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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.

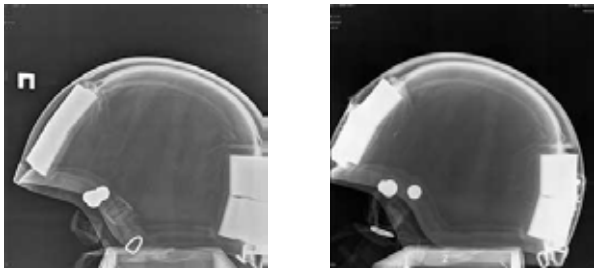
Characteristically that among the killed in the result of bullet wounds, 56% of hitting cases falls at a head and a chest. It is necessary also to note that such wounds in a head are in most cases undoubtedly fatal [1].

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.

The armor helmets were fired heat-strengthened core bullets of the long-barrel submachine weapon at the distance of 5 m. To evaluate the bullet resistance, the shots were fired into a frontal part of the helmet. The distance between two next hittings were 30 mm. Through piercings were absent.

At the second stage, we have developed a technology of manufacturing semi-closed ceramic shells based on silicon carbide and consisting of 5 sections with subsequent molding the energy-absorbing organic composite insert inside them.

Medical and biological tests of armor helmets have been conducted on the base of the St. Petersburg Military-Medical Academy. After fire testing, a state of the cervical vertebrae, brain, skull vault bones, etc. has been evaluated. As a result of medical and biological tests, it was determined that internal structures of the brain and spinal cord (jugular section) had no any visual damage; osseous structures of skull vault and base bones, as well as jugular section of spinal column were without injuries. The volume and expressness of the biological object injuries are not in excess of surface injuries of the skin epidermis and are not subject to the forensic medical estimation of health injury severity.

The residual beyond-armor projection did not exceed 3-4 mm even when hitting a bullet at the distance of 20 mm from the edge of the helmet, Figure 2.

Using a method of high-speed filming for this type

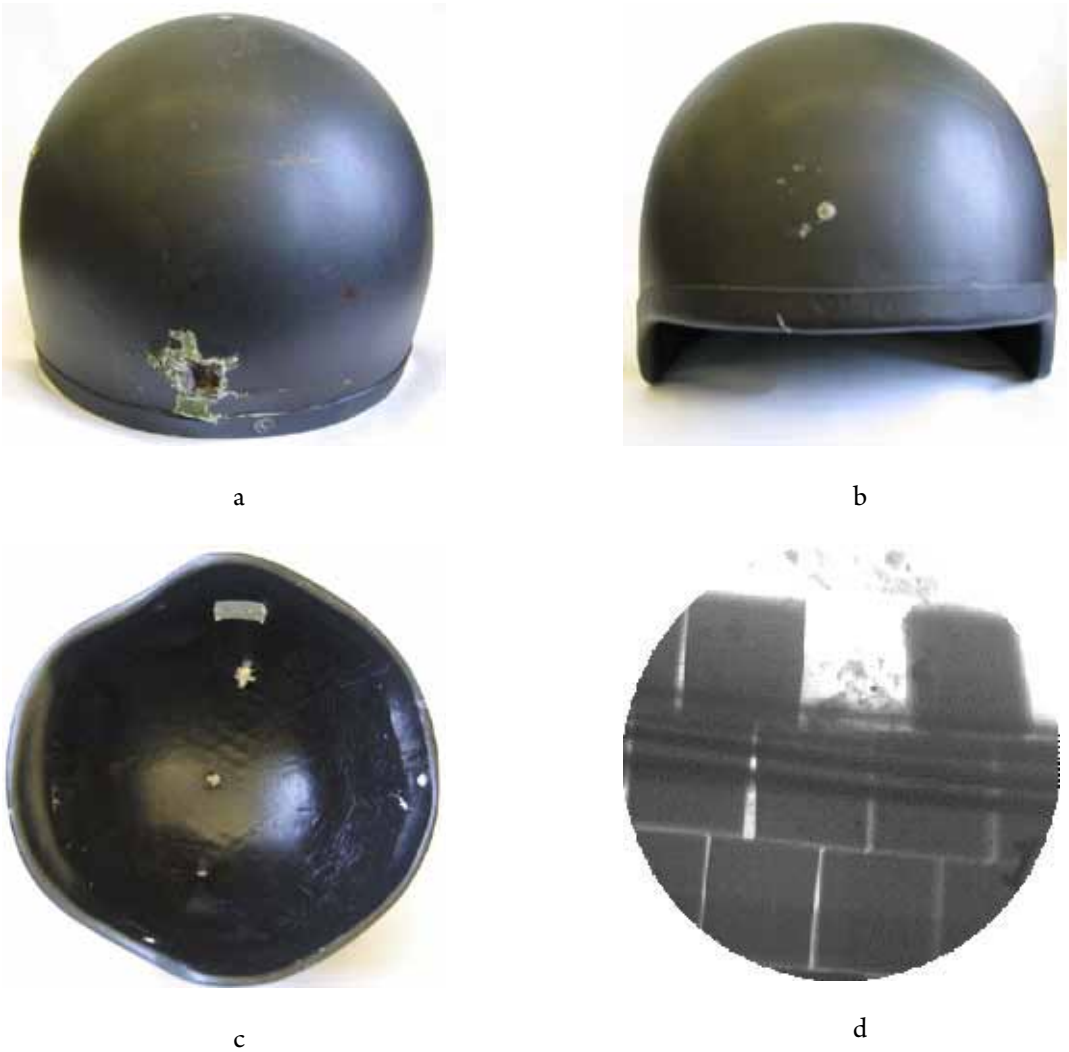


Figure 2. General view of organic-ceramic armor helmet after testing:
a - front view;
b - rear view;
c - inner surface of helmet after firing;
d - X-ray photograph of failed fragment of helmet (unpiercing).

of organic ceramics, we determined that the residual beyond-barrier projection is considerably less than the strain that is brought about at instant of bullet impact and ceramics failure. Figure 3 shows that the maximum strain is developed during the first 120 ms of the bullet-armor interaction and reaches 14 to 15 mm, then we see the back (negative) strain. The finite strain is found by 2 - 2.5 times less than the momentary strain.

Nevertheless, it is obvious that just a maximal value of the beyond-armor projection is of the most danger and when designing organic-ceramic helmets it is necessary to allow a gap at least 15 mm between inner surface of the helmet and a head. The structure of the underlining device material also plays a particular part. Through numerous experiments, we found an optimum combination of materials and a structural shape of the helmet underlining device protecting against high-energy bullets.

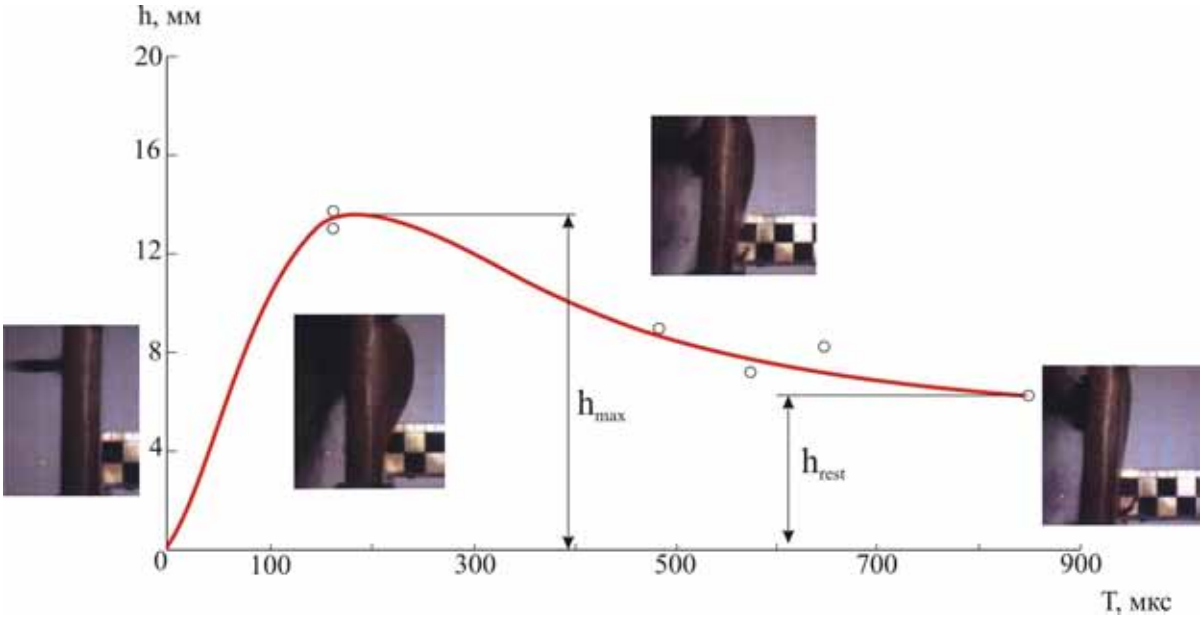


Figure 3. Changing the value of beyond-armor projection (h) as a function of time (t) when interacting bullet and armor.

Thus we have an assault helmet, first produced and passing comprehensive tests, with a weight less than 4.5 kg and a protection area over 13 dm^2, which protects servicemen against increased piercibility bullets of the hand long-barrel weapon with shots fired from minimally near distance of 5 m.

In comparison with steel counterparts having more low protection level, the helmet developed by us ensures:

- considerable decrease of battle losses of personnel in special sub-units when carrying out assault operations;
- lack of a ricochet and possible secondary fragment hitting in organic-ceramics armor helmet;
- much lesser thermal conductivity of composite shell that improves ergonomic characteristics of the organic-ceramic helmet, especially in a hot climate.

Literature

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