of the target (5mm) was obtained on 16 layers of dry fabric and on 8 layers of fabric impregnated with SiO_2 water suspension. At the same time the weight of the impregnated armor package increased by a factor of 1.5, i.e. total gain by areal density was 25%. Fig. 3shows the photos of rear surfaces of the dry and impregnated 8-layer armor packages impacted by a bayonet.

A similar experiment was conducted with an icepick impacting dry and STF-treated armor packages made of Article 56319A ballistic fabric with the impact energy of 31 J. In this case non-perforation of the dry package was obtained on 32 layers, and of the STF-treated package – on 16 layers. Thus, in this case the gain by the areal density was also 25%. Fig.5 presents the photos of the rear surfaces of the dry and STF-treated 16-layer armor packages impacted by an icepick.

Camouflage as the Additional Form of Protection during Special Operations

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INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Key Project No. POIG 01.03.01-00-006/08 entitled: „New generation barrier materials, protecting humans against the harmful environmental impact".

INTRODUCTION

The camouflaging materials used at present warrant a wide range of masking possibilities. They are found in two forms: as masking covers ensuring optical and radiolocation camouflage and anti-thermal sets. These sets are presently used for large objects, such as vessels, vehicles etc. It seems interesting to attempt designing materials that ensure the widest scope of camouflage possible. They should be made of raw materials of the newest generation and they should meet the requirements of the European standards.

A significant issue is introduction of camouflaging material in a wide range of personal protection devices, such as ponchos, tents, etc. and objects, such as curtains, tarpaulins etc. It is particularly significant due to the fact that at present, products of this kind are made of imported and very expensive raw materials.

THE OBJECTIVE OF CAMOUFLAGE

Ensuring of safety of soldiers and officers of services subordinate to the Ministry of Interior and Administration and the Ministry of Defense influences greatly their emotional shape during various operating activities and peacekeeping missions. The priority of the commanding officers must be to ensure protection of their staff throughout all stages of the operations carried out, which should be ensured thanks to the following undertakings: hiding, camouflage, dispersal of the forces, assets and activities and fortification development. Performance of the specific scope of camouflaging activities ensures such benefits as:

- Preventing recognition and identification of objects and people by the opponent;
- Limitation of own loss of life and equipment, and thus strengthening of the „fighting spirit" among the soldiers and officers;
- Ensuring of the proper conditions for effective use of the combat assets.

Camouflage and protection against detection are treated as components of threat prevention, which require substantially less financial expenditures than purchase of expensive equipment in the field of advanced technology.

CAMOUFLAGE TYPES

According to the scope of the tasks and objectives and the nature of organizational and executive undertakings, camouflage can be divided as follows:

1. Operational camouflage – activities coordinated with regard to organizational and technical aspects, aimed at [1]:

- hiding of preparations for performance of an operation,
- misinformation of the opponent with regard to the operation plans,
- hiding of the valuable targets against nuclear attacks (e.g. the command systems developed throughout the territory of the country),
- hiding of the nature of the activities of the national defense military forces,
- drawing the opponent's attention to targets of secondary importance and fake targets.

Fig. 1. Direct camouflage for the soldiers [3]

2. Direct camouflage – hiding or modification of appearance of detached or modular objects, devices, equipment, armament and people using the available means and masking materials and masking assets while securing the operations [2].

According to the type of devices used, direct camouflage can be divided into: disinformation, simulation and concealment.

Disinformation is intentional preparation and distribution or direct delivery to the reconnaissance forces of the opponent of misinformation concerning the military forces numbers and military plans using the press, agencies and radio-electronic devices [1].

Simulation is devising of fake objects and provoking of fake situations using mock-ups of equipment and armament, smoke-generating, pyrotechnical, sound and other devices [2].

Concealment is elimination or limitation of exposing signs that are typical for military forces, military objects and their operation [2].

This type of camouflage can be divided into [2]:

- camouflage within visibility range – making it difficult for the opponent to recognize objects visually with or without application of optical devices, within the range of visibility, wavelength range λ = (from 0.38×10^{-6} to 0.78×10^{-6})m,
- anti infrared camouflage – making it difficult for the opponent to detect objects using noctovision, infrared photography and thermovision, wavelength range λ = (from 0.78×10^{-6} to 14.00×10^{-6})m,

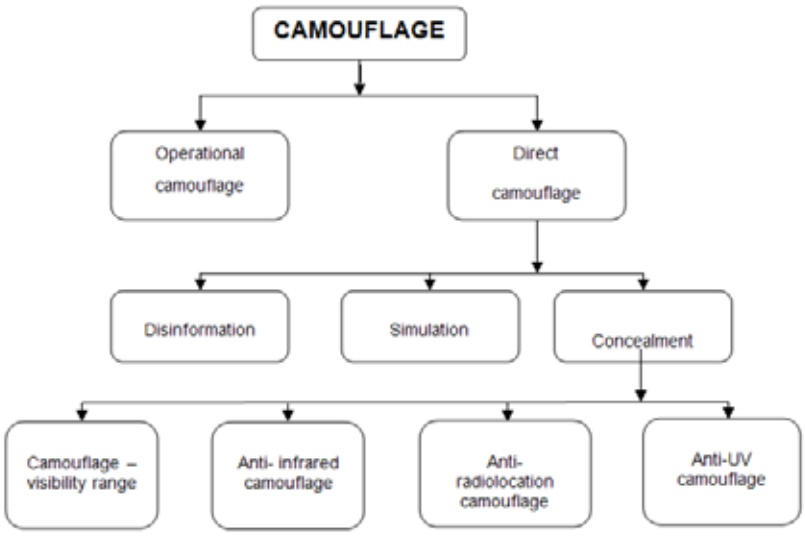

Fig. 2. Camouflage types

- anti-radiolocation camouflage - making it difficult for the opponent to detect objects using radiolocation devices within the microwave range of wavelength λ = (from 3.00 x 10^{-6} to 1.00)m,
- anti-UV camouflage - making it difficult for the opponent to detect objects using devices operating within the wavelength range of λ = (from 0.01x10^{-6} to 0.38 x10^{-6})m.

The leading armies of the world have at their disposal an impressive selection of camouflage devices for a wide range of electromagnetic radiation from UV to microwave radiation. These include:

- *deforming camouflage paints,*
- *camouflage covers,*
- *radar radiation absorbing materials (RAM),*
- *anti-thermal camouflage devices,*
- *active camouflage kits.*

The possibilities of camouflaging our armed forces had, until recently, been limited to the visibility range, which was definitely inconsistent with the demands of the modern battlefield. In the nineties, research work on models for concealment of tanks, trucks and anti-radar paints was concluded [4]. In the recent years, a complex set for concealment of T-72 tanks was devised, as well as a modern broadband camouflage cover BERBEFIG.

The ZMK-Cz set is designated for direct concealment of T-72 tank against reconnaissance devices working within the optical, thermal and radiolocation range and it consists of:

- the anti-thermal multi-layer unit, made of materials characterized by a low emission index to conceal the hottest tank components,
- the anti-radiolocation unit, made of an anti-radiolocation cover, which is sewn onto the carrying material.

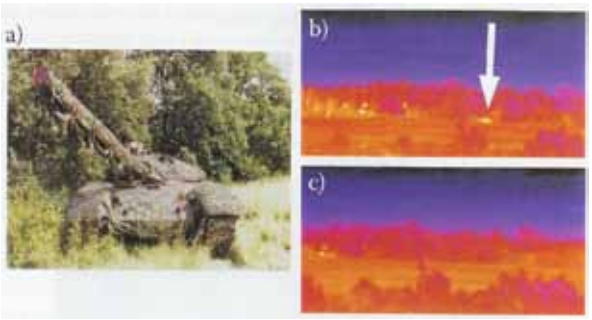

Fig. 3. A complex tank camouflaging set and the research results:
a) the set,
b) a tank without a set,
c) a tank with the set [4]

The broadband camouflage cover BERBERYS has been devised in cooperation with the Military Institute of Technical Engineering and „MIRANDA" Sp. z o.o.[5,6]. It is designated for camouflaging, in the period from the spring until the autumn and snowless winter, of deployed combat and technical equipment, material storage facilities, fortifications and other facilities. Each set consists of a cover and additional equipment (stakes, spikes, mounting brackets, guys and ropes), used to cover the camouflaged object. BERBERYS camouflage cover allows for masking of equipment and objects during ground and air observations falling into the following categories:

- Naked eye,
- Using visible light optical devices,
- Within the radiolocation range,
- Within the thermal range,
- Using noctovision optical devices.

Use of these covers eliminates the army masking defects only within the visibility range.

Fig. 4. BERBERYS camouflage cover [7]

Another issue, which is of great significance for protection of people during extraordinary operations, is the uniform and other equipment (including tents, groundsheets etc.) that are used for camouflage purposes.

The basic form of camouflage in products of this type is mimetic camouflage. In its simplest form, it constitutes of a product made of material of uniform color, which corresponds with the dominant color in the surrounding area.

Fig. 5. Examples of mimetic camouflage
a) uniform [8]
b) Technical Pneumatic Tent TNP/2008 [9]

The defects of these patterns include their low efficiency of camouflage at medium and small distances.

This problem has been solved by creation of camouflage patterns, which consist of polychromic patches of the size and shape similar to the natural elements of the environment, such as tree branches, leaves, grass tussocks or small stones.

Presented below are the most popular camouflage types and their short descriptions and exemplary application [11].

WOODLAND camouflage – excellent for operations in forested areas (four color). It is officially used by the US army [11].

There are several types of camouflage of this kind, which differ only with regard to the colors used (the shape and distribution of the pattern remains the same). The most popular ones include:

- METRO camouflage – used mainly for operations in urbanized areas,
- REDCAMO camouflage – civil camouflage,
- SKYBLUE camouflage – used mainly for operations in urbanized areas.

FLECKTRAN camouflage – used for operations in forested areas (five colors). Used by the German army since 1991 [11].

DESERT 3 (Three Color Desert) camouflage – excellent for operations in desert and sandy areas. Used by the US army (e.g. in Iraq) [11].

DESERT 6 (Six Color Desert) camouflage – used by the US army during desert exercises in the eighties and later during the "Desert Storm" operation. At present, it has been replaced by Three Color Desert camouflage [11].

TROPENTARN camouflage (Tropical FLECKTARN) – very similar to typical FLECKTARN (slightly darker). The difference, however, is crucial, as a different type of material has been used, which is more sheer and lighter. Originally, it has been used by the German soldiers during their military missions in forested areas and tropical geographic zones [11].

WUSTENTARN camouflage – currently used by the German armed forces. Excellent for operations in desert areas (three color)) [11].

TIGER STRIPE camouflage – created by Filipino armed forces, also used by the US special forces. Excellent for operations in forested areas [11].

DPM (Disruptive Pattern Material) camouflage – presently used by the British armed forces [11].

DANISH camouflage M84 – this camouflage consists of small, overlapping, round spots (pixels) in three colors – it is based on FLECKTARN camouflage. At present, used by the Danish armed forces [11].

CCE camouflage – presently used by the French armed forces. Very similar to the American WOODLAND (four color) [11].

THE NEW TRENDS IN CAMOUFLAGING TECHNOLOGY

In the late nineties of the 20th century, camouflages performed using modern techniques emerged. These were the so-called "pixel" camouflages. The first states to introduce these were Canada (CADPAT pattern – Fig. 6a) and the United States (MARPAT pattern – Fig. 6b).

The first generation of „pixel" camouflages was characterized by very small print. Masking of this type was particularly efficient mainly at small distances, but it was less effective at medium distances, while at great distances (>100 m) its efficiency differed little from that of uniform color camouflage.

Fig. 6a. Examples of „pixel" camouflage: CADPAT

Fig. 6b. Examples of „pixel" camouflage: MARPAT [8]

State-of-the-art achievements in the field of mimetic camouflage, produced using digital techniques, have been introduced in 2005 in the uniforms of the Finnish army (pattern M/05).

Individual spots, even the smallest ones, are not square- or rectangle-shaped „pixels", known from the earlier „digital" camouflage patterns, but irregular shapes with developed edges. Apart from chaotically scattered small spots, pattern M/05 includes larger spots as well (Fig. 7).

Fig. 7. The Finnish „pixel" camouflage pattern [12]

As a result of the proper selection of the spot size, the effectiveness of masking has increased in comparison with CADPAT pattern. At the same time, the new material has better mimetic characteristics than the classical WOODLAND type camouflage.

The typical modern field uniforms and equipment used by soldiers, although they use camouflage within the visible light range, does not make it possible to avoid detection in other radiation ranges. Therefore, works have been commenced to design multispectral camouflage uniforms. An example of such uni-

form is the Warrior field uniform (Fig. 8), designed by Saab Barracuda (in cooperation with the Norwegian company NFM Caseb). It ensures multispectral camouflage for such ranges as visible light, near infrared and the so-called thermal infrared (VIS, NIR, TIR). All components of the uniform are covered with sewn-in stripes made of a special synthetic material.

Fig. 8. Soldiers wearing Warrior uniforms during the night exercises in the urbanized areas(a) and in the forested area (b) [13]

DESIGNING OF REQUIREMENTS AND A RESEARCH PROGRAMME FOR MATERIALS DESIGNATED FOR MASKING PEOPLE OR EQUIPMENT

Topic V, analyzed by ITB „MORATEX", entitled „Barrier masking materials for VIS, IR and microwave radiation" for the Key Project „New generation barrier materials, protecting humans against the harmful environmental impact (No. POIG.01.03.01-00-006/08) is aimed at devising and production of a material or a set of materials used for: masking, passive and active concealment, disturbances and imitations for the broad wavelength range (VIS, IR, microwave, thermal radiation).

Within the framework of Task 1 for Topic V, among other things, the general requirements for the newly devised masking materials depending upon their designation have been prepared on the basis of the standards of the Polish Committee for Standardization and the Military Standardization Center.

The newly devised material/ set of materials should ensure:

- Masking in visible light (VIS) and near infrared (IR) for the wavelength range of $\lambda = 0.4 \times 10^{-6}$ to 1.1×10^{-6}m,
- Masking against radiolocation devices for wavelength range from $\lambda = 3 \times 10^{-3}$ to 0.15 m for equipment masking materials and from $\lambda = 3 \times 10^{-3}$ to 3.75×10^{-2} m for personal camouflage materials,
- Anti-thermal masking for the wavelength range from $\lambda = 3 \times 10^{-6}$ to 14×10^{-6} m,
- Protection against naked eye visibility under field conditions during ground and air observation from the distance or height of 1000 m or greater and on photographs taken at a scale of 1:5000 and lower while the linear resolution of photographs is 20 lines/mm,
- Decreasing of the index of reflection of radiation by the masked object so that the distance of its detection by the radars is decreased by at least 50% while decreasing the maximum reflection of electromagnetic waves by the masked object by at least 12 dB,
- Limiting of effectiveness of thermal detection thanks to deformation of thermal imaging of the masked object, changes in the spatial characteristics of radiation and decreasing of the thermal contrast between the masked object and the background to the value of k = 0.05 at a temperature difference up to 6 K.
- Meeting of requirements specified in the Regulation of the Council of Ministers of 6.04.2004, concerning the safety and marking of textile products, as amended.

It is forecasted that the newly devised material/set of materials is to be subjected to upgrading processing in accordance with the final designation of the product. The possible finishing techniques are: coloring and the following finishes: water-resistant, hydrophobic, oleophobic etc.

Literature

1. *K. Wieczorek „Maskowanie wojsk – cele i zadania"; materials from WITI seminar, Warsaw 10.1994*
2. *PN-V-01005:2000, Maskowanie bezpośrednie wojsk lądowych. Maskowanie ludzi, sprzętu i obiektów. Terminologia*
3. *http://pl.wikipedia.org/wiki/Maskowanie_taktyczne*
4. *Nowoczesne technologie systemów uzbrojenia, Collective work edited by Zygmunt Mierczyk, WAT, Warsaw 2008*
5. *Information materials of „MIRANDA" company - www.miranda.com.pl*
6. *Report MSPO 2/2008 – www.altair.com.pl*
7. *http://www.altair.com.pl/nsp-spec-98*

8. *http://militaria.wp.pl/kat,27395,wid,8759944,wiadomosc.html?ticaid=18634*
9. *http://www.lubawa.com.pl/indexw.php?pid=60*
10. *http://www.lubawa.com.pl/indexw.php?pid=61*
11. *http://www.militaryarea.pl/Rodzaje-kamuflazu-chelp-pol-17.html*
12. *http://militaria.wp.pl/kat,27395,wid,8898584,wiadomosc.html*
13. *http://www.specops.com.pl/technika/wachowski/Saab_warrior/Saab_warrior.htm*

Assault High Protection Level Armor Helmets Based on Ceramics and Organic Fiber-Reinforced Composites

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Statistics of combat losses in local military conflicts and anti-terrorist operations witnesses the considerable increase of the number of gunshot head wounds connected with features of combat action fighting.

In particular, the results of studying the gunshot wound structure that were obtained in the course of anti-terrorist operations in the Caucasus, show that the overwhelming majority of gunshot wounds among the killed are bullet wounds - 67%. This exceeds the similar indices of the Second World War by 1.5-2 times.

Characteristically that among the killed in the result of bullet wounds, 56% of hitting cases falls at a head and a chest. It is necessary also to note that such wounds in a head are in most cases undoubtedly fatal [1].

Optimum characteristics of armor helmets over the bullet resistance - weight range can be reached only using modern materials in their structure. Organic ceramics consisting of a screen based of ceramic elements and organic fiber-reinforced composite backing is one of these materials.

The especially hard ceramic screen provides breaking up the bullet core and simultaneously is failed, and the backing absorbs a flow of bullet and screen fragments. The power-consuming backing is a layered composite material on the basis of high-strength aramid fabric and elastic binder.

After choosing a protective structure for the strengthened assault helmet, the development of underlining device of the helmet is an important question when designing. The structure of the helmet underlining device should provide reliable fixing the helmet on a head and good shock-absorption, as well as prevent a contact impact by the helmet rear surface in the head.

On the basis of the above technical decisions and conducted work on the optimization of the organic fiber-reinforced plastic backing, we have developed experimental armor helmets with the increased protective level. At the first stage, strengthened organic-ceramic inserts were placed in frontal and rare parts of helmets. X-ray photographs of armor helmets are presented in Figure 1.

a b

Figure 1. X-ray photographs of increased protection level helmet with strengthened frontal and rear areas: a - before submachine-gun fire; b - after the fire.