Hardkill active protection countermeasure

based on explosively formed projectile, in particular intended for armoured tracked and wheeled vehicles and stationary equipment, consists of linear projectile profile explosively formed from metal liner (1) by means of plastic explosive initiatory elongated charge (2). The initiatory elongated charge (2) is placed at the back of the metal liner (1).

FIG. 3
Description

Field of the Invention

[0001] The invention concerns a hardkill active protection countermeasure, in particular, the protection of tracked and wheeled armoured vehicles and stationary equipment and especially the protection against high velocity projectiles.

Background of the Invention

[0002] Tracked, wheeled and stationary materiel is protected against KE (Kinetic Energy) and CE (Chemical Energy) threats by means of passive protection, possibly completed by additional reactive armour protection. Armour materials based on steel, aluminium alloys, ceramics and polymers in homogenous, layered or composite form mainly represent the passive protection. The additional reactive protection uses, except metals, also explosives and elastomers. With increasing demands on ballistic protection of armoured vehicles, the potential of passive and reactive protection is essentially reaching its limits. The perspective technique could be developed through use of active protection principles.

[0003] The reactive protection is usually applied as add on armouring in form of modules initiated at projectile impact. The modules of reactive protection are commonly designed as a steel armour plate accelerated by explosive energy etc.

[0004] The active armouring (DAS - Defence Aid Suite or APS - Active Protection System) represents the systems of protection, which are able to detect and track the incoming threats with following avoidance of weapon hit or reduction of their effect. The principle of so-called soft kill systems is based on the use of electromagnetic jamming, decoy and use of false signals. The goal of these techniques is avoiding the missile hit of the vehicle. The function of hard kill systems of active protection is focused on destruction, deviation or eventual damage of the missile before its target impact. The term “active protection” represents (further in text) the systems of hard kill type. Detection and tracking systems (microwave and infra-red) are components of the active protective system. These systems are supposed to detect the threat, to analyze its characteristics (velocity, size, direction etc.) and evaluate protected target hazard exposure. In the case that system detects target hazard the protective system is initiated. The countermeasure is fired against the approaching CE or KE threat. The counter-munition could have a form of high explosive charges - fragments, large number of small axial symmetrical EFP or shape charges, bars or “flying” plates accelerated explosively or electro-magnetically.

[0005] Different systems of active ballistic protection are also known from available patent documents. For example, the document US 5577432 describes protective countermeasure against threats based on reactive armouring. The armouring consists of individual modules with explosively accelerated plate. The plate is accelerated against the threats according to signal from additional armour, which is placed in proper distance in front of reactive armour.

[0006] The document US 5625160 describes protective device fitted on the structure placed on the front side of protected armour vehicle. The device consists of two parallel plates with accelerating device placed between them. On the base of signal from monitoring and control unit, the plates are explosively or electromagnetically fired in mutually opposite directions against attacking projectiles.

[0007] The document US 6244156 describes another kind of protection based on firing the high explosive energy shell against the attacking threat, especially against KE projectile. Monitoring and control unit belonging to protected object determines an optimal timing for shell firing.

[0008] Another active protection consisting of at least one module equipped by shape charge and monitoring, control and firing unit is known from document US 6227955. The control system provides start reaction of given shape charges consequently destroying attacking projectile in the case of emergency.

[0009] Protective device formed from explosive charge intended for accelerating the metal block(s) against attacking projectile is known from document US 2003164087. The blocks are designed into the shape of long bars with length size equal or larger than 10x the smallest profile dimension. The blocks are accelerated in accordance with signal from monitoring and control unit.

[0010] Another system is described in the document US 5661254. The countermeasure is formed from two main parts, container represents the first one with at least one launcher for fragmenting charge. The second one consists of control and tracking unit. Fragments are defeating the incoming warhead.

[0011] Following system intended for vehicle or stationary equipment protection is known from document GB 2234334. The system consists of independent modules, which are formed from plates or tubes fitted with conductive strips. The contact between the strip and attacking projectile is detected by the control unit, which provides appropriate countermeasure. Such countermeasure can be performed by means of module plates motion or explosive acceleration of other elements against projectile.

[0012] The document EP 922924 describes object protection based on acceleration of elements of different shapes against incoming projectile. The elements can be accelerated by chemical, mechanical, pneumatic or hybrid way with possibility of accelerating to different directions.

[0013] Another system is described in the document DE 19640991. The system consists of boxes formed from two plates segregated by explosive. The box also con-
the hard kill active protection countermeasure according to invention may not be reached.

[0021] The shaped stripe of the liner is to advantage created in the following way. There is at least one area rounding and/or at least one rectangular or obtuse angle cranking in the longitudinal axis. The rounding can be performed by way of cylindrical, oval or similar surface, the cranking by way of one or two bends (from 90 to 180°). Both forming, rounding and cranking, can be possibly combined.

[0022] The metal liner is thus open at the side en face the initiatory elongated charge. This fact supports explosive forming of linear projectile profile as a hard kill active protection countermeasure according to invention. Nevertheless, the metal liner could be in principle formed even by flat stripe.

[0023] The metal liner is in its standard design formed by stripe, which is at least 3x longer than wide.

[0024] On account of creating the linear explosively formed projectile profile, the metal liner (or stripe, which is the liner formed from) can vary in its thickness along the cross section. The metal liner is generally thickest in its middle part and the thickness is decreasing in the direction to longer edges. Thickness of the edges can vary from 0.1 to 1.0 multiple of the maximum liner thickness.

[0025] The elongated charge is often formed from disruptive plastic explosive with minimal hexogen (RDX) or oktogen (HMX) content of 80 % by weight and detonation velocity over 7000 m/s. The amount of explosive is to be set according to final ballistic coefficient (the ratio between explosive weight and metal liner weight), which is supposed to be min. 1.2.

[0026] On account of creating the linear explosively formed projectile, the explosive layer can vary in its thickness along the cross section. The explosive layer is generally thickest in its middle part and the thickness is decreasing in the direction to longer edges. The thickness of the edges can vary from 0.1 to 1.0 multiple of the maximum explosive thickness.

[0027] The hardkill active protection countermeasure according to invention is a powerful tool when protecting vehicles or stationary objects. The explosively formed linear projectile profile can be formed by means of interactions violate the integrity of long-rod projectile, missile with shaped charge or EFP or change their trajectory.

**Summary of the Invention**

[0018] Such disadvantage is eliminated by hardkill active protection countermeasure, based on, according to the invention, linear explosively formed projectile (EFA). This system is intended for tracked and wheeled vehicles as well as stationary equipment. The principle of the invention is based on following facts. The system consists of linear projectile profile formed by explosion from the metal liner by means of initiatory plastic explosive elongated charge. The initiatory elongated charge is placed at the back of the metal liner.

[0019] The explosion of initiatory elongated charge forms the metal liner into a profile of "axe-like" shape. This profile, when fired against the moving projectile, destroys, bends or diverts the projectile.

[0020] The metal liner is to advantage composed of appropriately shaped metal stripe. The minimum density of the material is 7.8 g/cm³, which is density minimally equal or higher than density of iron. The material must show high plasticity, proved by minimal ductility of 20%. Such material could be represented by commercially pure iron, low carbon unalloyed steel, commercially pure tantalum and tantalum alloys, commercially pure molybdenum and molybdenum alloys, commercially pure wolfram and wolfram alloys, commercially pure copper and copper alloys or commercially pure nickel and nickel alloys. However the metal liner can be manufactured from material with lower density than density of iron. In such case the optimal or even the highest possible effect of the hard kill active protection countermeasure according to invention may not be reached.

[0021] The shaped stripe of the liner is to advantage created in the following way. There is at least one area rounding and/or at least one rectangular or obtuse angle cranking in the longitudinal axis. The rounding can be performed by way of cylindrical, oval or similar surface, the cranking by way of one or two bends (from 90 to 180°). Both forming, rounding and cranking, can be possibly combined.

[0022] The metal liner is thus open at the side en face the initiatory elongated charge. This fact supports explosive forming of linear projectile profile as a hard kill active protection countermeasure according to invention. Nevertheless, the metal liner could be in principle formed even by flat stripe.

[0023] The metal liner is in its standard design formed by stripe, which is at least 3x longer than wide.

[0024] On account of creating the linear explosively formed projectile profile, the metal liner (or stripe, which is the liner formed from) can vary in its thickness along the cross section. The metal liner is generally thickest in its middle part and the thickness is decreasing in the direction to longer edges. Thickness of the edges can vary from 0.1 to 1.0 multiple of the maximum liner thickness.

[0025] The elongated charge is often formed from disruptive plastic explosive with minimal hexogen (RDX) or oktogen (HMX) content of 80 % by weight and detonation velocity over 7000 m/s. The amount of explosive is to be set according to final ballistic coefficient (the ratio between explosive weight and metal liner weight), which is supposed to be min. 1.2.

[0026] On account of creating the linear explosively formed projectile, the explosive layer can vary in its thickness along the cross section. The explosive layer is generally thickest in its middle part and the thickness is decreasing in the direction to longer edges. The thickness of the edges can vary from 0.1 to 1.0 multiple of the maximum explosive thickness.

[0027] The hardkill active protection countermeasure according to invention is a powerful tool when protecting vehicles or stationary objects. The explosively formed linear projectile profile can be formed by means of interactions violate the integrity of long-rod projectile, missile with shaped charge or EFP or change their trajectory.

**Brief Description of the Drawing**

[0028] The invention will be further explained using example drawings of the hardkill active protection countermeasure according to invention. Following figures are displayed in the perspective.

Fig. 1 hardkill active protection countermeasure with metal liner - angle 180°

Fig. 2 hardkill active protection countermeasure with metal liner - angle 90°
Fig. 3  hardkill active protection countermeasure with metal liner - angle 150° and varying thickness

Fig. 4  hardkill active protection countermeasure with metal liner with multiple bends

Fig. 5  hardkill active protection countermeasure with metal liner shaped as a part of cylindrical surface

Description of the Preferred Embodiment

Example 1

[0029] The hardkill active protection countermeasure (Fig. 1) consists of linear projectile profile formed by explosion from metal liner 1 by means of initiatory plastic explosive elongated charge 2. The initiatory elongated charge 2 is placed at the back of the metal liner 1. The metal liner 1 is a flat stripe manufactured from plain low carbon steel with opening angle 180°. The initiatory elongated charge 2 is made from plastic explosive with hexogen content of 88 % by weight and detonation velocity 7850 m/s.

[0030] The length of the metal liner stripe 1 is 250 mm, width 33 mm and thickness 3 mm. The thickness of the initiatory charge 2 is 30 mm.

Example 2

[0031] The hardkill active protection countermeasure (Fig. 2) consists of linear projectile profile formed by explosion from metal liner 1 by means of initiatory plastic explosive elongated charge 2. The initiatory elongated charge 2 is placed at the back of the metal liner 1. The metal liner 1 is the shaped stripe manufactured from commercial pure tantalum, which is rounded in the direction of its longitudinal axis (150°). The initiatory elongated charge 2 is made from plastic explosive with oktogen content of 88 % by weight and detonation velocity 8 100 m/s.

[0032] The length of the metal liner stripe 1 is 250 mm, width 36 mm and thickness 2 mm. The length of the side wings, created by cranking, is 8 mm. The thickness of the initiatory elongated charge 2 is 25 mm in the whole cross-section.

Example 3

[0033] The hardkill active protection countermeasure (Fig. 3) consists, same as previous examples, of linear projectile profile formed by explosion from metal liner 1 by means of initiatory plastic explosive elongated charge 2. The initiatory elongated charge 2 is placed at the back of the metal liner 1. The metal liner 1 is the shaped stripe manufactured from commercially pure copper of variable thickness. The stripe is cranked in the direction of its longitudinal axis (angle 150°). The initiatory elongated charge 2 is also made from plastic explosive with hexogen content of 88 % by weight and its thickness is variable.

[0034] The length of the metal liner stripe 1 is 250 mm, width 35 mm. The thickness is maximal in the axis of the bend, where it reaches 3 mm and it is regularly reduced to 0.3 mm at the edges. The thickness of the initiatory charge 2 is maximal in the axis of the bend, where it is 30 mm and it is regularly reduced to 3 mm at the edges.

Example 4

[0035] The hardkill active protection countermeasure (Fig. 4) is similar to previous examples. The metal liner 1 consists of shaped stripe made from nickel alloy containing 65 % by weight of nickel, 31 % by weight of copper, 2 % by weight of iron, 1.5 % by weight of manganese and usual accompanying elements and impurities. The stripe is doubly cranked in the direction of its longitudinal axis (150°). The initiatory elongated charge 2 is made from plastic explosive with oktogen content of 88 % by weight and detonation velocity 8 200 m/s.

[0036] The length of the metal liner stripe 1 is 250 mm, width 36 mm and thickness 2 mm. The length of the side wings, created by cranking, is 8 mm. The thickness of the initiatory elongated charge 2 is 25 mm in the whole cross-section.

Example 5

[0037] The hardkill active protection countermeasure (Fig. 5) differs from the previous examples in its design. The metal liner 1 consists of shaped stripe made from commercially pure tantalum, which is rounded in the direction of its longitudinal axis. The radius of rounding is 85 mm. The initiatory elongated charge 2 is made from plastic explosive with oktogen content of 90 % by weight and detonation velocity 8 200 m/s.

[0038] The length of the metal liner stripe 1 is 250 mm, width 34 mm and thickness 1.5 mm. The thickness of the initiatory elongated charge 2 is 28 mm in the whole cross-section.

Field of the Application

[0039] The hardkill active protection countermeasure according to invention has a wide use, especially as an element of sensor operated systems intended for protection against moving missiles.

Claims

1. The hardkill active protection countermeasure based on explosively formed projectile, particular intended for armoured tracked and wheeled vehicles and stationary equipment, characterized by the fact, that it consists of linear projectile profile explosively

Field of the Application
formed from metal liner (1) by means of plastic explosive initiatory elongated charge (2), whereas the initiatory elongated charge (2) is placed at the back of the metal liner (1).

2. The hardkill active protection countermeasure according to claim 1 characterized by the fact, that the metal liner (1) consists of shaped stripe made from metallic material of minimum density 7.8 g/cm³ and high plasticity proved by ductility of 20 % or higher.

3. The hardkill active protection countermeasure according to claim 2 characterized by the fact, that the shaped stripe of the metal liner (1) is at least once area rounded and/or at least once cranked under rectangular or obtuse angle in the direction of its longitudinal axis.

4. The hardkill active protection countermeasure according to claim 2 characterized by the fact, that the shaped stripe of the metal liner (1) is in its standard design at least 3x longer than wide.

5. The hardkill active protection countermeasure according to at least one of the previous claims characterized by the fact, that thickness of the metal liner (1) varies and decreases in the edges direction, whereas thickness of the edges can vary from 0.1 to 1.0 multiple of its maximum thickness.

6. The hardkill active protection countermeasure according to at least one of the previous claims characterized by the fact, that the initiatory elongated charge (2) consists of plastic explosive with minimal hexogen (RDX) or oktogen (HMX) content of 80 % by weight and detonation velocity over 7000 m/s, whereas value of the ballistic coefficient is at least 1.2.

7. The hardkill active protection countermeasure according to at least one of the previous claims characterized by the fact, that thickness of the initiatory elongated charge (2) varies and decreases in the edges direction, whereas thickness of the edges can vary from 0.1 to 1.0 multiple of its maximum thickness.