A rigid structure for ballistic protection is described. The structure comprises a plurality of textile elements which are distinct from each other and co-operate with each other to stop an incident bullet along a direction. A third element is placed between two of the textile elements. Such third element is aimed at creating a discontinuity surface between the two adjacent elements, which provides a further reduction of the trauma value and increase of the stopping capability.
MULTILAYERED STRUCTURE FOR BALLISTIC PROTECTION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to Italian patent application MI2009/A001223 filed on Jul. 9, 2009, which is incorporated herein by reference in its entirety. The present application may also be related to U.S. patent application Ser. No. _____ entitled “Structure for Ballistic Protection”, Attorney docket no. P434-US, filed on even date herewith, and incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to a structure for making ballistic protections, in particular rigid protections.

BACKGROUND

[0003] It is known that in order to provide protection against bullets fired from a gun (with the speed in the range of 400 m/s), elements are used, which are obtained by superimposing soft or flexible textile structures, composed of high resistance fibres. These structures can be impregnated in synthetic matrices to improve their ballistic behavior, that is to increase their capability of absorbing the impact, without altering their softness and flexibility. However, the so obtained ballistic structures are not suitable for stopping an incident bullet, and consequently to provide appropriate protection, when the bullet has been fired from a rifle. In this situations, composite rigid structures are used instead.

[0004] Examples of rigid structures for ballistic protection are provided in patents U.S. Pat. No. 4,836,084, U.S. Pat. No. 4,613,535 and U.S. Pat. No. 6,893,704.

[0005] There are available on the market ballistic plates obtained by superimposing and compacting layers of unidirectional fabrics, including UHMW polyethylene fibres, as for example, the fibres marketed under the trademarks Dyneema® and Spectra®. Such structures are able to stop bullets of the Nato 7.62 Ball type fired with a speed of 830 m/s, theoretically even with weight about 16 kg/m²; however, they do not comply with the requirements imposed by regulations (in particular, the N.I.J. regulations 0101.03 and 0101.04), because they exceed the maximum allowed trauma value of 44 mm. Thus, it is necessary to use such plates in combination with a soft bullet-proof jacket that contributes to trauma reduction or to increase its weight up to about 19 kg/m²; such changes however, not only cause the user’s discomfort when he wears the protection, due to the higher weight, but they also cause the protective element cost to increase.

SUMMARY

[0006] Embodiments of the present disclosure are directed to a ballistic protection element, which allows a reduction of trauma values, without jeopardizing the capability of stopping bullets fired from either a gun or a rifle, and a reduction in costs and times for the protective element manufacturing.

[0007] This result is obtained by creating a structure for ballistic protections, which comprises at least a plurality of textile elements, which are distinct from each other and cooperate with each other to dissipate the energy associated with an incident bullet impact, along a direction (X), the structure being characterized in that, between a first textile element (1) and a second textile element (2) of the plurality of elements, a third element (3) is interposed, thus creating a discontinuity layer therebetween.

[0008] This third element can be textile or of another material, such as for example foams, elastomers, rubbers, honeycomb structures (e.g. of aluminum) or compressible materials in general. According to an embodiment of the present disclosure, the third element has a hardness at least 10% lower with respect to said plurality of textile elements.

[0009] According to a further embodiment, the textile elements (1, 2) comprise fibres capable of dissipating part of the energy associated with the incident bullet impact owing to a change of the crystalline phase. Such fibres can also undergo a physical state transition due to the incident bullet impact, for example by fusion.

[0010] Furthermore, the textile elements can comprise polyethylene fibres, in particular UHMW polyethylene fibres, such as Dyneema® or Spectra® fibres.

[0011] According to a further embodiment, a fourth element is situated behind the plurality of textile elements (1, 2) and aimed at further reducing the trauma value. Such fourth element can be made of compressible material such as, for example, felt, foams, elastomers, rubber, honeycomb structures (e.g. of aluminum).

[0012] Moreover, the structure can include also a ceramic element situated before said textile elements. This ceramic element can be obtained for example with carbide oxides or nitrides (for example alumina, boron carbide, silicon carbide, boron nitride and silicon nitride) based ceramics.

[0013] According to a further embodiment, said plurality of textile elements can be obtained with yams having tensile strength higher than or equal to 30 g/den.

[0014] According to another embodiment, the fibres of said various layers of textile elements can be either parallel to each other, or oriented with respect to each other at an angle of 0° to 90° (for example) 45°.

[0015] The various layers of textile elements can also be impregnated even partially with thermoplastic, thermosetting or elastomeric polymers and combinations thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] According to the present disclosure, it is possible to obtain a ballistic protection element, which is particularly effective for bullets fired from a gun as well as bullets fired from a rifle. Furthermore, a protective element according to the disclosure leads to a reduction of the trauma values without reducing the capability of stopping incident bullets and, at the same time, allows a protection weight and cost reduction.

[0017] Further features of the present disclosure will be better understood by those skilled in the art from the following description and from the enclosed drawings, with reference to non-limiting embodiments described by way of illustrative examples, and therefore not to be considered limiting, in which:

[0018] FIG. 1 is a schematic vertical section view of a structure for making ballistic protections according to a possible embodiment of the present invention; and

[0019] FIG. 2 is a schematic exploded view of the structure of FIG. 1.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0020] With reference to the figures in the enclosed drawings, a ballistic protection according to the present disclosure
includes a structure (S) with two or more textile elements (1, 2), distinct from each other. By placing an element (3) between the elements (1) and (2) and creating a discontinuity between these elements, the trauma value is reduced (~8 mm) and the V50 increased (+20 m/s).

[0021] The discontinuity element (3) can be made of any material, even for example paper, various type polymer sheets or films. In particular, compressible materials can be used, having hardness lower than the plurality of the textile elements (1, 2), as for example: felts, foams, viscoelastic, thermoplastic or thermosetting, or elastomeric polymers, sheets of foam having various thickness, nonwoven fabrics, nets, honeycomb structures (e.g. of aluminum).

[0022] The discontinuity element (3) has normally a thickness in the range of 0.05 mm to 10 mm. In an embodiment of the present disclosure, this thickness is in the range of 2 to 3 mm.

[0023] The example depicted in FIG. 1 shows, for sake of convenience, two textile elements (1 and 2) and one discontinuity element between the two textile elements (1, 2). However, it is possible to provide a plurality of textile elements, instead of only two elements, and, likewise, more than one discontinuity element (3) between adjacent textile elements.

[0024] Moreover, according to an embodiment of the present disclosure, a fourth element is situated in a rear position with respect to the textile elements (1, 2) in relation to the direction (X) of the incident bullet, to further reduce the trauma caused by the bullet impact. Such fourth element can also be made of compressible materials, such as for example: felts, foams, viscoelastic, thermoplastic or thermosetting, or elastomeric polymers, sheets of foam of various thickness, nonwoven fabrics, honeycomb structures (e.g. of aluminum).

[0025] One or more ceramic elements (C) can be associated to the above described structure.

[0026] The structure (S) may lack the ceramic elements (C), if it is aimed at producing elements providing protection from not armour-piercing bullets. The use of the ceramic elements (C) is useful if the structure (S) is intended to make elements for providing protection from bullets fired from a rifle, in particular penetrating type bullets (7.62×51AP), for example with IRC64 minimum hardness steel or tungsten carbide core. Said ceramic elements (C), which can be obtained, for example, from carbide oxides or nitrides based ceramics, can be monolithic or made of juxtaposed ceramic sub-elements, as schematically shown in FIG. 1 and FIG. 2. Such ceramic elements can also have noncoplanar surface for better energy dissipation.

[0027] Furthermore, the textile elements (1, 2), situated behind the ceramic elements, can be made of UHMW polyethylene fibres, like Dyneema® or Spectra® fibres, that can be impregnated with Knton® elastomers.

[0028] The polyethylene from which the fibres of the textile elements (1, 2) are obtained can be chosen from the group comprising UHMW polyethylene, HDPE polyethylene and mixtures thereof.

[0029] The fibres of various layers of textile elements (1, 2) can be either parallel to each other, or oriented at an angle comprised between 0° and 90° with respect to each other (for example, at an angle of 45°, as shown schematically in FIG. 2, wherein the fibres of the first textile element are designated as “F1” and those of the second textile element are designated as “F2”).

[0030] The textile elements (1, 2) can also be impregnated with thermoplastic or thermosetting or elastomeric polymers and combinations thereof. The use of thermoplastic or thermosetting or elastomeric resins, if necessary, mixed among them, allows the element (1) to help to stop the incident bullet, due to the cohesion induced in the fibrils that constitute the structure of the textile element therebetween. According to an embodiment of the present disclosure, the textile elements (1, 2) can be formed by superimposing and compacting more layers of unidirectional fabric made up of fibres having an elasticity modulus higher than 60 Gpa.

[0031] Said fibres can also present an elongation over 5%, orientation of the molecular chains (Hermann orientation parameter) over 80%, crystallinity higher than 65%, and specific weight in the range of 0.94 to 0.99 kg/m³.

[0032] The above described structure (S) allows a drastic reduction of trauma values and, at the same time, a V50 value substantially equal or even higher that of a structure of the same weight. It is thus possible to obtain ballistic plates which are lighter but which wholly comply with the regulations in force, respecting the parameters imposed by the specifications, with reference to the trauma values as well as to the V50.

[0033] The “packages” formed by the plurality of textile elements (1, 2) and by the at least one discontinuity element (3) of the structure (S) can be glued to each other firmly, weakly or not at all.

[0034] Experimental tests have surprisingly ascertained that, with the same V50, when the elements (1), (2) and (3) are not glued to each other, the trauma value is reduced (~6 mm) with respect to the trauma value obtained by a structure formed by the same elements (1), (2) and (3) that are glued. Consequently, the V50.

[0035] According to a further embodiment of the present disclosure, the structure (S) is composed of about 60% by weight of element (1), about 30% by weight of element (2) and about 4% by weight of element (3).

[0036] It goes without saying that further combinations are possible, depending on the required combination of the trauma value and V50.

[0037] The structure (S) can be obtained using presses, autoclave apparatus and other traditional production systems.

[0038] The term “polymer” as used herein applies both to a polymeric material and resins, natural or synthetic, and mixtures thereof. The term “fiber” as used herein applies to elongated bodies, with longitudinal dimension much greater than the transversal one.

[0039] In practice, the realization details can vary in any case, in a corresponding way, as for single constructive elements described and illustrated, and as for the indicated materials nature without departing from the adopted solution concept and consequently, remaining within the protection provided by the present patent.

1. A structure for rigid ballistic protections, comprising a plurality of textile elements, which are distinct from each other and which co-operate with each other to dissipate energy associated to impact of an incident bullet along a direction, the structure comprising a third element between a first textile element and a second textile element, the third element forming a discontinuity layer between the first textile element and the second textile element.

2. The structure as claimed in claim 1, wherein the third element is made of compressible material, whose hardness...
value is lower with respect to the hardness of each textile element of the plurality of textile elements.

3. The structure as claimed in claim 2, wherein the third element is made of one of: elastomeric polymer foams, plastomers, thermosetting silicones and mixtures thereof as films, nets, felt, honeycomb structures, and rubber.

4. The structure according to claim 1, wherein at least one of the textile elements includes fibers capable of dissipating a part of the energy associated to the impact of the incident bullet modifying the crystalline phase and inducing a physical state transition.

5. The structure as claimed in claim 4, wherein said fibers capable of dissipating include polyethylene UHMW fibers.

6. The structure according to claim 1, further comprising a fourth element, made of compressible material, situated behind the plurality of textile elements.

7. The structure according to claim 1, wherein a first element of the plurality of textile elements is situated in front of the other elements of the plurality of elements with respect to the direction of the incident bullet and constitutes at least 60% of the total weight of the structure.

8. The structure according to claim 1, further comprising at least one ceramic element arranged externally with respect to and before said plurality of textile elements along the direction of the incident bullet.

9. The structure as claimed in claim 8, wherein said at least one ceramic element is made of ceramics based on carbide oxides and/or nitrides.

10. The structure according to claim 1, wherein at least one of the textile elements is impregnated with thermoplastic, thermosetting, or elastomeric polymers, or a combination thereof.

11. A rigid ballistic protective article, comprising the structure according to claim 1.

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