Composite Ballistic Shields

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Preface

No composite ballistic shields are manufactured in Poland. It still isn't a well-known matter, especially regarding specific, textile ballistic products. In this case the method of making the fibrous composite structural cohesion and homogeneity while providing its protective features calls for study. Consequently, the research towards designing and developing the objective composite product is essential.

The Institute of Security Technology „MORATEX", a body incorporated into hierarchy of the Ministry of Interior and Administration, executes currently the Key Project within the frame of Operational Programme Innovative Economy No.POIG01.03.01-10-005/08entitled:„Modernballisticbody armours and covers for transportation means as well as for buildings made on a basis of textile composites". The goaloftheProjectisdevelopmentofinnovativeproducts, that provide security to the officers of: Police, Border Guard, Government Protection Bureau and Fire Brigades. One of the product is the range of composite ballistic shields – the equipment for direct protection of health and life of officers who take parts in operational actions..

Bibliography says, that all of currently leading worldwide manufacturers make individual ballistic protectors, including the shields, of the fibrous composites on a basis of para-aramide or PE fibres. Such products feature unhesitatingly lower areal density then those of traditional materials i.e. armour steel, while providing the same level of protection. Yet they don't need maintenance and are corrosion-proof. Moreover, they are resistant to abrasion, strokes, chemical agents and water, UV radiation as well as to variable atmospheric conditions. In some cases they also act as effective cover against radar and thermovision [1, 2].

PE composite is of remarkable importance – it's the only available fibrous composite, which provides effective protection against standard carbine bullets 7.62x39 model 43 PS and against 7.62x51 NATO BALL. Other fibrous composites (e.g. aramide-phenolic or aramide-rubber) require reinforcing with a layer of ceramics or steel in order to reach similar class of protection. Among the materials resistant to the projectiles mentioned above (table 1), the PE composite allows for remarkable reduction of the product weight, thus increasing the usage comfort as well as improving the officer's mobility.

Table 1. Areal densities of selected materials [3].

item	Material	Areal density [kg/m^2]
1.	PE composite	21
2.	Composite of aramid + Al_2O_3 ceramics	38
3.	Ballistic steel	45
4.	Composite of glass + Al_2O_3 ceramics	54
5.	Aluminium	70

The information available across the Internet as well as the review and analysis of brochures form ballistic shields' worldwide manufacturers [6-8, 10-12] leads to conclusion, that the Police units in many countries are equipped with such a kind of product. The covers differ mainly with their level of protection, dimensions, design of handle, and extra accessories.

From the review one could conclude that the ballistic resistance of the shields is mainly defined by the requirements of NIJ Standard 0108.01 [4]. Concerning the ballistic resistance the shields might be divided into two groups i.e.: resistant to small arms (level III-A) and carbine bullets (level III, IV).

No matter what is the ballistic protection level, the shields consist of the following design elements:

- ballistic jacket,
- edge band,
- cushioning insert,
- handle,

and extra equipment.

The dimensions of ballistic jacket vary. However typical dimensions are:

- shields resistant to bullets shot from small arms: ~ 45 x 80 cm,
- shields resistant to bullets shot from carbine or rifle: ~ 50 x 100 cm.

The shield's jacket may feature flat profile, flat profile with bent margin or cylindrical profile. Mostly often applied radius of the cylindrical shield's jacket is 800 mm. The shields of various jacket's profile are presented on the Figure 1.

Fig. 1. View of shields featuring flat profile [5], flat profile with bent margin [6] and cylindrical profile [7].

Fig. 2. View of shield „Kent Shield" featuring special profile of jacket [8].

The edge band protects edge of shield's jacket against mechanical damage and against access of humidity. Mostly often it is made of rubber profile or other polymer.

The cushioning insert is designed for attenuating the stroke energy. It is made of foamed plastic. No information on kind of the plastic neither it's energy attenuation capabilities is published.

A handle is handy for transportation and allows for usage during operations. Mostly often it's made of metal bent pipes, or textile technical bands. Typical handle design allows for using the shield both by right -handed and left-handed individuals.

Fig. 3. Views of shield handles made as profiles of metal pipes [9]

Extra equipment for the shields allows for improving operational advantages of such product. It may be e.g. bullet-proof visor, light source, a support for keeping the shield in stable vertical position, or a carriage (Fig. 4).

Fig. 4. Views of typical extra equipment for ballistic shields [10-12].

Developing the innovative model of ballistic shield made with composite technology, and resistant to the carbine bullets, in compliance with the requirements of level III according to NIJ Standard 0108.01 is expected within a frame of the currently realized key project.

Preliminary works of project assume, that the model of shield shall be developed without extra equipment. Nevertheless along the latest worldwide technology trends, our developers introduce design solutions, which allow for applying the extra equipment e.g. bullet-proof visor, light source or carriage, thus inducing optimum adjusting the product to the users needs. Novelty of the ballistic shield aims to provide its usage properties of the level higher than those in use so far among our officers.

The elements of design of composite ballistic shield under development are shown on figure 5.

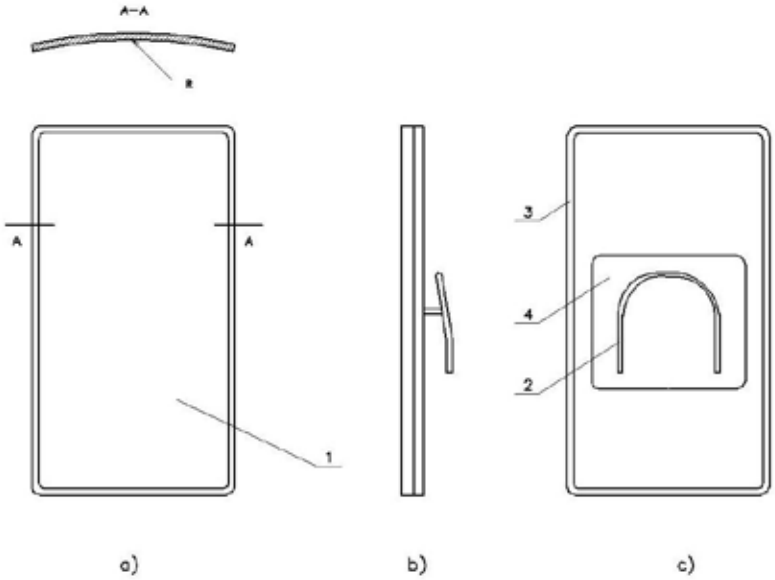

Fig. 5. Composite ballistic shield (no accessories): a) front view; b) side view; c) rear view.

Moreover, the following assumptions have been defined during R&D works:

- ballistic jacket shall be made of PE composite.
- edge band made of suitably shaped polymer material would allow for securing the edge of shield against mechanical damage and humidity access.
- cushioning insert made on a basis of foamed plastic shall provide adequate level of stroke energy attenuation.
- handle made of ergonomic system of metal pipes will allow the user for using the shield by both right-handed and left-handed individuals. Properly designed handle structure will not need incorporating any system for adjusting the angle between handle and the axe of shield's jacket.

Advanced technologies of preparing the composites [13] of thermoplastic warp offer wide possibilities of optimum development of product's properties. With the support from latest science achievements, the technology of manufacturing the composite dedicated for making the ballistic shield shall be based on the process of thermal pressure joining the unwoven sheets of polyethylene. Figure 6 [14] presents key technology parameters of the process.

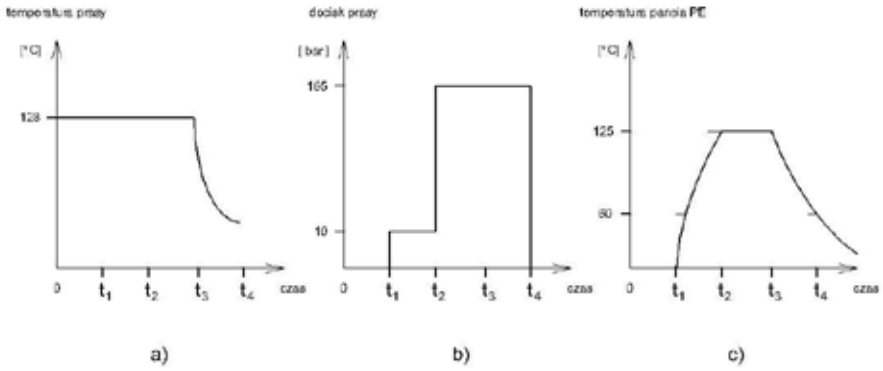

Fig. 6. Schema of the thermal pressure process of manufacturing the polyethylene composite; (a) changes of press temperature, (b) changes of moulding pressure, (c) changes of polyethylene panel's temperature, times t1 – t4 parameter determined experimentally dependent on the PE sheet type and on thickness of composite being manufactured.

In order to gain objective product, the research shall be supported with series of experiments concerning effects of pressure, high temperatures, time etc. on the presumed designs of composites. The experiments shall be executed i.a. with using a special press and moulds, which allow for manufacturing the fibrous composites featuring multi-layer, cohesive structure and precisely defined, modifiable ballistic properties.

Summary

Completing the project shall allow for delivery of new and innovative solution for manufacturing the ballistic shields. Until now, no composite ballistic shields were offered by domestic manufacturers. The new product will be based on the newest fibrous ballistic materials, which arise in recent years on the worldwide market, and benefit from latest technologies. Developing the product will take execution of multi-directional research, results of which shall allow for optimization models made-up. Reduction of shield's weight and diversification of extra equipment will lead to optimum matching to the needs of the officers of special units subordinated to Ministry of Interior and Administration.

Moreover the commercialization of the research results will happen. The preliminary technical and technological documentation regarding practical applications ready to use/implement will be made. Grant of patent protection is expected for the results of project.

Literature

1. *A. Wilczyński; „Polimerowe kompozyty włókniste"; Wydawnictwa Naukowo-Techniczne 1996 Warszawa.*
2. *W. Jabłoński, J. Wnuk; „Włókno aramidowe bazą produktów innowacyjnych"; BIT; 2000 Bielsko-Biała.*
3. *W. Błaszczyk, M. Łandwijt; Zeszyty Naukowe Akademii Marynarki Wojennej Rok XLIX Nr 172 K/2; 2008 str. 15.*
4. *NIJ Standard 0108.01:1985 „Ballistic Resistant Protective Materials".*
5. *Tencate Advanced Armour Francja, materiały reklamowe; Warunki Techniczne WT-364/ ITWW/2003, ITWW „MORATEX", unpublished.*
6. *http://www.thefind.com/sports/browse-ballistic-shield-level*
7. *http://www.specops.com.pl/taktyka_czarna/wyposazenie/tarcze_balistyczne/tarcze_balistyczne.htm*
8. *K. Suddes "The Kent Shield revolutionizes ballistic protection", internet publication (13.02.2007), The One Resource for Police and Law Enforcement (http://www.policeone.com).*
9. *Warunki Techniczne WT-347/ITWW/2003, ITWW „MORATEX", unpublished.*
10. *http://www.protechtactical.com/bshields.aspx*
11. *http://www.global-security-solutions.com/BallisticShield.htm*
12. *http://www.securityprousa.com/bashleiiiwig.html*
13. *JEC Composites Magazine, nr 8 str. 26, 2006.*
14. *„Manual for Dyneema® ballistic panels" – information brochure by DSM.*

Computer Simulation of AP Projectile Penetration into RHA

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1. Introduction

Four stages can be noted in the process of the projectile penetration into armour [1]. In the first stage a wave is created, propagating from the top of the projectile toward its back and generating stresses many times bigger than strength of projectile material, causing plastic strain at its top. The same occurs in the armour, where the stresses cause local transition of armour material in liquid state and, in effect, create a crater.