape of an overall demi-spherical cap. They are conventionally carried out by molding thermoplastic foam.

Today, prior is rather poor in the field of research on new kinetic munitions that are less lethal (LL) and in particular in the improvement of the terminal effect of the corresponding projectiles.

Indeed, prior embodiments aimed to render more ductile the materials comprising these projectiles thinking that the more the projectile is "soft" the less lethal it is. As far as the applicant is aware, no concrete thought has been given as to the understanding of the relationships between the physical parameters and the lesion effects during the impact of an LL projectile on a human target. The identification of the "correct" physical parameter makes it possible to search for pertinent technical solutions.

In order to respond to this objective, a study was carried out and demonstrated and validated through tests and simulations:

- that energy is not the universal mechanical parameter of severity

- that this parameter is in fact the force at the impact.

Recall that controlling the low likelihood of causing a fatal outcome with a less lethal projectile, serious injuries or permanent lesions on an individual is not easy to obtain due to a physical phenomenon that is well-known to ballistics experts which is the loss of speed over the trajectory of the projectile, caused by the resistance of the air to the progression of the latter. As such, with current projectiles, a very low level of effectiveness can be had at a distance of 50 m and a substantial level of deleterious effects at 10 m, which poses enormous problems of use for law enforcement and the armed forces.

As was said previously, the physical parameter that is important at the impact from the point of view of lesion effects is the force at impact exerted on the target.

In order to improve the effectiveness and not the lethality of less lethal projectiles, the main objective of the invention is to transmit to the impact a programmed force which is always the same, or substantially the same, regardless of the terminal speed, and correlatively regardless of the firing distance (and this within the conventional ranges of speed at the time of impact (i.e. about between 50 to 100 m/s).

For this, the LLW projectile according to the invention, which has an overall cylindrical shape of longitudinal axis L, comprising a front end in the shape of a spherical or approximately spherical cap and a rear end, is characterized by the fact that it comprises:

- a core made from aluminum foam, said core has an overall cylindrical shape centered on said axis L, comprising a front end in the shape of a spherical or substantially spherical cap, and a rear end with a rear face,
- a base assembled with said rear end of the core, said base comprises a wall, arranged transversally to said axis L, which covers said rear face of said core, and
- an outer case covering at least the front end of said core.

The base of the projectile is deformed during the firing by the scratches of the tube of the weapon which allows for the putting into rotation of the projectile.

The core made of aluminum foam is very light and it offers the characteristics of crushing and of absorbing energy that are very interesting, homogeneous and independent of the speed of deformation in all directions; the outer case makes it possible to optimize the

ballistic flight of the projectile and to lessen at the moment of impact the first projectile-target contact.

The force of impact of this projectile is constant or almost constant regardless of its speed (in the conventional ranges of impact speed, in particular between 50 and 100 m/s). This
5 impact force is in particular according to the density of the aluminum foam, a parameter chosen according to the force of impact sought.

Preferably, the density of the aluminum foam used for the core of the LLW projectile in accordance with the invention is between 30 and 300 kg/m³.

The base of the projectile is advantageously made from thermoplastic material and its
10 case of thermoplastic foam.

According to an interesting characteristic, the transversal wall of the base is extended towards the rear by a tubular wall, centered on the longitudinal axis L, delimiting an opening rear cavity.

According to a particular embodiment, the transversal wall of the base is extended
15 towards the front by a tubular extension, centered on the longitudinal axis L, in order to form a housing for the reception of the rear end of the core made of aluminum foam.

According again to a particular embodiment, said rear tubular wall, or said front tubular extension, comprises an annular exterior ring for guidance.

According again to a particular embodiment, the transversal wall of the base is
20 extended towards the front by an axial tenon allowing for the centering of the front portion of the projectile.

According again to another particularity, the outer case extends to the rear base to cover the entire exposed face of the core.

In a particularly interesting embodiment, the rear end of the outer case comprises a
25 bead, directed inwards, which penetrates into an annular receiving groove arranged in the core made of aluminum foam.

In this case, the front end of the base advantageously covers the rear end of the outer case, in order to lock into position said bead in the receiving groove.

In addition, the front end of the base and the rear end of the outer case cooperate more preferably through complementary shoulders.

On the other hand, the core can comprise an axial recess opening into its rear face facing the front transversal wall of the base. This recess makes it possible in particular to
5 program two levels of impact force by selecting two densities of aluminum foam. It can remain as is or be filled by a more or less dense aluminum foam, in order to program the severity of the impact.

According again to a particular embodiment, the projectile comprises an annular contraction between its front and rear ends, corresponding to a decrease in diameter, said
10 contraction extends towards the front starting from the front end of the base.

This particularity has in particular for objective to prevent the contact of the base as an inclined impact with the target.

On the other hand, the projectile in accordance with the invention can comprise a structure made of a reversible deformation material, inserted in the front, on the axis L,
15 between the outer case and the core. This material can be a thermoplastic foam or be comprised of microbeads.

The base, the core and the outer case of the projectile are carried out independently and they are assembled together by any suitable means.

The invention will be further illustrated, without be restricted in any way, by the
20 following description of several possible embodiments, given solely by way of example and shown in the annexed drawings wherein:

- figure 1 is a perspective view of an LLW projectile in accordance with the invention;
- figure 2 is an axial cross-section view of the projectile of figure 1;
- figure 3 is an axial cross-section view of a first alternative embodiment of the
25 projectile in accordance with the invention;
- figure 4 is a perspective view of a second alternative of the projectile in accordance with the invention;
- figure 5 is an axial cross-section view of the projectile of figure 4;

- figures 6 and 7 are curves showing the variation of the force during the impact according to time for projectiles according to the invention;

- figure 8 is an axial cross-section view of a third alternative of the projectile in accordance with the invention.

5 The LLW projectile 1 shown in the figures 1 and 2 has an overall cylindrical shape of longitudinal axis L. Its length can be of a magnitude of 50 to 70 mm and its diameter of a magnitude of 35 to 45 mm.

10 The rear end 2 of this projectile 1 terminates according to a plane perpendicular to the longitudinal axis L. At this level, an opening axial recess 3 allows for the conventional receiving of a certain pyrotechnic propulsion, or other method of propulsion. Its front end 4 is in the shape of a spherical or approximately spherical cap.

 This projectile 1, symmetrical around its longitudinal axis L, is comprised of a rear base 5, extended towards the front by a core 6 of which the external face is practically entirely covered by a case 7.

15 The rear base 5 comprises a cylindrical tubular wall 8, centered on the axis L, which is closed on its front end by a transversal wall 9. The tubular wall 8 is not closed towards the rear, and, with the front transversal wall 9, it delimited the aforementioned axial recess 3.

20 Facing this front transversal wall 9, note that the tubular wall 8 comprises a single-piece annular ring 10 which extends as a projection outwards. The outside surface of this ring 10, of overall cylindrical shape, defines the maximum outside encumbrance of the projectile and it constitutes a guiding face inside the barrel of the propulsion weapon.

 The outside surface of the tubular wall 5 has a diameter that is a few millimeters less than that of the guiding surface of the single-piece ring 10.

25 On the side of the face 11 directed towards the front end 4 of the projectile, the transversal wall 9 of the base 5 comprises a cylindrical single-piece tenon 12, centered on the axis L. This tenon 12 has a diameter of a magnitude of half of the diameter of the projectile 1; its height is of a few millimeters.

 The base 5, comprising the tubular wall 8, the transversal wall 9, the ring 10 and the tenon 12, is carried out as a single piece by molding thermoplastic material (polycarbonate for

example). The density of the thermoplastic material used can be of a magnitude of 1200 to 1600 kg/m³.

It has for function to give the projectile a substantial portion of its mass, allow for its propulsion and the connection at the front of the portion that absorbs the energy and programming the force of impact.

The core 6 of the projectile 1 has an overall cylindrical shape centered on the axis L.

Its rear end 13 has a diameter that is slightly less than the diameter of the guiding surface of the ring 10 of the base 5, and its rear face 14 is structured to hug the front face of this base 5, with the tenon 12.

For this, this rear face 14 extends in the plane of the front face 11 of the base 5, and it comprises an axial reservation 15, corresponding to the shape of the tenon 12.

The front end 16 of the core 6 is in the shape of a spherical or approximately spherical cap, centered on the axis L.

This core 6 can have a length between 30 and 50 mm. It is made from aluminum foam (honeycombed structure of aluminum) of which the density is advantageously between 30 and 300 kg/m³. The length of the core 6 and the density of the aluminum foam used are according to the force of impact sought and according to the quantity of energy to be absorbed.

The core 6 is carried out by molding or any other method of forming or machining of honeycombed materials.

For example, an aluminum foam is used manufactured by the company CYMAT Corporation (Canada) under the designation "Cymat stabilized aluminum foam" (registered trademark), or by the company SHINKO WIRE CO Ltd (Japan), under the designation "Alporas" (registered trademark).

Such a core structure 6 has for function to limit at the impact the impact force predetermined beforehand during the absorption of the energy, regardless of the impact speed of the projectile. The shape at the front of this honeycombed structure in addition makes it possible to retain the time for coming to force of the impact, until nominal level, below the critical burst value of the scalp for example.

The rear end 13 of the core 6 is assembled with the front end 11, 12 of the base 5 by any suitable means, for example by gluing.

The front end 16 of the core 6 is covered by the case 7 made advantageously from thermoplastic foam; the density of this thermoplastic foam is advantageously between 100 and 150 kg/m³. For example rubber, an EPDM material or a nitrile-teflon mixture (registered trademark) can be used.

This outer case 7 has a thickness of a few millimeters (for example 1 to 3 mm, advantageously of a magnitude of 2 mm).

In the embodiment shown, it covers all of the front and lateral external surface of the core 6, except for an annular strip 18 of the rear end 13 of said core 6. So that its external surface is located in the extension of the external surface of this "free" annular strip 18, the case 7 is housed in an adapted reservation 19 arranged on the external face facing the core 6.

This case 7, is the shape of a tube closed at its front end by a spherical or substantially spherical cap, is fixed onto the core 6 by any suitable means, for example by gluing.

The case 7 has for function to improve the ballistic flight of the projectile, prevent at the first target-projectile contact the local bursting of the biological material of the target and allow for the pre-crushing of the honeycombed structure of aluminum.

Figure 3 shows an alternative embodiment of the projectile of the figures 1 and 2. The portions that are identical to the preceding embodiment retain the same marks in order to facilitate comprehension.

In the corresponding projectile 1', the core 6 comprises a blind axial recess 20 that opens into its rear face 14. This recess 20 advantageously has a cylindrical shape of which the diameter corresponds, to the nearest clearance, to that of the axial tenon 12 of the base 5. Its function is to make it possible to carry out during the impact an impact force profile at two levels programmed beforehand, according to the severity sought.

Still in the alternative embodiments, the recess 20 can be filled with an added material. This added material can for example consist of an aluminum foam that is denser than that used for the periphery of the core 6, in such a way as to increase the effectiveness of the impact of the projectile.

For this projectile 1', note that the length of the core 6 is less than that of the projectile core 1 of figures 1 and 2.

Figures 4 and 5 show another possible embodiment of a projectile in accordance with the invention.

5 Here again, portions that are identical to the embodiments of figures 1 to 3 retain the same marks in order to facilitate comprehension.

The corresponding projectile 1" comprises a rear base 5, extended towards the front by a core 6 made from aluminum foam of which the external face is covered by a case 7.

10 Note that the tubular wall 8 of the base 5 is extended towards the front, beyond the transversal wall 9, by a tubular single-piece extension 21. The guiding ring 10 extends facing the transversal wall 9 of the base 5, over a portion of the tubular wall 8 and over practically all of the length of the extension 21.

15 This extension 21 and the wall 9 of the base 5 form a housing 22 for receiving the rear end 13 of the core 6. The single-piece tenon 12 of the preceding embodiments is no longer present.

Here again, the core 6 and the base 5 are assembled by any suitable means, more preferably by gluing.

20 On the other hand, in this embodiment, note that the case 7 covers all of the exposed surface of the core 6; it extends to the base 5, and in particular to the front end of the extension 21.

The embodiment of figures 4 and 5 is also distinguished from the preceding ones, by the presence of a contraction 23, corresponding to a reduction in diameter, between its rear 2 and front 4 ends.

25 This contraction 23 has for function to prevent, as an inclined impact of the projectile, the plastic base-target contact, preventing as such a level of contact impact that is incompatible with the programming of the efforts by the aluminum foam.

It is substantially obtained by a decrease in the diameter of the rear end 13 of the core 6.

The presence of the contraction 23 confers upon the core 6 a particular longitudinal section, with a rear end 13 of cylindrical shape extended by a front end 16 in the shape of a bead or bulge, of an overall spherical shape.

5 The surface of the front end 4 of this projectile 1" is particular: the spherical end surface 4a is extended by a truncated cone surface 4b which itself is extended by a cylindrical surface 4c (of which the diameter corresponds approximately to the diameter of the ring 10) which is again extended by a "re-entrant" surface 4d ending at the contraction 23. This particular shape of the front end 4 of the projectile 1" makes it possible to calibrate the rate of the increase in effort (level of the force programmed over the time taken to reach it), thus
10 preventing the local bursting of the biological structures (scalp for example as a cranial impact).

The shapes of these projectiles all have a perfect correspondence between their center of gravity and their center of thrust in order to obtain good external ballistics.

15 Figure 6 is a curve showing the variation of the force during the impact according to the impact time, for the projectiles 1 and 1" of figures 1 and 2, on the one hand, and 4 and 5 on the other hand.

The following are distinguished:

- the rate of climbing (constant force a over the rate of climbing b).

20 This rate of climbing must be less than a critical value in order to not burst the biological surface structures,

- the constant level of the force a programmed by the density of the aluminum foam and the geometry of the core.

This level a is calibrated in order to determine beforehand the damage and the severity sought.

25 - the end of the impact c, still with a constant or substantially constant force a.

Figure 7 shows the force/time variation for a projectile with double density (such as shown in figure 3). The level d is obtained by the peripheral foam of the core, and the level e

is defined by the central foam of the core of which the density is higher than the peripheral foam.

Figure 8 further shows another possible embodiment of a projectile in accordance with the invention.

5 In the corresponding figure, the portions that are identical to the embodiments of figures 1 to 5 retain the same marks in order to facilitate comprehension.

This projectile 1''' comprises a rear base 5 which covers the rear portion of a core 6 made from aluminum foam of which the external face of the front portion is covered by a case 7.

10 The material used for these various portions 5, 6 and 7 correspond to those described hereinabove in relation with the embodiments of figures 1 to 5.

As can be seen in figure 8, the case 7 covers the front portion of the core 6, to the base 5.

15 On its rear end, this case 7 comprises a bead 24 protruding inwards, which penetrates into a reservation or annular groove 25 arranged in the core 6 made from aluminum foam, providing for the assembly between the two elements 6 and 7.

This annular groove 25 of the core 6 extends in a plane perpendicular to the longitudinal axis L of the projectile 1'''.

20 On the rear end of the case 7, note again the presence of a shoulder 26, directed outwards, facing the bead 24.

The setting in place of the case 7 on the front end of the core 6 is carried out by forced embedding, thanks to the elasticity of the material that this case 7 is comprised of.

25 On its side, the base 5 comprises a rear transversal wall 9, which is extended towards the front by a tubular single-piece extension 21 which covers the rear end 13 of the core 6 made from aluminum foam.

The internal face of the transversal wall 9 is thrust against the rear face 14 of the core 6. The external face of the tubular extension 21 comprises the protruding guiding ring 10.

On its front end, the extension 21 comprises an annular shoulder 27 directed inwards. This annular shoulder 27 of the base 5 is complementary to the annular shoulder 26 of the case 7.

The base 5 is added on the rear end of the core 6, after the case 7 is set into place.

5 In this framework, its annular shoulder 27 covers the complementary shoulder 26 of the case 7, in such a way as to lock the case 7/core 6 assembly.

The base 5 is fixed onto the rear end of the core 6 by any suitable means, more preferably by gluing.

10 The internal face of the tubular extension 21 comprises more preferably striations or a set of grooves/ribs which make it possible to optimize the corresponding gluing.

On the other hand, more preferably, the base 5 and the case 7 are also made integral through gluing, on their complementary shoulders 26 and 27.

After attaching, the external faces of the front end of the base 5 and of the rear end of the case 7 are located in the continuity of each other.

15 The absence of gluing of the case 7 on the front end of the core 6 makes it possible to leave this case 7 free during the crushing and to prevent, or at least limit, the contact between the base 5 and the target, in offset impacts in relation to the longitudinal axis L.

20 If needed, the tubular wall 21 can be extended, towards the rear, beyond the transversal wall 9, in order to comprise an opening rear cavity, similar to the cavity 3 present in the embodiments if figures 1 to 5.

As shown in figure 8, the front end of the core 6 can be truncated in order to allow for the positioning of a structure 28 (shown as a dotted line) making it possible to dampen the shock at impact.

25 This structure 28 can be added between the case 7 and the front end of the core 6; any shock-absorbing material with reversible deformation can be used, for example a thermoplastic foam with a suitable duration, or microbeads (for example of a diameter between 0.5 and 2 mm, made from an elastomeric material or any other material with reversible deformation).

In an alternative embodiment, the shock-absorbing structure 28 can be obtained as a single-piece with the case 7, by the material comprising this case 7.

CLAIMS

1. Projectile for less lethal weapon, having an overall cylindrical shape of longitudinal axis (L), said projectile (1, 1', 1'', 1''') comprises a front end (4) having a shape of a spherical or approximately spherical cap and a rear end (2), characterized in that it comprises:
 - 5 - a core (6) made from aluminum foam, said core (6) has an overall cylindrical shape centered on said axis (L), comprising a front end (16) in the shape of a spherical or substantially spherical cap, and a rear end (13) with a rear face (14),
 - 10 - a base (5) assembled with said rear end (13) of the core (6), said base (5) comprises a wall (9), arranged transversally to said axis (L), which covers said rear face (14) of said core (6), and,
 - an outer case (7) covers at least the front end (16) of said core (6).
2. Projectile according to claim 1, characterized in that said core (6) is made from aluminum foam having a density between 30 and 300 kg/m³,
3. Projectile according to any of claims 1 or 2, characterized in that said base (5) is made
 - 15 from a thermoplastic material.
4. Projectile according to any of claims 1 to 3, characterized in that said outer case (7) is made from thermoplastic foam.
5. Projectile according to any of claims 1 to 4, characterized in that the transversal wall (9) of the base (5) is extended towards the rear by a tubular wall (8), centered on said axis (L),
 - 20 delimiting an opening rear cavity (3).
6. Projectile according to any of claims 1 to 5, characterized in that the transversal wall (9) of the base (5) is extended towards the front by a tubular extension (21), centered on said axis (L), in order to form a housing (22) for receiving the rear end (13) of the core (6) made from aluminum foam.
7. Projectile according to any of claims 5 or 6, characterized in that said rear tubular wall (8), or said front tubular extension (21), comprises an annular exterior guiding ring (10).
8. Projectile according to any of claims 1 to 7, characterized in that the transversal wall (9) of the base (5) is extended towards the front by an axial tenon (12).

9. Projectile according to any of claims 1 to 8, characterized in that said outer case (7) is extended to the rear base (5) to cover the entire exposed face of the core (6).

10. Projectile according to claim 9, characterized in that the rear end of the case (7) comprises a bead (24), directed inwards, which penetrates into an annular receiving groove
5 (25) arranged in the core (6).

11. Projectile according to claim 10, characterized in that the front end of the base (5) covers the rear end of the case (7) in order to lock into position said bead (24) in said groove
(25).

12. Projectile according to claim 11, characterized in that the front end of the base (5) and
10 the rear end of the case (7) cooperate through complementary shoulders (26, 27).

13. Projectile according to any of claims 1 to 12, characterized in that the core (6) comprises an axial recess (20) opening into its rear face (14) facing the front transversal wall
(9) of the base (5).

14. Projectile according to any of claims 1 to 13, characterized in that it comprises an
15 annular contraction (23) between its front (4) and rear (2) ends, corresponding to a decrease in diameter, said contraction (23) extends towards the front starting from the front end (21) of the base (5).

15. Projectile according to any of claims 1 to 14, characterized in that it comprises a
20 structure (28) made of reversible deformation material, inserted on the axis (L), between the case (7) and the core (6).