Active Protection System for AFV application – Current trends and future requirement – A study report

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Abstract

A combat vehicle is a self-propelled weapon platform. Light Weight and high performance are the key factors for the design of a combat vehicle. Most of the weight is distributed to structural armour purposes. Rolled Homogenous Armour (RHA) steel and composite armour played a dominant role to counter these threats. But the threat to the combat vehicles has increased manifold due to advancement in weapon technologies and there is a necessity of protecting the vehicles from these threats. The protections by means of RHA steel will lead to increase in weight, which affects the mobility of the vehicle. Hence there is a need to adopt active protection technologies to effectively counter the incoming anti-tank threats/ammunitions before hitting the vehicle thereby enhancing its survivability. This paper highlights the current trends and future requirement in the field of Active Protection technologies.

1. Introduction

A combat vehicle is a complex weapon platform. It accommodates weapon system and fire control systems for accurate firing and high-density power pack, automatic transmission system, hydro pneumatic suspension for better mobility and crew comfort. The schematic diagram of a generalised combat vehicle is shown in the Fig.1.

Light Weight and high performance are the key factors for the design of a combat vehicle. Most of the weight is distributed to structural armour purposes. The protections by means of RHA steel will lead to increase in weight, which affects the mobility of the vehicle. Rolled Homogenous Armour (RHA) steel and composite armour played a dominant role to counter these threats. But the threat to the combat vehicles has increased manifold due to advancement in weapon technologies and there is a necessity of protecting the vehicles from these threats. The protections by means of RHA steel will lead to increase in weight, which affects the mobility of the vehicle. Hence there is a need to adopt Hit Avoidance technologies to effectively counter the incoming anti-tank threats/ammunitions before hitting the vehicle thereby enhancing its survivability.

2. Armour vehicle design philosophy (1)

The traditional philosophy of the Armour protection is accept a weapon hit and resist its penetration by incorporating passive armour materials – Rolled Homogenous Armour (RHA) steel will have very high hardness and high toughness. These materials will be used individually or in combination to achieve desired protection level. But this approach will lead to increase in weight of the vehicle to counter the future threat due to which the primary purpose of mobility of a combat vehicle is...

Figure 1. Schematic diagram of a Combat Vehicle
compromised. Thus, passive means alone will not be sufficient to protect the vehicle. There is need to develop new methodologies to counter the future threats. The four basic principles under which the new protection philosophy revolves are

- Do not be get detected
- If detected, do not get hit.
- If hit, do not get penetrated.
- If penetrated, the system should survive.

3. Detection Avoidance Technologies

The prevention of being detected or identified is an important measure to improve survivability, as the undetected vehicle is no target and therefore cannot be defeated. Current MBTs are applied with paints with some pattern or employ static camouflage net to merge with the surroundings. These techniques will provide protection only to the selected / limited band of electromagnetic spectrum. Multi spectral Mobile camouflage system – (Visual, IR, Thermal IR and Radar range) is a essential upgrade to reduce the probability of detection by the modern sensor system. The multi layer passive material has been used for multispectral camouflage system. The methods of obtaining camouflage in the various electromagnetic regions are given below:

- Visual (0.4 to 0.7 micron): Vehicle should be applied with paints with color with some pattern, texture to match with the background. So that the contrast between the background the vehicle will be minumum.
- NIR (0.7-2.5 micron) : The reflectance characteristics of material should be match with the reflectance characteristics of the background when viewed by image intensifier and low light TV. The paint based on metal oxide or iron balls will reduce the emissivity of the surface.
- Thermal IR: Objects are detected based on the heat energy they emit or reflect and detected by thermal imaging devices. 3-5 & 8-12 micron are two bands / windows the atmosphere is sufficiently transparent to the thermal radiation case pass through to allow long range surveillance and target acquisition. Hence above thermal IR windows are to be camouflaged to avoid detection. By having thermal blanket cover with different emissivity, thermo barrier coating at the exhaust pipe and mixing cool air at the exhaust, camouflaging in thermal IR region can be achieved.
- Radar: Scattering and absorbing the radar waves. The Radar waves will be scattered having material with 3D leafy structure and. Absorbing Radar waves is by incorporating layers of Radar Absorbing material - carbon black, ferrite based.

It is very difficult to camouflage the vehicle with passive materials alone as the background terrain is changing dynamically. Adoptive camouflage system is being developed to for this purpose. This system will have multi spectral sensors system which captures the images of the background in various electromagnetic regions. These images will be processed and the displayed on the flexible LCD panel mounted on the vehicle. Adaptive camouflage will be achieved by mimicking the background surroundings. Whereas now meta materials are being developed for making the combat vehicle invisible in the selective EM region. The development of the adoptive camouflage system and meta-material is still in the conceptual stage. That is the reason why the development of hit avoidance systems is gaining more importance now-a-days.

4. Hit Avoidance Technologies

Hit Avoidance System is a closest range of anti armor system that creates an active protection area at a safe distance around the vehicle. In Hit Avoidance System, it is necessary to detect and destroy an incoming weapon before hitting the target vehicle. This system is intended to increase the survivability of the ground based by either diverting or defeating the all the known anti-armour threat effectively. There are two types of Hit Avoidance System:

- Soft Kill
- Active Protection System or Hard Kill.

4.1. Soft kill system

It is an Electro – optical countermeasure system (2) required to confuse the missile guidance system and divert the missile threat away from the target. Two types of the soft kill system have been developed

IR Jammer / Illuminator -This system has IR Beacons fitted in the vehicle that seduces the IR tracker of missile guidance posts away from the missile’s flares and missile control systems send false signals so that the missiles miss their targets.
This system is required to counter the semi active command to line of sight missile (SACLOS).

Laser warning system - comprises of Laser warning devices, control system and aerosol screening mechanism. The system is activated as soon as the laser-warning devices detect the threat. The system triggers the grenade launcher automatically. The grenade will be launched in the direction of the projectile and the aerosol smoke screen will be formed, which screens and obscures the missile guidance system and thereby missile will be diverted away from the vehicle. This system will counter the Laser based Anti tank guided missile threats.

The Soft kill system is effective against only SACLOS and LASER guided missiles. Hence, there is need for development of active protection system to neutralize all types of Anti Tank ammunition threat.

5. Active Protection System

Active Protection System (2) is a close range active defence system, required to destroy the projectile physically by launching counter ammunition. This system intended to counter all types Anti Tank Missile and Rocket Propelled Grenades (RPG). This system will have Multi role radar to continuously scan the entire protected sector. As soon the Radar identifies the projectile, the system tracks it and triggers a super quick action, defensive ammunition to engage and destroy the attacking missiles at a standoff distance from the vehicle. It has control equipment, which is built around a dedicated computer for automatic control of the operation of the radar and system as a whole. The major modules of the Active Protection System are Radar, Computer & Control System and Counter Ammunition.

5.1. Radar

The radar should be very small as it has to be incorporated on the tracked vehicles. The radar is to perform the functions like detection, confirmation, decision making and finally firing counter ammunition towards the incoming missile/projectile. The Radar system is required to search 360º deg in azimuth and 60º in elevation to detect the incoming threats. The system is required to detect the incoming threat at a distance of 50-100 m from the vehicle, classify, predict its direction and then track the anti tank missile whose speed is around 300 m/s and finally it has to provide signal for firing counter-ammunition at a safe distance of 30 m. RCS of the anti tank missile will be around \(10^{-2}\) m. This system has surveillance radar and tracking radar. The radar will be pulsed Doppler type. The Doppler and its sign can be extracted for velocity discrimination of various incoming and outgoing targets. The surveillance radar can be S band or MMW (35 GHz) and Tracking radar will be MMW phased array type

5.2. Computer and control system

The computer and control system is required to have fast reaction time for detection, confirmation, decision making friend & foe and finally firing counter ammunition which is around 50 – 80 millisecond. This computer & control unit will classify the threats, predicts its direction & velocity and compute the optimum time for initiation of the counter ammunition.

5.3. Countermeasure ammunition

Most of the Anti Tank Missiles are shaped charged chemical energy warhead. The main purposes counter ammunition is to neutralize the threat by premature initiation of a shaped charge (e.g., too great stand-off), but most likely improper initiation, thereby impeding optimum jet development of the metallic lining, usually copper, in the shaped charge. The copper jet provides most of the anti armor capabilities of shaped charge weapons. Also by the destruction of the airframe of an inbound missile or shell, the damage effectiveness of the missile will be reduced.

Following types of counter ammunition will be used for the Active protection system.

Fragmenting warhead - This is basically claymore mine type warhead that could release an annular spray of fragments designed to knock out the threat in the given sector defined by the sensor.

Multiple Explosively Formed Warhead (MEFP) - It has a liner face in the shape of a shallow dish. The force of the blast moulds the liner into any of a number of shapes, depending on the shape of the plate and how the explosive is detonated. The liner of an MEFP generally comprises a number of dimples that intersect each other at sharp angles. Upon detonation the liner fragments along these intersections to form up to dozens of small, generally spherical projectiles. The pattern of impacts on target can be finely
controlled based on the design of the liner and the manner in which the explosive charge is detonated. The advantage of the EFP is that it will directly attack the fuse, avoids ignition time delay, has velocity advantage and shortest reaction time.

6. Active Protection Systems developed worldwide – Current trends

Russian Active Protection System (APS) - Arena (3), (4) has a multidirectional radar mounted on the roof of the MBT constantly scans for approaching ATGMs and locates any target approaching within 50 meters of the tank within the designated speed band. The radar then operates in the target-tracking mode, locking onto the target at between 7.8 and 10.06 meters from the tank, and enters target data into the computer. After processing this data, the computer selects the counter ammunition, one of the rounds of protective ammunition that are housed in 20 silos around the turret, and fires a small projectile (similar to a Claymore mine) into the path of the approaching ATGM. At the determined moment, the computer generates command signals via a converter unit to the selected ammunition. The ammunition detonates 1.3 to 3.9 meters from the target, generating a directed field of destructive elements, which destroy or disable the target to levels which are no longer dangerous. After .2-.4 seconds, the system is ready to repel the next target.

Israeli Rafael’s Trophy (5), (6), (7) employs a network of four radar sensors covering a 360 hemisphere around the protected tank. The radar is integrated with the platform’s battle management system through the system’s processor, providing instantaneous detection of a threat immediately when firing a missile or projectile at the tank. The Trophy radar provides an accurate solution enabling the crew to engage the firing source even when they have launched missile is in the air, effectively suppressing the guidance or eliminating the threat altogether. Furthermore, using network centric connectivity, the location of the target can be transferred to other weapon systems for suppression, while the tank takes evasive actions. Once the incoming weapon is fully classified, the computers calculate the optimal time and angle to fire the neutralizers. The response comes from two rotating launchers installed on the sides of the vehicle. The launchers fire the counter-ammunition Multiple Explosively Formed Projectiles (MEFP). Mounted on the pedestal, this module is pointed at the direction of the incoming threat and explodes, sending the ultra-fast MEFP for destroying the threat. This hard-kill countermeasure is effective against all types of Anti-Tank Guided Missile (ATGM), Anti-Tank Rockets or High Explosive Anti-Tank (HEAT) projectiles. Relying on a highly directional explosive for both propulsion and kill mechanism, the Trophy APS delivers response time and kill probability significantly higher than other systems. The Trophy system can simultaneously engage multiple threats arriving from different directions and is effective on stationary or moving platforms.
Many other countries are also developed Active Protection System – South Africa- SAAB Avitronics; Ukrain- Zaslon, USA.

5.5. Future requirement

A kinetic energy penetrator (8) does not contain explosives and uses kinetic energy to penetrate the target. The principle of the kinetic energy penetrator is that it uses its kinetic energy, which is a function of mass and velocity, to force its way through armour. If the armor is defeated, the heat and spalling (particle spray) generated by the penetrator going through the armor, and the pressure wave that would develop, would destroy the target. The modern KE weapon maximizes KE and minimizes the area over which it is delivered by being fired with a very high muzzle velocity in the order of 1750 m/s to 2000 m/s.

Concentrating the force in a small impact area while still retaining a relatively large mass maximizing the mass of whatever volume is occupied by the projectile—that is, using the densest metals like tungsten alloy. This has led to the current designs which resemble a long metal arrow. Fin Stabilised Armour piercing Discarding Sabot (FSAPDS) is a kinetic energy type armour defeating round. It consists of a fin-stabilised sub-projectile with aluminium fin, and a tungsten alloy penetrator with ballistic tip to reduce drag. The propulsion system uses an obturating case base with combustible wall. This growth potential round features modern technology high length to diameter (l/d), tungsten alloy penetrator and lightweight sabot. The RCS of a kinetic energy projectile is around 10-4 m.

Till now there is no mechanism to counter the hyper velocity kinetic energy long rod penetrator with the diameter of 25-30 mm. If there is a mechanism to counter these missiles, the weight the vehicle can be reduced drastically.

As the velocity is very high, the KE countermeasures require longer detection range and faster data processing, to provide for effective response rate against the faster threat. Disturbance of the stability of a kinetic energy penetrator which will decrease its penetration ability as the deflection angle increases. Hence, by adopting blast deflection mechanism as well as momentum transfer methods the KE threat can be countered.

6. Conclusion

Development of a mechanism to counter the high velocity kinetic energy projectiles will be one major breakthrough in the field of the modern active protection system.

7. References

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