

POSSIBILITY OF PROTECTION OF HELICOPTERS AGAINST PROJECTILES LAUNCHED FROM RPG-7

The protection of helicopters against the destruction with projectiles launched from the RPG-7 rocket-propelled grenade launcher has been analyzed from the point of view of the possibility of the use of passive, reactive-passive and electric armours. The 30% probability of the protection of the witness plate, situated behind the PAWA-1 passive armour, has been obtained as a model to protect the helicopter. This result has been obtained in consequence of lack of initiation of the PG-7 projectile during the firing of the PAWA-1 armour and in consequence of mechanical destruction of this projectile. Besides this, the use of UAV for the reconnaissance of the terrain before or during flight of the helicopter in the system of the manual or automatic control, has been analyzed.

1. The introduction

In order to protect the helicopter the passive armour has been considered as the armour able to protect first of all the crew of the helicopter against typical projectiles and armour-piercing projectiles with the calibre of 7,62÷12,7 mm (Fig. 1) which except the perforation of the target (of the armour) cause the burning of inflammable materials after the perforation.

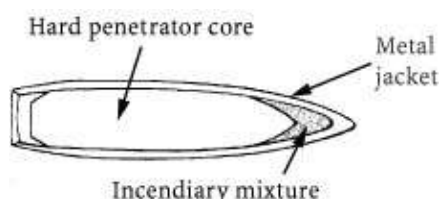


Fig. 1. Typical AP-I projectile

The protection of the helicopter refers mostly to the seat and to the bottom and side-part of the cockpit. For this purpose composite armours [1] are used, assembled inside of the helicopter, containing eg. ceramics (Fig. 2).



Fig. 2. Composite armours for floor, seats and doors protection

In view of very large limitations of additional loading of the helicopter (200÷300 kg) the protection of other vital places, such as the engine, cylinders of the compressed gas, hydraulic systems, etc. and the floor of the helicopter, is taken into account to a lesser degree. Thereby the external armouring, in the form of steel armours, titanic and composite armours with the ceramics, is mostly used.

The example of such protected helicopters is Polish Mi-24W (Fig. 2) with titanic metal sheets protecting the cockpit and the engine.



Fig. 2. Polish gunship - Mi-24W helicopter with the additional protection of the cockpit (1) and the engine (2) against the perforation with 7,62 mm armour-piercing projectiles

In the Czech gunship Mi-171Š (Fig. 3) pilot seats, partly windows, the cabin, the cockpit and the engine are protected against perforation of armour-piercing projectiles with the calibre of 7,62÷12,7 mm. The external fuel tanks and other vital parts of the helicopter are planned to be armoured in the future.



Fig. 3. The Czech gunship Mi-171Š with the additional protection of the pilot seats (1), windows (2), the cabin (3), the cockpit (4) and the engine (5) against the perforation with 7,62÷12,7 mm armour-piercing projectiles

2. Protection of helicopters from rocket-propelled grenades (RPG-7)

For the first time in NATO's history of armaments co-operation, NATO's National Armaments Directors (NADs) at their Spring Conference of 2004, took "Defense Against Terrorism (DAT)" work to a new level and elected to rapidly develop and implement an ambitious roadmap for the creation of new and improved technologies to fight against terrorism.

The Program of Work for Defense Against Terrorism (PoW-DAT) is, in its first stages, focused on developing 8 different kinds of system that are designed to help prevent specific forms of terrorist attack (such as truck/car/roadside bombs) and to give militaries new, cutting-edge technologies to detect, disrupt, and pursue terrorists. Specifically, the initiative will lead to better ways for NATO militaries to protect helicopters from rocket-propelled grenades.

Major cases of casualties during recent conflicts (IInd Gulf War) have been attacks on helicopters using rocket-propelled grenades and small-arms fire. NATO has begun developing Mission Equipment Packages which address self-protection and threat detection for helicopters, as well as means of countering these threats. NATO is now examining how technologies can be incorporated into existing and future rotary-wings aircraft, ranging from air bags and flak-wing-resistant seats to certain RPG-resistant coatings and materials that were originally designed for armoured personnel carriers, and a partnership with industry will be launched in 2004 to further refine these ideas. The plan is to assemble a package of technologies that can be emplaced on helicopters so that when they are required to operate in a high-threat environment, they have a better level of protection than currently is the case.

Bulgaria as a Lead Nation is continuing tests of passive protection aids and Poland in support to the efforts of the Lead Nation is to conduct consecutive trials on passive armour.

Within the framework of this programme Bulgaria presented the type of the protection from PG-7 projectiles with the electric armour. In such armour the shaped charge jet flies by the electric field between electrodes (Fig. 3) and as a liquid of copper deviates and undergoes fragmentation (Fig. 4).

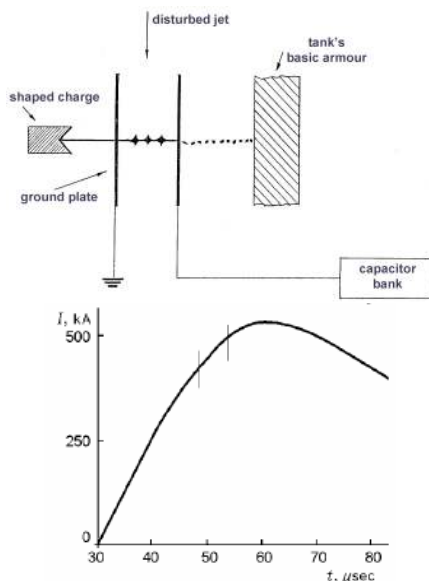


Fig. 3. The scheme of the effect of the electric armour (1) and the range of the power supply of such armour

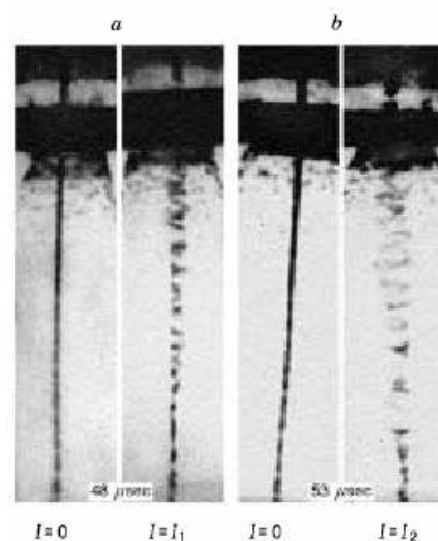


Fig. 4. X-rays of the flight of the shaped charged jet undisturbed ($I=0$) and dis-

during (2) its operation

turbed ($I=I_1$ and $I=I_2$) by the electric armour

In this way it is possible the only slight diminution of the ability of the penetration of the shaped charge jet.

2. Tests of the PAWA-1 passive armour

Military Institute of Armament Technology (MIAT) analyzed passive armours (PA), Explosive Reactive Armour (ERA) and electric armours (EA) in order to protect helicopter against PG-7 projectile (Fig. 5) launched from RPG-7 rocket-propelled grenade launcher. The different types of passive and passive-reactive armours were designed and tested [2] in order to gain good protection results as radical decrease of:

1. the depth of penetration of witness plate after penetrating of tested armour with the use of cooper jets of the PG-7 projectiles which were initiated and blasted while:
 - the static tests with different stands off, etc.,
 - the dynamic tests,
2. the possibility of initiating of the PG-7 projectiles while penetration of tested armours.

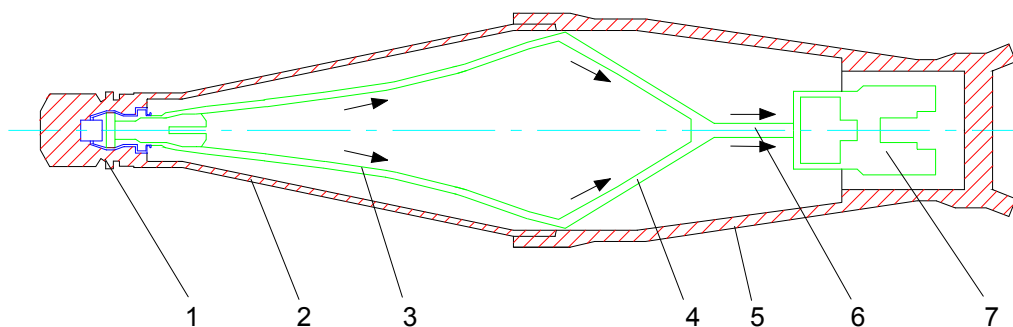


Fig. 5. Scheme of the PG-7 shaped charge warhead of grenade launcher, 1 – the warhead part of WP-7 fuse, 2 – ballistic cap, 3 – internal cone, 4 – liner, 5 – casing, 6 – connector, 7 – the bottom part of WP-7 fuse

The PG-7 projectiles were initiated electrically while the static tests, and they were launched from the RPG-7 rocket-propelled grenade launcher while the dynamic tests. The tested armours were always installed on the stiff stand which contained soft steel plate as the witness plate, sized 1000x1000x(3÷10) mm, situated behind the tested armours. The RPG-7 rocket-propelled grenade launcher was installed on the stiff stand situated 18÷20 mm from tested armours. The RPG-7 launcher was initiated mechanically. All tests were registered with the speed camera and the results were analyzed.

Additionally, MIAT analyzed and tested 7 types of very small UAVs (Unmanned Aerial Vehicles) in order to protect the helicopter against shooting down from PG-7 launched from RPG-7. UAV can be used for reconnaissance tasks by video or IR camera before or during the mission when controlled from the helicopter.

MIAT carried out a demonstration of PAWA-1 passive armour for NATO members on 10 October 2005. The PAWA-1 passive armour can protect the helicopter against PG-7 projectiles. It was a first preliminary stage of testing helicopter protection means against such projectiles by their mechanical destruction and preventing their explosion.

The PAWA-1 passive armour (Fig. 6, 7) with the mass of $m \leq 60 \text{ kg/m}^2$, sized $500 \times 500 \times (<100) \text{ mm}$, was stiffly assembled on the stand which was stiffly mounted on the ground. The PAWA-1 could not move during impact of PG-7 projectile, and was mounted at the distance $500 \pm 700 \text{ mm}$ from soft steel witness plate, sized $2000 \times 1000 \times 3 \text{ mm}$. The PAWA-1 can protect a helicopter with the probability level $\sim 30\%$. The PG-7 projectiles were fired from RPG-7 rocket-propelled grenade launcher which was assembled stiffly on the stand (Fig. 6, 7). Two shots were taken during the test on 10 October, 2005. The result of the first shot was bad because the PG-7 projectile exploded and the cooper jet penetrated the witness plate (Fig. 8). The result of the second shot was very good because the PG-7 projectile was only mechanically destroyed without explosions (Fig. 9).

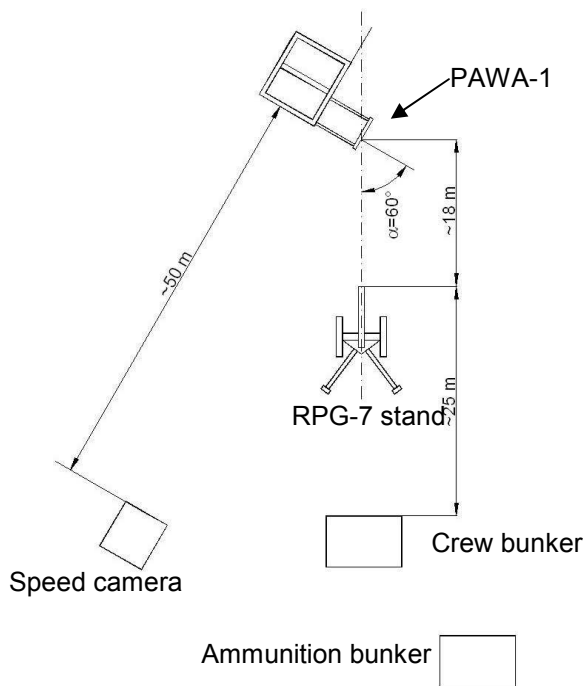


Fig. 6. Scheme of testing of PAWA-1 passive armour with the use of RPG-7 on the MIAT firing range



Fig. 7. PAWA-1 armour on the stand with steel witness plate



Fig. 8. Steel witness plate after 1st firing



Fig. 9. Steel witness plate after 2nd firing

Obtained result of the second shot is correct, because there was not:

1. the explosion of the bullet PG-7 whose:
 - the shaped charge jet (Fig. 10) and
 - the aerial shock wave (Fig. 11) with fragments would be able to destroy different external parts of the helicopter,

2. the spall on the witness plate (Fig. 12) which would be able to offend the crew or to destroy different parts inside of the helicopter.

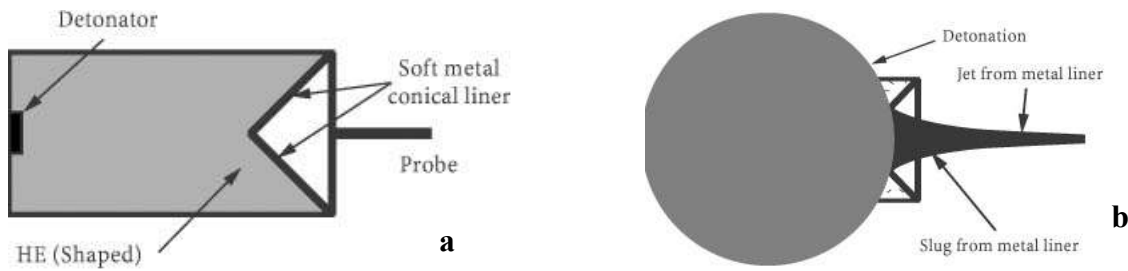


Fig. 10. The creation process of shaped charge jet and of the aerial shock wave: a - conical - shaped charge of PG-7, b - idealized detonation of a conical shaped charge

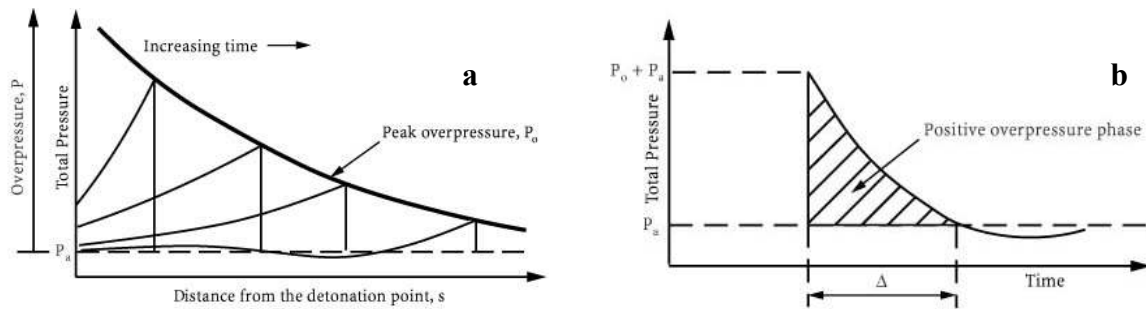


Fig. 11. The change of pressure in the aerial shock wave: a - overpressure in the blast at several instances of time, b - pressure at particular distance from detonation as a function of time

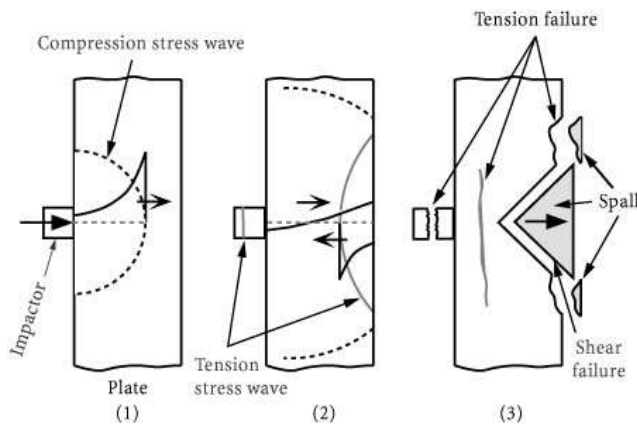


Fig. 12. A similar compression stress wave (1) and reflected tension wave (2) which cause spallation (3)

The construction and the assembly of the armour on the helicopter must take into account very large aerodynamic force called thrust T resulted in-flight of the helicopter (Fig. 13). This thrust called a thrust of the rotor counterbalances not only to the balance of the weight G , the resistance of the helicopter, but also to its control. The thrust T produced on the rotor of the area F [m²] results from the accelerating of air masses with the thickness ρ [kg/m³] which obtain the velocity acceleration called the induced velocity v_{i0}

$$T=2\rho F v_{i0}^2, \text{ [N]}, \tag{1}$$

Introducing the definition of the disk loading

$$\rho=T / F, \text{ [N/m}^2\text{]}, \tag{2}$$

the formula of the induced velocity in the hovering of the helicopter can be received

$$v_{io} = (\rho / 2\rho)^{0.5}, \text{ [m/s]}. \quad (3)$$

In typical helicopters in which the disk loading is $\rho = 200 \text{ N/m}^2$, the induced velocity in the hovering of the helicopter is $v_{io} \sim 9 \text{ m/s}$, and when the hovering is far from the ground, then at the distance of the rotor greater than its one diameter the velocity $v_{io} \sim 18 \text{ m/s}$ (Fig. 13) [3].

Therefore the way of mounting, and especially the shape of the armour mounted from the both sides and at the bottom of the helicopter, should not disturb the movement of air masses with the velocity $v_{io} \sim 9 \text{ m/s}$ excessively.

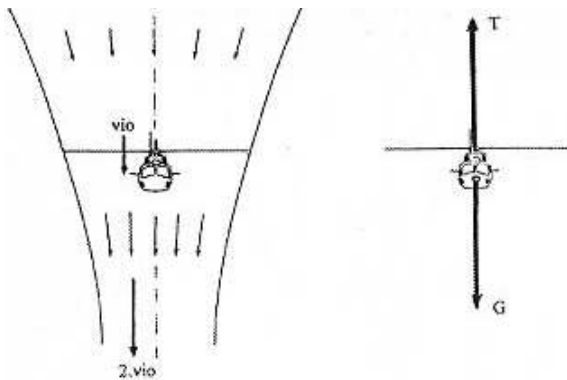


Fig. 13. The distribution of aerodynamic lift T and the gravity force G and the induced velocity of air masses of the helicopter rotor

The next important problem is the choice of places vital to the protection of the helicopter. There are too many vital places in helicopter to protect all of them. Therefore from vital places in the helicopter should be chosen depending on the helicopter construction. The additional armour mass should not cause the excessive loss of manoeuvrability of the helicopter.

The example some vulnerability reduction features on the UH-60A with armoured pilot and copilot seats with one-piece bucket has been presented in Fig. 12 [4].

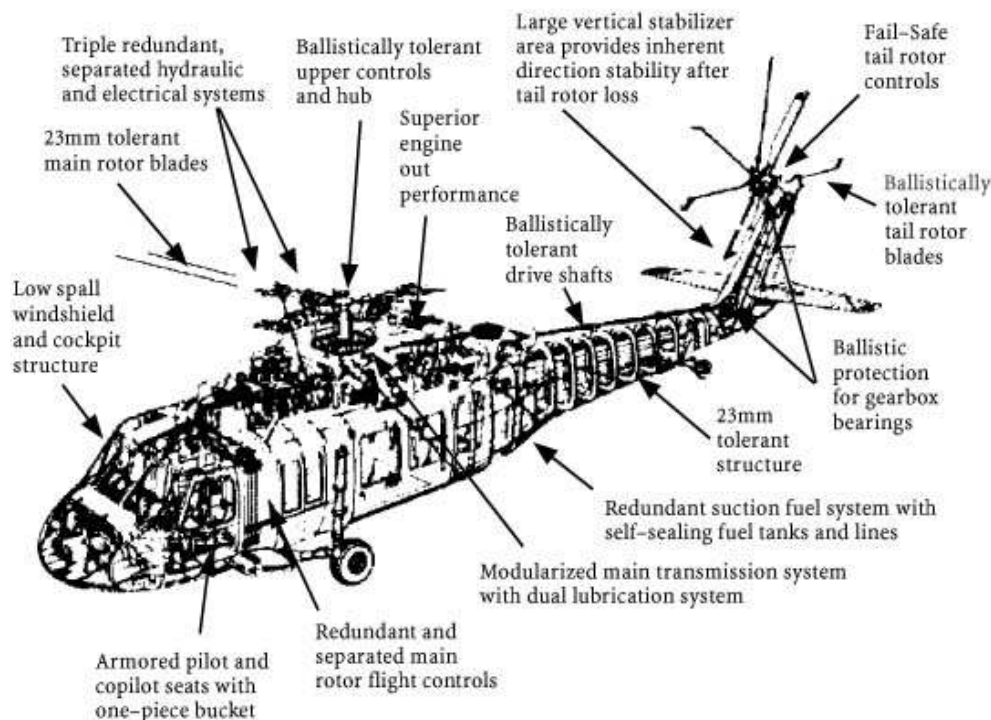


Fig. 12. Some vulnerability reduction features on the UH-60A

This UAV may be controlled in both cases through a predicted path by GPS data or manually and at each moment it is possible to select between them.

The SOFAR is a mini UAV crated for airborne terrain recognition. The SOFAR is mainly used for: battlefield surveillance, target acquisition and designation, battlefield monitoring, damage assessment and air strike control.



Fig. 9. View of SOFAR UAV with camera (1) and electric propulsion (2)

The main parameters of SOFAR are the following:

- mass - 3,9 kg,
- very quiet - unhearable from 15 m,
- long durability - 1,3 h,
- long range - up to 100 km,
- width speed range - 20÷92 km/h,
- flight height - up to 3000 m,
- climbing rate - up to 7 m/s.

SOFAR is equipped with 3 types of cameras:

- day light 3 CCD camera (25x zoom, high resolution),
- night vision camera 10x zoom, needs only 0.0003 lux),
- IR camera for thermal vision.

3. Conclusions

1. Every type of an armour which even stopped shaped charge jet of the RPG-7 projectile, like reactive and electric armour, would not be able to protect other parts of the helicopter, like rotor blades, against destructive impact of its explosion and fragments.
2. All protection tests of helicopters (or models of helicopter) should be carried out with the use of stiff stands without the possibility of moving of tested armours.
3. The tested PAWA-1 passive armour can protect helicopter with the probability level ~ 30%.
4. The PAWA-1 passive armour does not cause the explosions of PG-7 projectiles which were only mechanically destructed.
5. The tests of the PAWA-1 passive armour should be carried out in the future in order to check:
 - final probability of protection level with the use of the stiff stand and the witness plate as a model of helicopter,

- possibility of the different kinds of mounting of the PAWA-1 on the helicopter,
 - final probability of protection level with the use of wreck of helicopter,
 - the behavior of helicopter and the PAWA-1 armour during flight.
6. The UAV type of SOFAR is proper to reconnaissance tasks by video or IR camera before or during the mission when controlled from the helicopter.
 7. Tests of the UAV SOFAR with the video camera under the autonomous and manual control from the ground and a flying helicopter should be made in the future.

4. References

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Możliwość ochrony helikopterów przed pociskami wystrzelonymi z RPG-7

Streszczenie

Ochrona helikopterów przed zniszczeniem pociskami wystrzelonymi z ręcznej wyrzutni RPG-7 została przeanalizowana pod kątem możliwości użycia pancerzy pasywnych, reaktywno-pasywnych i elektrycznych. Uzyskano 30% prawdopodobieństwo ochrony płyty świadek umieszczonej za pasywnym pancierzem PAWA-1 jako modelu do ochrony helikoptera. Wynik ten uzyskano w wyniku niepobudzenia pocisku PG-7 podczas ostrzału pancierza PAWA-1 i jego mechanicznego zniszczenia. Ponadto analizowano użycie UAV do rozpoznania terenu przed lub w trakcie lotu helikoptera w systemie sterowania ręcznego lub automatycznego.