Application Trend of Nonmetallic Materials in the Construction and Development of Armored Equipment

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Abstract: On the basis of expounding the outstanding characteristics of the new armor materials, this paper comprehensively compares the research, application and development trend of the U.S. Army, and combining with the current research situation in China, puts forward some suggestions on the application of nonmetallic materials in armored vehicles in China.

1. Summary

With the continuous development of automation technology and intelligent technology, the future armored equipment will fight in a more complex and harsh environment. In this environment, if the armored equipment wants to overcome the enemy and improve the survivability, in addition to considering the basic design, it should comprehensively use various advanced technologies, of which armored protection is one of the main means to obtain the survivability of the armored equipment. The armored equipment is single It is difficult to resist by traditional defense means such as increasing armor thickness. This puts forward higher requirements for the survivability, maneuverability, deployability and economic affordability of all kinds of armored equipment, such as tanks, armored combat vehicles and other military platforms. These requirements are mainly reflected in the weight, maneuverability flexibility, stealth and protection ability and manufacturing process of armored equipment. The traditional metal structure materials (such as armor steel, armor aluminum, etc.) are difficult to meet the urgent needs of the new generation of advanced ground weapon platform because of their heavy weight, single function and high life cycle cost.

The new anti bullet / stealth / structural composite material, which is mainly composed of advanced resin matrix composite material, is a kind of armored vehicle material which is rising rapidly in recent years. The United States, the United Kingdom and other western countries have widely carried out the research of composite turret, car body, load wheel, gun barrel and some equipment applications. Compared with the traditional metal structure material and armor material, this kind of material has the following outstanding characteristics:

1.1. Light weight

Composite structure can get the best performance in the direction of maximum load, which is the biggest difference between composite and metal materials. According to the calculation, the armor weight of the armored vehicle with composite materials will be reduced by 35% - 40%. The use of composite armor can reduce the weight, reduce the cost and improve the survivability of the battlefield.

1.2. Good protection performance

Under a certain weight, the composite material has the characteristics of high strength, high rigidity and good impact resistance. Therefore, it can further improve the protection ability of the tank and the survival ability of the weapon system when it is used in the armor material of the armor equipment.

1.3. Good stealth performance

The composite is weaker than metal in reflecting light wave and radar wave, and can absorb part of radar wave. It has the ability of material performance and design of structure shape to make the best invisible structure shape.

1.4. Good man-machine environment

Nonmetal composite materials can effectively suppress and absorb the noise and vibration produced by armored vehicles, and have good heat insulation effect. It can improve the human-machine environment, guarantee and improve the continuous combat effectiveness of the crew.

1.5. Strong corrosion resistance

One of the outstanding advantages of the composite is its resistance to salt water corrosion. The epoxy based composite can resist the corrosion of most of the chemicals used in armored vehicles. It can significantly reduce the maintenance costs caused by corrosion problems.

1.6. Simple manufacturing process, high efficiency and low cost‘

It can form large parts such as turret and car body at one time, with high production efficiency and good product quality consistency; under the condition of mass production, the process cost is reduced.

It can be seen that it is of great significance for the design and development of the new generation ground weapon platform of our army to develop the research and application technology of non-metallic matrix composite armored vehicles (including main battle tanks).

2. Research, Application and Development Trend of US Military

The United States is the first country to systematically study the application of composite vehicles and their typical components. From 1985 to 1987, FMC and Owens Corning cooperated to develop the S-2 high strength glass fiber / polyester resin composite system. The ballistic properties of this material are better than mil-12560 armor steel, 5083 aluminum, E-glass fiber composite and kevlar-29 composite. From 1987 to 1989, FMC company developed the composite turret of Bradley infantry combat vehicle and the composite principle sample vehicle of M113 armored transport vehicle for the military by using this kind of materials and hot pressing tank forming method, with the weight reduction efficiency of 15-20%.

From 1989 to 1992, FMC successfully obtained the "composite infantry fighting vehicle" funded by the US military materials laboratory. In this research plan, five kinds of composite infantry combat vehicles are designed and manufactured with the above composite materials. After strict field test, the maximum weight reduction efficiency is 27%, the signal characteristics are reduced and the stealth characteristics are improved.

According to the research results and existing problems of the cifv program, from 1994 to 1998, the U.S. military research laboratory (ARL) cooperated with several units to carry out the "advanced technology verification vehicle program for composite armored vehicles" (CAV ATD). In this project, a new type of anti missile / stealth / structure / electromagnetic shielding and other multi-functional composite material system has been successfully developed. In 1997, CAV plans to use the above materials to complete the design and manufacture of CAV ATD, an advanced technology verification vehicle for composite armored vehicles, and has passed the field sports car experiment of more than 6000 miles. Its weight reduction efficiency has reached more than 33%, and its stealth performance is very outstanding. The project has achieved great success.

With the development of resin matrix composite, high-performance engineering plastics and their molding and processing technology, in addition to light armored vehicles, the U.S. Army has carried out a study on the principle and concept of using composite materials on 70 ton main battle tanks, and has successfully applied this kind of material technology of CAV to its most advanced "Crusader 155mm advanced field artillery system" and "aaav2000 advanced field artillery system"

Enter the body and turret of the amphibious assault vehicle. In the United States, a breakthrough has been made in the research on the use of high-performance resin matrix composite materials to make load wheels.

In order to fully study the way to reduce the weight and improve the reliability of armored vehicles, the United States has successfully applied the belt type rubber track to M113 vehicles with a weight of 12 tons, with a service life of 3000 kilometers. The track developed by Goodyear tire and rubber company for AAAV advanced amphibious assault vehicle equipped with the U.S. Marine Corps is a light rubber belt track, 40% less than the steel track, the weight is nearly 100kg less than that of aluminum based track shoes.

To sum up, the United States has carried out more than ten application research projects in the research process of composite vehicles, and conducted a lot of tests in the aspects of material basic system and composite structure optimization, typical component design, manufacturing technology and other application technologies. In the CAV plan, the application technology of such materials is basically mature, and can support the design and manufacturing of future advanced weapon platforms 。 This has important reference value for the research and development of composite material or plastic chariot in China.

3. Domestic Research and Application Status

The research on the application of nonmetallic composite materials in armored vehicles began in the middle of 1990s. China follows up the application research of S-2 glass fiber anti elastic composite abroad, and develops the epoxy phenolic anti elastic composite system based on domestic high-strength No.2 glass fiber, which has excellent structural performance, anti elastic performance and good molding technology. RTM technology can be used to realize the efficient and low-cost manufacturing of large-scale components. At the same time, the application research and verification of this kind of material in the secondary load-bearing parts of the door and hatch cover of the infantry combat vehicle are carried out.

At the end of last century, the research on the application of resin based composite material in tank and vehicle was started, and the feasibility study on the load wheel of resin based composite material was carried out, and the research on the load wheel of composite material was carried out with the second generation infantry combat vehicle as the object. The bench test shows that the static pressure strength of the single composite wheel reaches 180kn, which can meet the strength requirements of the second generation infantry chariot for the composite wheel. The weight of the single composite wheel is 27% less than that of the aluminum wheel, and the total weight of the whole vehicle is 180kg. It lays a foundation for the application research of high performance resin matrix composite wheel.

Later, the research of composite structure gun barrel technology was carried out. The composite barrel of 25 mm high bore pressure gun was wound with CF / PI composite material, and the weight was reduced by 14.6%. Through the examination of real firing test, the maximum temperature of continuous firing reached 282 ℃, which proved that the composite barrel can bear the dynamic load of high pressure and high temperature.

Due to the gap in composite material and its processing technology level, as well as the lack of understanding of materials, especially non-metallic composite materials, in the overall design of ground weapon equipment in China, the research on the whole composite material chariot in China is in its infancy.

4. Suggestions on the Research and Application of Nonmetallic Materials for Armored Vehicles in China

The structural materials of foreign armored vehicles have experienced three generations of evolution mode from armor steel to armor aluminum to composite materials. The development of advanced weapon platform in China is in the process of evolution from armor steel to armor aluminum. Compared with armored aluminum, composite materials can still achieve 15% - 20%

weight reduction efficiency, and have multiple functions such as invisibility and corrosion resistance. Therefore, it is necessary to strengthen the application research of non-metallic materials in armored vehicles, so as to promote the leapfrog development of advanced weapon platform design technology and combat effectiveness in China in the future.

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