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(54) **Improved warhead casing**

(57) A casing for warhead components, and a warhead comprising such casing,
wherein the casing is made up of a laser sintered material. The laser sintered material may comprise metal powder such as aluminium powder and binder particles. The casing may be provided with a lacquer coating, and optionally an outer lining. A warhead comprising a casing as defined in claims 1-8.

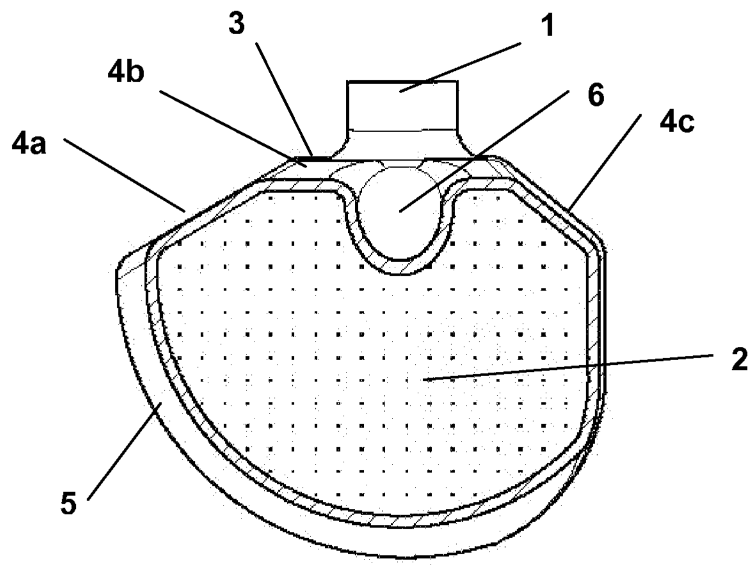

Figure 1

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Description

[0001] The present invention relates to a casing for a warhead or a warhead module.

Prior art

[0002] Warheads used for various weapons systems typically comprise warhead casings manufactured from aluminium or steel. These materials are chosen for the casings since they need to be strong and have sufficiently low weight. However, such warheads have the disadvantage that they are likely to cause collateral damage, due to splinter from the warhead casing.

[0003] Attempts have been made to find alternative materials for warhead casings. In US 5000093 A, a warhead casing is described which is made by isostatically pressing a mixture of magnesium and aluminium powder into a preform and then sintering the preform. This method may be suitable for simple warhead configurations, whereas more complicated configurations require additional machining after sintering. DE 10208228 describes a rotation symmetrical grenade having a casing of porous aluminium.

[0004] There is a desire to avoid collateral damage, and thus there is a need to provide a warhead casing that fulfils the requirements set on warhead casings regarding weight and strength, but which does not cause collateral damage.

Summary of the invention

[0005] According to the present invention a warhead casing is provided which is made up of laser sintered material. A laser sintered warhead casing presents several advantages over the casings previously available. It is splinter proof, whereby collateral damage can be avoided, and it can be made in one piece as opposed to steel or aluminium metal casings which have to be manufactured in separate components which are finally assembled. Moreover, laser sintering of the warhead casing allows for more complex geometries than have previously been possible to obtain for warheads in a simple way.

[0006] The laser sintered material has a density that is sufficiently low, for use in a warhead casing, and the weight is lower than the weight of aluminium alloys, which have a density of 2,7-2,8 g/cm^3.

Brief description of the drawings

[0007]

Figures 1-3 illustrate examples of different geometries for warhead casings.

Detailed description of the invention

[0008] By manufacturing casings for warheads or warhead modules by selective laser sintering technique, a decrease in the weight of such components can be achieved, since laser sintered materials have lower density than solid materials.

[0009] Warhead casings are typically rotationally symmetrical. However, due to the flexibility of laser sintering other geometries may be contemplated, so that the warhead casing may be unsymmetrical. The warhead casing has the form of a hollow container, which is typically provided with an opening for filling of explosive. The hollow container comprises one or more wall surface portions, which constitute the container wall. The wall surface portions may be flat or curved. The filling opening may be a cylindrical portion protruding from one of the wall surfaces.

[0010] As an example, the warhead casing may have an unsymmetrical geometry, defining a hollow body, having a flat upper wall and a somewhat curved lower wall opposite the upper wall, a rear flat wall and a front flat wall. The height of the hollow body is larger at the rear end, than at the front end. An opening for filling with explosives is arranged in the flat upper surface, close to the rear wall.

[0011] Figures 1-3 illustrate examples of different geometries for warhead casings. The warhead casing of Fig. **1** has an opening **1** for filling of explosive **2**, arranged in a flat upper wall **3**, from which three flat wall surfaces **4a, 4b, 4c** extend sloping slightly downwards. All these three flat wall surfaces are connected to a rounded wall surface **5** which constitutes the wall opposite the filling opening. In one of the flat surfaces **4b** and partly in the rounded wall surface is provided an indentation **6.**

[0012] Fig. 2 illustrates a geometry in which the filling opening **7** extends from a circular surface 8, from which a rounded surface 9 extends downwardly in the form of a truncated cone. At the lower end of the lower wide end of the conical surface flat surfaces **10** extend. Three indentations **11** are provided in these flat surfaces. The bottom surface **12** opposite to the filling opening is flat.

[0013] The geometry illustrated in Fig. 3 has the form of an elongated container having the filling opening (not shown) arranged in a side wall at the end of a truncated cone. The longitudinal cross-sectional area at the centre of the container (the cross-section of which is shown in Fig. 3) is larger than the cross-sectional area at each side of the container. Indentations **13** are provided in the central portion of the container wall surface.

[0014] Laser sintering has hitherto primarily been used for manufacturing of prototypes for this application. The strength of laser sintered material is not sufficient without reinforcement for extremely high launch forces, but good enough for moderate launch forces. Laser sintering allows for shaping of complex geometries in one piece, and normally no further machining is required, except possibly clearing of screw threads. An example of the laser sintering technology is described in EP0734842A1.

[0015] Laser sintering technology utilizes a model of the object to be manufactured, such as a CAD model. A laser beam is moved layer by layer over a powder bed of fine particles in accordance with the model. The laser beam locally heats the powder to the melting point, without the temperature exceeding the melting point, and the powder grains are thereby sintered together. An article having the same geometry as the model is thus built up layer by layer. On cooling the finished model is broken out of the "cake" of unsintered powder and brushed clean. Selective laser sintering allows generating complex three dimensional objects by consolidating successive layers of powder material on top of each other.

[0016] The powder blend for manufacture of the warhead casing of the present invention comprises metal particles and particles of a binding component. The powder blend may comprise fine grained aluminium powder and polymer powder.

[0017] The preferred average grain size of the aluminium powder is 10-90 μm, more preferably 30-70 μm, and most preferably 45-55 μm.

[0018] The polymer used is preferably a polyamide, such as nylon powder, which may have a particle diameter of 0,05-0,2 mm. The polyamide improves the binding of the particles to each other. An example of a laser sintered material suitable for warhead casings or warhead modules is Alumide®, available from EOS Gmbh, Germany. Alumide® is made up of 50% fine aluminium powder suspended in polyamide (Nylon 12).

[0019] An alternative polymer may be polychlorotrifluoroethylene (PCTFE) which is fluorocarbon based polymer. PCTFE may be favourable in view of the enhanced combustion properties.

[0020] An alternative to aluminium powder in the laser sintered material may be magnesium powder.

[0021] The surfaces of the laser sintered parts can be finished by grinding, polishing, or coating. An additional advantage is that low tool-wear machining is possible, e.g. milling, drilling, or tuning.

[0022] Subsequent to forming, the laser sintered warhead casing is filled with a desired explosive composition. The explosive composition preferably includes aluminium powder. Aluminium plays an important role in both the shock response and energy release rates of energetic materials.

[0023] When the explosive composition detonates, the aluminium powder of the explosive composition is dispersed and rapidly burns. At the same time the casing is disintegrated. As the warhead casing is made up of laser sintered aluminium and/or magnesium, the metal grains that the casing was made up of will participate in the explosive reaction and will thus contribute to the effect obtained.

[0024] The explosive composition used in the in the warhead may include aluminium powder in an amount of 15-50 % by weight of the total composition, which reacts with the air oxygen. Too high aluminium powder content doesn't serve any purpose, since the air oxygen available for reaction is limited. An aluminium powder content of approximately 19-21 % by weight, results in an explosive composition that is easy to handle and easy to fill in the warhead casing. The aluminium powder typically has an average particle size between 12 and 18 μm.

[0025] The explosive composition may be based on a nitroamine explosive, such as RDX (hexogen or cyclotrimethylene-trinitramine) or HMX (octogen or cyclotetramethylene-tetranitramine), and may in addition to aluminium powder also comprise a binder. The amount of nitroamine explosive (e.g. RDX) may be approximately 65% by weight of the explosive composition. The binder may be present in approximately 15% by weight.

[0026] The binder may comprise a binder agent (e.g. HTPB (hydroxyl-terminated polybutadiene)), plasticizer (e.g. DOA (dioctyl adipate)), surfactant (e.g. DHE (N,N-di-(2-hydroxyethyl)-4,4-dimethylhydantoin)), cure catalyst (e.g. triphenylbismuth) and curing agent (e.g. IDPI (isophorone diisocyanate)).
A specific example of a suitable explosive is PBXN-109, comprising 65% RDX, 15% HTPB (binder) and 20% Al.

[0027] As the laser sintered material is not completely impermeable, it may be necessary to provide the casing with a sealing lacquer coating before filling it with the explosive, in order to enhance the impermeability. The lacquer coating must be compatible with the explosive, to avoid undesired reactions. The lacquer may for example be an epoxy resin lacquer, such as RenLam®, comprising resin and curing agent (e.g. RenLam LY 113/HY 97).

[0028] The laser sintered casing may also be reinforced by an outer lining of reinforced fibre type, e.g. carbon or Kevlar, to be able to withstand large launching forces.

[0029] The warhead casing thus manufactured will be splinter free, unless it is not provided with an additional metal casing.

[0030] As the explosive composition of the warhead detonates, the aluminium powder of the explosive composition will ignite and burn.

Example

[0031] A test warhead casing was manufactured by laser sintering of Alumide®. The test warhead was a cylindrical, hollow body with a material thickness of 4mm and a weight of 375 g, which was filled with 2 kg explosive composition PBXN-1 09. The warhead was lacquered with RenLam®.

[0032] The test warhead casing was subjected to low temperature and high temperature tests. In each test the test warhead casing was placed in Weiss 1 climate chamber. Under a first period of time, the temperature in the climate chamber was changed from an initial temperature to a goal temperature. Under a second period of time the temperature in the climate chamber was maintained at the goal temperature, and under a third period of time the temperature in the climate chamber was changed from the goal temperature to en end temperature.

[0033] After each test, the test warhead was examined for damages, by means of ocular inspection. No damages could be observed.

[0034] Temperatures and duration of time periods are displayed in Table 1 below.

Table 1

	Initial temp (°C)	Goal temp. (°C)	Time to reach goal temp. (hours)	Time period maintained at end temp. (hours)	End temp. (°C)	Time to reach end temp. (hours)	Damages observed after test period (yes/no)
Low temperature test	+21	-46	12	24	+21	12	no
High temperature test	+21	+75	12	48	+21	12	no

[0035] The test warhead was also subjected to a vibration test (STANAG 4242/APO-34). In this test the warhead was mounted on a fixture of a test equipment (vibrator system LDS 954, amplifier MPA 32, control system DACTRON Dual DSP) and was subjected to vibrations for two hours in each of three directions (x-, y-, and z-directions) in a temperature of approx. 20 °C. The measuring equipment used was an accelerometer KISTLER ICP. Thereafter, the test casing was examined for damages. No damages could be observed.

[0036] Comparative calculations performed on warhead casing of steel and laser sintered Alumide® show that the laser sintered Alumide® casing should theoretically result in an increased over pressure of 28% in a volume of 40 m^3.

Claims

1. A casing for warhead components, which casing is made up of a laser sintered material.

2. The casing of claim 1, wherein the laser sintered material comprises metal powder and binder particles.

3. The casing of claim 2, wherein laser sintered material comprises aluminium powder and polymer particles.

4. The casing of claim 3, wherein said aluminium powder has an average grain size of 10-90, preferably 45-55 μm.

5. The casing of claim 2 or 3, wherein the polymer particles comprise a polyamide.

6. The casing of claim 2 or 3, wherein the polymer particles comprise a polychlorotrifluoroethylene.

7. The casing of any one of claims 1-6, wherein the casing is provided with a lacquer coating.

8. The casing of any one of claims 1-7, wherein the casing is provided with an outer lining of e.g. Kevlar.

9. A warhead comprising a casing as defined in claims 1-8.

10. The warhead of claim 9, wherein the casing is filled with a polymer bonded explosive composition comprising a binder, and aluminium powder.

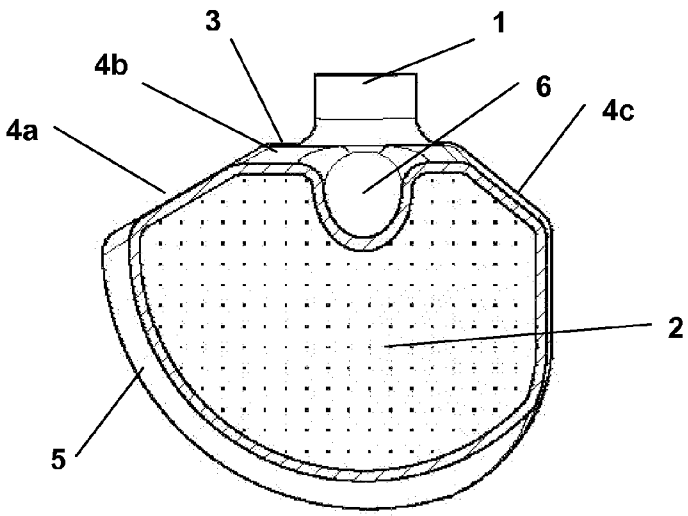

Figure 1

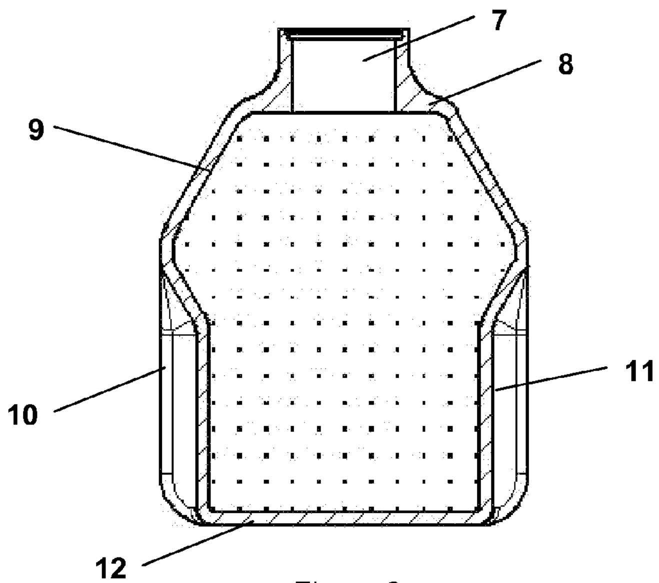

Figure 2

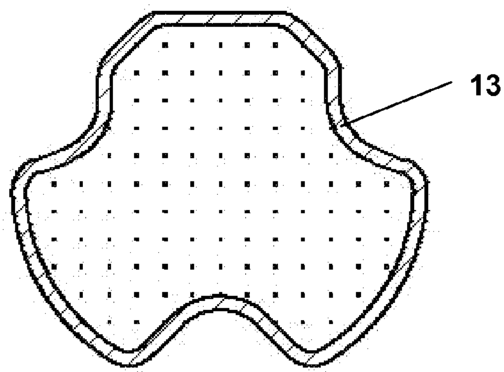

Figure 3

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EUROPEAN SEARCH REPORT

Application Number
EP 07 12 3506

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2005/235862 A1 (GOUSMAN KENNETH G [US] ET AL) 27 October 2005 (2005-10-27) * abstract * * paragraphs [0006], [0007], [0030], [0031], [0037], [0040], [0047] * * figures 1,3 * -----	1-10	INV. F42B12/76
X	EP 0 392 084 A (RHEINMETALL GMBH [DE]) 17 October 1990 (1990-10-17) * abstract * * column 4, line 25 - column 6, line 2 * * claims 7,11 * * figures 1,2 * -----	1,2,5-9	
D,A	EP 0 734 842 A (EOS ELECTRO OPTICAL SYST [DE]) 2 October 1996 (1996-10-02) -----		

TECHNICAL FIELDS SEARCHED (IPC)	F42B B29C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	27 May 2008	Menier, Renan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 07 12 3506

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27-05-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005235862 A1	27-10-2005	NONE	
EP 0392084 A	17-10-1990	DE 3911575 A1	11-10-1990
EP 0734842 A	02-10-1996	DE 19511772 A1	02-10-1996
		JP 4054075 B2	27-02-2008
		JP 8281807 A	29-10-1996
		US 5753274 A	19-05-1998

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5000093 A **[0003]**
- DE 10208228 **[0003]**
- EP 0734842 A1 **[0014]**