

Description

Technical Field

The present invention relates to a reactive (or « dynamic ») protective armour for protection against a hollow explosive charge jet travelling in a path obliquely impinging on the armour, comprising two mutually spaced parallel metal plates, which can be penetrated by the jet to form a hole in said two plates, and further comprising an interlayer of non-explosive material located between the two plates. An example of this type of armour is shown in DE-A-2 201 637.

Background Prior Art

One conventional explosive-type reactive armour is known from U. S. Patent Specification No. 4 368 660. Incorporated between the plates of this known armour is an explosive substance which will detonate when a hollow charge jet or like projectile impinges on the reactive armour, the subsequent detonation pressure causing the two plates to move away from each other and therewith greatly degrade the hollow charge jet.

The plates of such protective armour, however, need to be relatively large in order to function effectively, and consequently commensurately large quantities of explosive must be used in order to achieve the effect desired. One drawback in this regard is that the explosive forces generated by such large quantities of explosive are liable to result in damage to the object protected by the armour (e. g. an armoured vehicle or tank).

Armours are also known having an interlayer of a nonexplosive material between the plates. Such an armour is disclosed in DE-A-2 151 015 and DE-A-2 201 637 having an interlayer of polyamide and polyurethane foam, respectively, i. e. a compressible material. The compressible material is disadvantageous since almost all of the energy present in the shockwaves created in the plates by the hollow charge jet will be dissipated in dislodging or punching material from the plates.

FR-A-2 029 343 discloses an armour having one single steel plate with several oxygenous layers. The hollow charge jet is to be disturbed solely by combustion of the oxygenous layers. In order to fasten the combustion a catalysator may be provided, in which case the steel plate is divided into two plates, the catalysator being located therebetween.

Summary of the Invention

The object of the present invention is to provide a protective reactive armour which makes use of a nonexplosive charge to fulfill its protective function, and which is based upon a new discovery that shockwaves created by the jet in the two plates can be used to effectively disturb the jet.

This object is achieved with a reactive armour arrangement having the inventive features set

forth in the characterizing clause of the following Claim 1.

Further developments of the invention are set forth in the depending claims.

The invention is based on the discovery that the intrinsic energy of the hollow explosive charge jet in itself can be used to create shockwaves of different pressures in the plates and in an interlayer of the reactive armour arrangement. The pressure differentials created result in two counter-directional forces which tend to move the plates away from one another, in a manner which causes fresh plate material to be moved progressively into the path of the hollow explosive charge jet, thereby reducing the energy of the jet.

Compressible materials such as, e. g. rubber, or gases, e. g. air, cannot be used to form the interlayer since almost all of the energy present in the shockwaves is dissipated in dislodging or punching material from the plates. The interlayer material should therefore be incompressible and possess a high dynamic mechanical strength.

The physical explanation of the shockwave effect is that practically total reflection of a shockwave takes place when the shockwave moves from a medium of relatively high density to a medium of lower density. Thus, in the case of the inventive protective arrangement, an impinging hollow charge jet will initiate in the outer plate a first shockwave which is reflected towards the thinner interlayer, this procedure being repeated some microseconds later behind the tip of the jet or thorn in the inner plate. This results in two forces which act in mutually opposite directions and which tend to draw the plates apart. It has been found, in accordance with the invention, that an optimal shockwave effect is obtained when the interlayer comprises an incompressible material and has a density which is at most 1/3 of the density of the plates.

The hollow charge jet will create in the protective armour arrangement a hole which is inversely proportional to the flow stress of the outer material and which is greater than the diameter of the hollow charge jet. Due to the aforesaid counter-direction forces, the edges around the hole will be lifted to form a bulged or crater-like surround, such that the plate material around the hole will move progressively into the path of the obliquely impinging jet, thereby causing the jet to penetrate further material with a subsequent decrease in jet energy.

The invention can also be explained in terms of shockwave pressure. For example, it has been established experimentally that when the shockwave pressure in the plates is p_1 pressure units and the shockwave pressure in the interlayer is p_2 pressure units, the optimal outward bulging or lifting of the plate material surrounding the hole is obtained when $p_1/p_2 =$ about 7. An acceptable outward lifting of the hole-defining edges is obtained within the range $2 < p_1/p_2 < 12$.

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Thus, the energy transmitted from the hollow charge jet to the protective armour arrangement (excluding the penetration energy) is converted to kinetic energy for movement of the armour plates, which therewith expand at a certain velocity. The rate of expansion increases with the energy content of the jet tip or thorn, but decreases with the mass of the outer plates.

Degradation ceases when the jet no longer touches the protective armour, this loss of contact possibly being due to the fact that the plates have been lifted sufficiently in the region of the hole-defining edges thereof, or because the plates have ceased to expand.

The plates will suitably have a thickness between 2 and 20 mm, preferably between 2 and 10 mm, in order to ensure that the hole-defining edges will be lifted or upwardly bulged, to the extent desired, i.e. to ensure that sufficient plate material is shifted into the path of the hollow charge jet.

The plates are preferably joined together by strips which function as hinges and which concentrate the rate of expansion for the protective armour to the region thereof around the entrance hole. It has been found in practice, however, that the plate material located in the vicinity of the hole will tend to lift even when the plates are not connected together with the aid of such strips, thereby indicating that their presence is not absolutely necessary.

In order to degrade effectively the hollow charge jet, the plates should exhibit high dynamic mechanical strength, a high density, and have a high expansion rate. According to one preferred inventive feature the plates have a density greater than $4 \cdot 10^3 \text{ kg/m}^3$, and preferably greater than $7 \cdot 10^3 \text{ kg/m}^3$. The plates may suitably comprise e.g., steel and tungsten, which together with, e.g., ethylene plastic in the interlayer satisfactorily fulfils the aforesaid conditions.

The dynamic yield point or flow stress $\sigma_{0.2}$ of the inventive plate material should, in accordance with one inventive feature, exceed 60 MN/m^2 .

The interlayer is preferably comprised of a solid or liquid non-explosive material, e.g. rubber, plastic, water, or some other inert substance of low density, although at least 750 kg/m^3 , and low shockwave pressure in response to a hollow charge jet impact.

The interlayer may alternatively comprise a semi-inert material, i.e. a material which when subjected to high pressure, e.g. a pressure in the order 1-2 GPa, gives rise to partial deflagration (combustion) or detonation. By partial is meant here that deflagration or detonation only takes place in the high pressure regions, i.e. does not propagate from these regions.

Examples of such semi-inert materials are various solutions of formaldehyde or its compounds, e.g. an aqueous solution of formaldehyde or a solution of formaldehyde in water and methanol, or alternatively a formaldehyde trimer (trioxane) or various forms of homopolymers or copolymers of polyoxymethylene (polyformaldehyde). Other

substances rich in oxygen or halogens may also be used. Additional « activity » is achieved when readily sublimated substances are used, e.g. such as the aforesaid trioxane, or ethylene carbonate.

Brief Description of the Drawings

The invention will now be described in more detail with reference to the accompanying drawings.

Figure 1 illustrates a preferred embodiment of an inventive projective armour arrangement in a non-activated state.

Figure 2 illustrates the protective armour arrangement of Figure 1 in an activated state.

Figures 3a-d are schematic illustrations of four various stages of penetration of the hollow explosive charge jet into the protective armour arrangement.

Figure 4 illustrates from above a protective armour arrangement that has been penetrated by a hollow charge jet.

Description of a Preferred Embodiment

Figures 1 and 2 illustrate schematically a « dynamic » protective armour arrangement which comprises one or more panels structures 3, of which only one is shown and this in cross-section. Each panel structure 3 comprises two mutually parallel plates 4 and 5 which are joined together in spaced apart relationship with the aid of joining strips 6 and 7 located at the edges of respective plates, such that all plates together form a container-like structure, the plates being of square configuration for example, and said plates and said strips being made, e.g. of steel. The container-like structure thus formed is filled with an inert substance, e.g. rubber, plastic or water, which forms the aforementioned interlayer.

When the hollow charge projectile 2 detonates, it generates, in a known manner, a hollow charge jet or thorn 9 which bores a hole 10 in the outer plate 4 and a hole 11 in the inner plate 5 of the container-like structure. The resultant shockwaves are reflected in the plates 4 and 5 in the aforescribed manner, therewith to lift the plate material around the holes 10 and 11 forming conical or crater-like bulges at the hole-surrounds, as illustrated in Figure 2. The jet or thorn is therewith degraded, as shown at 9a, and will penetrate the target 1 to the extent illustrated by reference 9b in Figure 2. The reference 9c designates the extent to which a hollow charge jet would penetrate the target if the target were not protected by the inventive dynamic armour arrangement.

The movement executed by the plates 4 and 5 is illustrated more clearly in Figures 3a-d.

Figure 3a illustrates a hollow explosive charge jet which impinges obliquely on the outer plate 4 of the protective armour arrangement. Figure 3b shows how the jet will penetrate the plates 4 and 5, to form a hole 10 in the outer plate 4 and a hole

11 in the inner plate 5. As beforementioned, the hollow explosive charge jet is degraded, as illustrated at 9a. The shockwave forces in the plates 4 and 5 create crater-like bulges 12a, 12b in the plate material surrounding the respective holes 10 and 11, cf. Figure 3c.

Because the plate material bulges around the holes 10, 11 in the aforesaid manner, fresh plate material will be progressively shifted into the path of the jet or thorn 9 as the bulges form. The length extension 13 in Figures 3d and 4 illustrates the extension of plate material moved into the path of the jet. The plates material contained in said displaced plate extension is sawn by the hollow charge jet in the manner illustrated at 14 in Figure 4, said Figure illustrating schematically a fragment of the plate 4 and show the appearance of the hole 10 subsequent to cessation of the hollow charge jet.

Claims

1. A reactive protective armour for protection against a hollow explosive charge jet travelling in a path obliquely impinging on the armour, comprising two mutually spaced parallel metal plates (4, 5) which can be penetrated by the jet to form a hole (10, 11) in said two plates, and further comprising an interlayer (8) of non-explosive material located between the two plates, characterized in that the two plates having a density greater than $4 \cdot 10^3 \text{ kg/m}^3$, a flow stress $\sigma_{0.2}$ greater than 60 MN/m^2 , and a thickness between 2 and 20 mm in order to ensure a desired lift of plate material around an edge of said hole as a result of shockwave pressure created in said two plates by said jet and in that the interlayer (8) is comprised of an incompressible material and has a density which is at the most $1/3$ of the density of respective plates, resulting in different shockwave pressures being created in the interlayer and in the plates, respectively, from which it follows that the different shockwave pressures will strive to move the plates apart, whereby said plate material around the edge of the hole will be moved progressively into said path of the jet.

2. A reactive protective armour according to Claim 1, characterized in that the interlayer has a density of at least 750 kg/m^3 .

3. A reactive protective armour according to any of the preceding Claims, characterized in that the plates (4, 5) are joined together at their respective edges, e. g. by means of strips (6, 7).

4. A reactive protective armour according to any of Claims 1-3, characterized in that the interlayer (8) is comprised of homopolymers or copolymers of polyoxymethylene in various forms (i. e. acetal resin).

5. A reactive protective armour according to any of Claims 1-3, characterized in that the interlayer (8) is comprised of a formaldehyde solution.

6. A reactive protective armour according to any of claims 1-3, characterized in that the inter-

layer (8) is comprised of a formaldehyde compound.

7. A reactive protective armour according to any of Claims 1-3, characterized in that the interlayer (8) is comprised of a readily sublimated substance, such as trioxane or ethylenecarbonate for example.

8. A protective armour arrangement according to any of Claims 1-3, characterized in that the interlayer (8) is comprised of substances rich on oxygen or halogens.

Patentansprüche

1. Reaktiver Schutzpanzer zum Schutz gegen ein Geschöß mit einer explosiven Hohlladung, das auf seiner Flugbahn schräg auf den Panzer auftrifft, der zwei wechselseitig beabstandete parallele Metallplatten (4, 5) aufweist, die von dem Geschöß durchdrungen werden können, um ein Loch (10, 11) in den zwei Platten zu bilden, und der weiterhin eine Zwischenschicht (8) aus nicht-explosivem Material aufweist, die zwischen den zwei Platten angeordnet ist, dadurch gekennzeichnet, daß die zwei platten eine Dichte größer als $4 \times 10^3 \text{ kg/m}^3$ haben, eine Zugbelastung $\sigma_{0.2}$ größer als 60 MN/m^2 , und eine Dicke zwischen 2 und 20 mm, um ein erwünschtes Abheben von Plattenmaterial um eine Kante des Loches als Ergebnis eines Verdichtungswellendrucks zu gewährleisten, der in den zwei Platten durch das Geschöß hervorgerufen wird und daß die Zwischenschicht (8) aus einem nichtverdichtbaren Material besteht und eine Dichte hat, die höchstens ein Drittel der Dichte der jeweiligen Platten beträgt, was zu unterschiedlichen Verdichtungswellendrücken führt, die in der Zwischenschicht in den Platten erzeugt werden, woraus folgt, daß die unterschiedlichen Verdichtungswellendrücke danach streben werden, die platten auseinanderzubewegen, wodurch das plattenmaterial um die Kanten des Loches zunehmend in den Geschößweg bewegt wird.

2. Reaktiver Schutzpanzer nach Anspruch 1, dadurch gekennzeichnet, daß die Zwischenschicht eine Dichte von wenigstens 750 kg/m^3 hat.

3. Reaktiver Schutzpanzer nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Platten (4, 5) an ihren jeweiligen Kanten z. B. mittels Streifen (6, 7) miteinander verbunden werden.

4. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus Homopolymeren oder Kopolymeren aus Polyoxymethylen in verschiedenen Formen (z. B. Azetalharz) besteht.

5. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus einer Formaldehydlösung besteht.

6. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus einer Formaldehydver-

11 in the inner plate 5. As beforementioned, the hollow explosive charge jet is degraded, as illustrated at 9a. The shockwave forces in the plates 4 and 5 create crater-like bulges 12a, 12b in the plate material surrounding the respective holes 10 and 11, cf. Figure 3c.

Because the plate material bulges around the holes 10, 11 in the aforesaid manner, fresh plate material will be progressively shifted into the path of the jet or thorn 9 as the bulges form. The length extension 13 in Figures 3d and 4 illustrates the extension of plate material moved into the path of the jet. The plates material contained in said displaced plate extension is sawn by the hollow charge jet in the manner illustrated at 14 in Figure 4, said Figure illustrating schematically a fragment of the plate 4 and show the appearance of the hole 10 subsequent to cessation of the hollow charge jet.

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2. Reaktiver Schutzpanzer nach Anspruch 1, dadurch gekennzeichnet, daß die Zwischenschicht eine Dichte von wenigstens 750 kg/m^3 hat.

3. Reaktiver Schutzpanzer nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Platten (4, 5) an ihren jeweiligen Kanten z. B. mittels Streifen (6, 7) miteinander verbunden werden.

4. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus Homopolymeren oder Kopolymeren aus Polyoxymethylen in verschiedenen Formen (z. B. Azetalharz) besteht.

5. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus einer Formaldehydlösung besteht.

6. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus einer Formaldehydver-



bindung besteht.

7. Reaktiver Schutzpanzer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus einer leicht-sublimierten Substanz besteht, wie z. B. Trioxan oder Ethylenkarbonat.

8. Schutzpanzeranordnung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zwischenschicht (8) aus Substanzen besteht, die reich an Sauerstoff oder Halogenen sind.

Revendications

1. Blindage de protection réactif pour assurer la protection contre une fusée explosive à charge creuse se déplaçant suivant une trajectoire tombant obliquement sur le blindage, comprenant deux plaques métalliques parallèles mutuellement espacées (4, 5) pouvant être traversées par la fusée pour former un trou (10, 11) dans ces deux plaques, et comprenant en outre une couche intermédiaire (8) en matériau non explosif placée entre les deux plaques, caractérisé en ce que les deux plaques présentent une densité supérieure à $4 \cdot 10^3 \text{ kg/m}^3$, une résistance au fluage $\sigma_{0.2}$ supérieure à 60 MN/m^2 , et une épaisseur comprise entre 2 et 20 mm, de manière à s'assurer d'un soulèvement voulu du matériau de plaque autour d'un bord du trou, par suite de la pression d'onde de choc créée dans les deux plaques par la fusée, et en ce que la couche intermédiaire (8) est constituée par un matériau incompressible et présente une densité atteignant au maximum 1/3 de la densité des plaques respectives, ce qui conduit à la création de pressions d'onde de choc différentes respectivement dans la couche intermédiaire et dans les plaques, d'où il résulte que les pressions d'onde de choc différentes doivent

tendre à écarter les plaques l'une de l'autre, de sorte que le matériau des plaques entourant le bord du trou doit être entraîné progressivement dans le chemin de la fusée.

2. Blindage de protection réactif selon la revendication 1, caractérisé en ce que la couche intermédiaire présente une densité d'au moins 750 kg/m^3 .

3. Blindage de protection réactif selon l'une quelconque des revendications précédentes, caractérisé en ce que les plaques (4, 5) sont reliées ensemble à l'endroit de leurs bords respectifs, par exemple au moyen de bandes (6, 7).

4. Blindage de protection réactif selon l'une quelconque des revendications 1 à 3, caractérisé en ce que la couche intermédiaire (8) est constituée par des homopolymères ou des copolymères de polyoxyméthylène sous différentes formes (c'est-à-dire de résine d'acétal).

5. Blindage de protection réactif selon l'une quelconque des revendications 1 à 3, caractérisé en ce que la couche intermédiaire (8) est constituée par une solution de formaldéhyde.

6. Blindage de protection réactif selon l'une quelconque des revendications 1 à 3, caractérisé en ce que la couche intermédiaire (8) est constituée par un composé de formaldéhyde.

7. Blindage de protection réactif selon l'une quelconque des revendications 1 à 3, caractérisé en ce que la couche intermédiaire (8) est constituée par une substance se sublimant facilement, telle que du trioxane ou de l'éthylènegarbonate par exemple.

8. Blindage de protection selon l'une quelconque des revendications 1 à 3, caractérisé en ce que la couche intermédiaire (8) est constituée par des substances riches en oxygène ou en halogènes.

