

A summary of the working principle and development of the remote control weapon station

Sicong Wang

Army Engineering University, Shijiazhuang 050003 China.

370753023@qq.com

Abstract

The remote control weapon station is a new modular weapon, which can greatly improve the survivability of the combat personnel in the battlefield. On the basis of the analysis of the composition of a remote control weapon station, Researching the basic principle and related technology of remote control weapon station, summarize the development status of remote control weapon station, and summarize the development trend of remote control weapon station. This has a certain technical reference value for the research of remote control weapon station in China.

Keywords

The remote control weapon, working principle, key technology, development trend.

1. Introduction

With the advent of modern city war, fighting terrorism and other new combat style, to carry out combat missions in armored vehicles to solve occupant exposure to body outside shooting, vulnerable to enemy sniper, shrapnel, simple explosive device damage problem, many countries have developed and equipped remote weapon station, in order to improve the survivability of occupant. Remote weapon station is a new type of modular weapon system, unit and vehicle controlled by general electric powered unmanned turret, turret on the integrated weapon system, sighting system and servo system, vehicle control unit includes a fire control computer, monitor, operation handle and control panel. Remote control weapon station integrates advanced situational awareness technology and fire control system. It can effectively cope with high maneuverability and high risk targets on the battlefield, and overcome the danger of shooter operation on weapon platform. It has become an object of active research and development by military powers.

2. Remote control weapon station composition

The remote control weapon station is usually composed of fire system, fire control system and auxiliary device, as shown in [Fig. 1](#).

The firepower system includes weapon subsystem and rack subsystem. The weapon subsystem can be equipped with various caliber machine guns, automatic grenade launchers, organ cannons, and missiles [1]. In order to meet the low intensity needs of high intensity operations and counter-terrorism, riot, peacekeeping and other low intensity demands in the urban and mountainous environment, we need to achieve effective attack on different targets, which requires that the weapon system must have diversified firepower strike capability. For example, in the city, mountain combat effective strength environment can be used in large caliber machine guns, small caliber automatic gun. In the fight against tanks, armored targets, use of anti-tank missile. Small caliber machine guns, smoke launchers, etc. can be used in the execution of riot and peacekeeping missions [2].

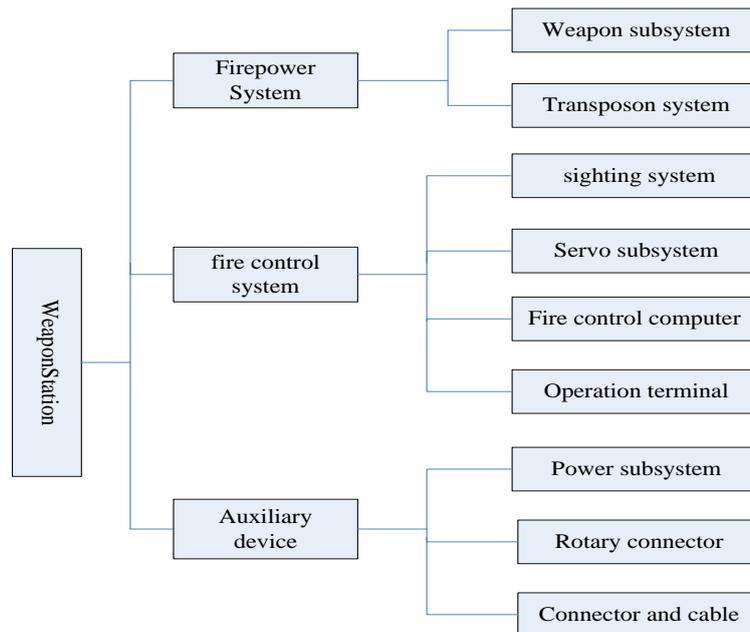


Fig. 1 The composition of remote control weapon station

The frame system is used to install various kinds of weapons, which are usually made up of cradle, bracket, seat ring, buffer, balance machine and so on. In order to realize the diversified configuration of firepower and the rapid replacement of various weapons, the general weapon frame is usually used in the foreign top mounted weapon stations. The Belgian general weapon rack of the latest design to install the machine gun or different caliber is 40 mm automatic grenade launcher, but also with the use of a new soft gun, the weapon recoil less [3]. The Israeli RCWS-30 vehicle mounted top weapon station adopts the unique lifting support mechanism, which can increase the weapon and increase the pitch angle, and enter the firing state. It can also reduce the height of the weapon and turn it into the transportation state. In addition, the universal seat ring is also widely used in foreign vehicle top weapon stations, which is very beneficial to the installation of the weapon stations on the various armored vehicles.

The fire control system is mainly used to realize remote control, weapons, day and night observation target trajectory calculation, stability control, including sighting subsystem, servo control system, fire control computer and control terminal, wherein the sighting subsystem configurable optical sight, CCD camera, camera and laser range finder [4]. The auxiliary equipment mainly includes the power supply subsystem, the rotary connector, the connector and the cable. In the future war, the night or bad weather conditions, the operation will be more frequent, the sniper target and simple explosives fighting environment will be more common. In order to meet the needs of the battlefield, sight system of foreign vehicle overhead weapon station are usually equipped with a color camera, thermal infrared imager, laser rangefinder and the stability of the system, some can also optional sniper detection system and improvised explosive detection system, which has a rapid observation all-weather, and precisely target tracking capability [5].

3. Basic principle of remote control weapon station

3.1 Basic principle

The remote control weapon station is composed of weapon system, sighting and pointing system, servo system, fire control computer, display, operation handle and control panel [6]. Its working principle is shown in Fig. 2. First view the system automatically or the operator manually control the battlefield target search, location, distance measurement, and transmit video signals to the fire control computer. Searching, locating and ranging goals by daytime white CCD imaging system and laser

rangefinder. The search, location and distance measurement of night targets are completed by infrared thermal imaging system and laser rangefinder. Then the fire control computer displays the received day and night image information through the master controller on the control terminal's display. At the same time, we use the information of target height, azimuth and distance measured by the sighting system to track the trajectory or to deal with the firing table, get the parameter information such as aiming angle and azimuth, and display the future aiming point on the monitor to help the Gunners aim. In the end, the operator remotely operates the weapon based on the target information on the display to aim and fire the target. In the process of observing and aiming system and weapon system, the high and low pitch and azimuth rotation are all servo systems based on the control signals sent by the fire control computer to drive the corresponding motors. The source of the control signal can be calculated by the fire control computer automatically according to the target parameters, and it can also come from manual input of the control panel and operation handle, or the composite signal of both.

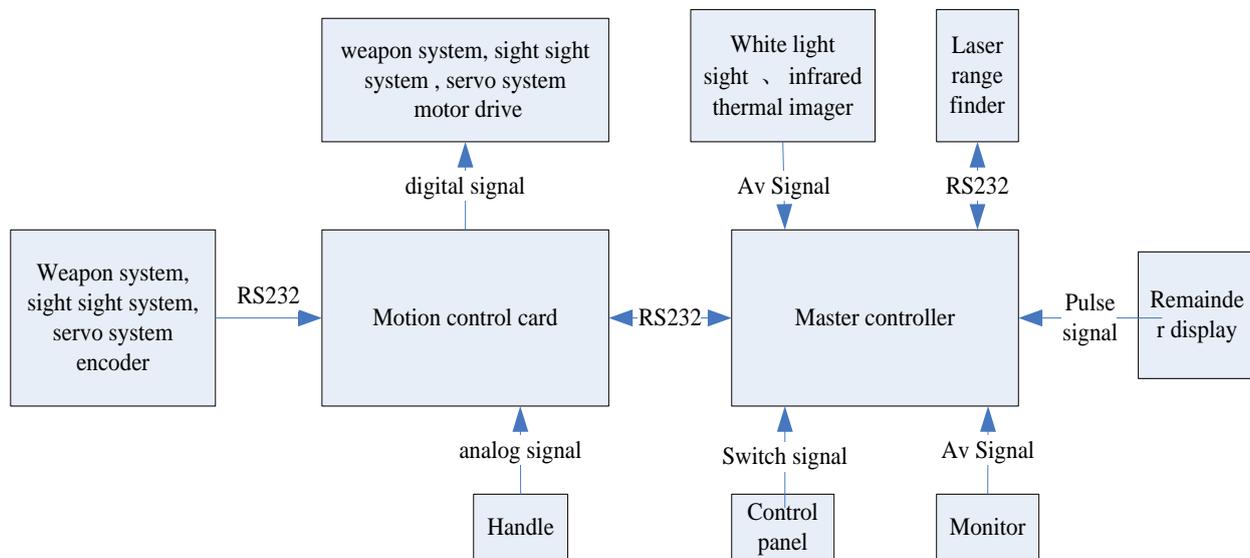


Fig. 2 The working principle of remote control weapon station

3.2 Related technology

The remote control weapon stations integrated subsystems such as weapons, ammunition, mobile platforms, photoelectric fire control, situation awareness, and information processing and network communication [7]. It covers the fields of mechanics, communications, optoelectronics, information, materials and other fields. Compared with the traditional automatic weapons, the remote control weapon stations with remote control, high precision, large range of fire shooting etc. The realization of these advantages depends on the breakthrough of corresponding key technologies, including general technology, high precision and fast response stable control technology, and all-weather situational awareness technology [8].

3.2.1 Overall technology

The overall technology includes overall structure planning and system integration, matching of dynamic characteristics between weapon and rack and vehicle, optimization of power supply and distribution, reliability and safety design, etc [9].

(1) Combined with the structure and use characteristics of the carrying weapons, we should reasonably plan the overall structure and minimize the overall size as far as possible, while avoiding the interaction between the components in the operation because of the too compact structure. System integration should adopt modular design ideas, not only to ensure the independence of functional modules, but also to fully consider the integration of each module. The multifunctional design and single function universal design of the system are realized, so that the function capacity in the limited space of the system is improved, and the upgrading and expansion of each subsystem function is also guaranteed.

(2) The influence of the firing accuracy of remote control weapon station mainly includes the matching relation of system dynamics characteristics, the fit clearance between different parts of the gun tower, the accuracy and accuracy of sight recognition, the accuracy of servo control and the speed of response. In the general technology, the matching problem of the dynamic characteristics of the system is solved, and the other factors will be discussed in other key technologies. For a weapon station equipped with a machine gun or an automatic grenade launcher, the technical way to match the dynamic characteristics is as follows.

① Optimizing the mass and the distribution of the center of gravity of the gun, so that the natural frequency of the gun tower avoids the frequency of the radiofrequency and the vibration of the body, so as to avoid the resonance and vibration of the tower.

② The optimum location of the gun on the seat frame, the influence of unbalanced torque and torque of gun gun tower stability decreases when shooting.

③ Reasonable design of frame buffer, using two-way buffer structure, reduce the body back into place and impact.

(3) The optimization of power supply and distribution includes the use of low power consumption and the optimization of power supply lines, and the power consumption of the system should be minimized under the condition of satisfying the system function.

(4) Combined with the characteristics of weapon use, reasonable design of the feeding and conveying mechanism, electromechanical interface, and insurance device is carried out to ensure the reliability and safety of the system. At the same time, effective shielding measures are adopted to avoid electromagnetic interference between the system and the system and the external equipment.

3.2.2 Stable control technology with high precision and fast response

The remote control weapon station is mounted on all kinds of mobile platforms, while solving the high mobility of the weapon, it also brings difficulties for the target to observe, aim and shoot for the target because of the rapid maneuverability of the platform. The stability control technology is the main means to solve this problem at present. It includes fast response and high precision drive and servo control [10].

For the mechanical transmission part, the clearance of the transmission chain should be allocated reasonably, and the clearance of the transmission terminal should be reduced. The transmission friction should also be reduced, the transmission stiffness and the stability accuracy should be improved, the transmission chain and the transmission ratio should be matched reasonably to ensure the transmission precision and the response speed.

The fast response servo control technology is used to improve the stability of the system for the disturbance caused by the rapid maneuver of the platform. In the design of servo motor usually adopts high power density, strong overload capacity, good starting performance, wide speed range of the drive and rotary transformer with high precision position detection, and the formation of a current, speed and position closed-loop control system and the corresponding control circuit, in order to achieve high control precision and good servo performance. The servo control module takes the digital signal processor as the core and adopts the advanced compensation and control algorithm to effectively solve the contradiction between the accuracy, stability and rapidity of servo control, and improve the robustness of the system.

3.2.3 All-weather situation awareness Technology

The remote control remote weapon station, the shooter is no longer directly observed by the human eye target or through direct fire opticaimingdevice observation target, but the target observation and aiming at the image on the screen, this weapon station sighting system must have the ability to perceive the situation around the clock, in order to ensure the full remote operation of the battlefield observation and weapons. In order to adapt to the complex and diverse battlefield environment, the situation awareness

technology needs to focus on the problem of the normal use of view and sight system in bad environment [11].

(1) In low temperature, humidity, light, fog, bad weather, sight system and imaging quality are severely affected, to ensure the normal use of the system, we must improve its ability to adapt to bad weather. In the design by hand and an infrared filter in CCD camera, make full use of the CCD camera is sensitive to the near infrared band, on the other hand, the adaptive histogram equalization method for broadening the image contrast, more than 3 times the visibility observation effect, ensure the weapon station in harsh weather conditions of the horizon. A black silhouette for image quality observed target light or backlit conditions or time difference, using electronic shutter and light field to adjust the adjustable way adjusted by high threshold and low threshold setting flux adjustment, the light entering the CCD in the ideal range, guarantee system in non-normal light conditions for target imaging quality.

(2) A remote control weapon station usually carries various caliber machine guns and automatic grenade launchers. The load produced by the weapon firing has a strong impact on the precision optical devices of the sighting and pointing system. If the system works continuously and normally, it needs to take corresponding anti shock measures. At present, the method of increasing the force area of the lens is adopted to ensure the stability of the optical axis and the impact resistance of the optical element when the vibration is impacted.

4. Development status of remote control weapon station

4.1 U.S.A

The United States is the first country to develop and equip remote control weapons stations. Remote weapon station has become the standard equipment of military armored vehicles equipped with a variety of city, including combat survivability components of the M1A2 tank, the MRAP vehicles deployed in Iraq and Beckham Wei patrol car, has remote control weapon station including XM101 and the protectors. The XM101 universal remote weapon station is a light type dual axis stabilized remote weapon station, equipped with 18 times zoom infrared imager, 27 times zoom day sight, laser rangefinder and trajectory calculation computer, detection distance of 5 km, the recognition distance of 2 km, can be installed 5.56 mm class 7.62 mm light machine guns, machine guns, heavy machine guns, 12.7 mm 40 mm grenade launcher. The new XM101 is equipped with type DSP-3000 high performance fiber optic gyroscope system, it can control the recoil to provide optical stability and precise weapons for remote weapon station, whether the vehicle is stationary or moving to hit the target precisely. Protector remote weapon station developed by Norway Constable Berg Company, can be equipped with a variety of machine gun and automatic grenade launcher, can select javelin anti-tank missile. The early Protector was mainly used as a suppressing weapon, with only daylight and infrared sight, which did not have the ability to strike accurately. In 2004, the Protector was upgraded to cooperate with US forces in Iraq and other areas. The laser rangefinder and weapon stabilization system are added. The refrigerated thermal imager is replaced by the non-refrigerating mode, which improves the target recognition ability, the combat capability and the strike accuracy during the night. The cartridge case and new weapon rack have been modified to suit the installation requirements of various weapons. Reducing the unnecessary smoke projectile launcher, adding protective armor to make it simpler but more protective.

4.2 Israel

Israel is the rapid development of the remote control weapon station. Israel is the other country other than the United States to put the remote arms station into real war. At the end of the 1970s, Israel drew lessons from the war of atonement day, and proposed the idea of developing a remote control weapon station for armored vehicles. At present, Israel has developed the Heroes series, Wave series of nearly 10 kinds of remote weapon station. Warrior -30 is the most typical representative, it adopts bi stable structure, equipped with 10 times zoom photopia color CCD and infrared thermal imager, the distance

is more than 4 km, day and night observation, identification and automatic tracking, can be equipped with 7.62 mm machine guns, automatic grenade launcher, small caliber automatic cannon and spike anti-tank missile launcher. Warrior -30 completely overhead, can be installed in any light armored high maneuvering chariot, it is the biggest characteristic of the lifting support mechanism of novel, weapons can be increase the pitch angle, can be reduced by the air medium transport aircraft, weapons station equipped Israeli MBT, armored transport vehicles and high mobile multipurpose wheeled vehicle, and the actual deployment in Gaza Strip. In order to further improve the ability of remote weapon station against improvised explosive devices, Israel is also preparing for the "Heroes" series of weapons assembly station "Thor" directed energy weapons, it can be at a safe distance to IEDs burned or degraded explosion, so that the loss of the ability to attack.

4.3 Sweden

Sweden has successfully applied the modular concept to the design of remote control weapon station. Sweden has entered the remote control weapon station late, but its Tracking Shooting remote control weapon station has a high reputation. The weapon station is developed on the basis of the earlier development of the shipborne EOS500 photoelectric command instrument, which can be installed in various military vehicles and ships. It uses a modular design, composed of stable type sensors, weapons platform, control panel and supporting electronic equipment, weapons platform optional 5.56 mm, 7.62 mm, 12.7 mm or 40 mm gun automatic grenade launcher. The sensor module according to the different optional weapons suite or remote middle suite. The medium range package includes a color CCD camera with the ability of image electronic amplification, a 8 um to 12 um uncooled thermal imager and a laser rangefinder. The remote kit includes a 3um to 5 um uncooled thermal imager, which is far away from the detection range, and the rest is the same as the medium range kit. The superior performance of the Tracking Shooting weapon station is shown as follows.

It has good structural stability, and the vehicle can also shoot normally when it is through complex terrain.

It has the ability of automatic search and automatic tracking, which greatly improves the system's ability to monitor the battlefield situation and the ability to capture the target.

With a rich external interface, it can be integrated with a variety of information sources, such as combat management system, vehicle fire control system, auxiliary defense component, navigation system and so on.

It has the function of filling in the car, and the manipulator can complete the ammunition loading under the armor protection to avoid the personnel exposed to the outside of the car.

4.4 Belgium

Belgium has launched the remote controlled weapons stations known as the most advanced Arrow-300 in the world. The weapon station is developed by FN Company, equipped with dual field of view night vision system and CCD daytime vision system. It is found that the distance is 2km, the recognition distance is 1.2 km, and it has the ability of automatic tracking and self-stabilization. It can be equipped with 7.62 mm general-purpose machine gun, 12.7 mm heavy machine gun and 40mm automatic grenade launcher, which can be installed on various armored vehicles for carrying out operations, riot, peacekeeping and border patrol tasks. It uses a soft seat gun advanced technology, the weapon recoil is very small, with very high firing accuracy and speed.

4.5 Germany

Germany has also developed several advanced remote control weapons stations. KMW has launched a series of FLW remote control weapons stations in recent years, using a fully stable system that can shoot in the line. It can install 5.56 mm, 7.62 mm, 12.7 mm machine guns, or 40 mm automatic grenade launchers. The sighting and pointing system includes CCD color camera and an uncooled thermal imager with human eye safety laser rangefinder. It can achieve precise strike on long distance

target, and the weapon station can automatically identify weapon types and adapt to its ballistic characteristics after changing weapons. This series of weapon stations can not only serve as the main weapons of light armored vehicles, but also can be used as auxiliary weapons of heavy armored vehicles, so it is especially suitable for installation on tanks for urban operation tasks.

5. Development trend of remote control weapon station

5.1 Intelligentization

Research on Intelligent Vehicle overhead weapon station, on the one hand is to actively carry out intelligent vehicle overhead weapon station architecture, model identification, signal processing, control and optimization of the theoretical study, continuously push forward the process of the intelligent equipment; on the other hand is a new type of equipment by photoelectric sensor, battlefield management systems etc [12]. and continuously improve the operation of intelligent vehicle and charge integration level, at the same time on the battlefield into the overhead weapon station management system realizes the sharing of network information, make it become a network node with network warfare capability, enhance the operational efficiency of the system. The development of automatic vehicle tracking overhead weapon station is one of the important trends in recent years, this kind of weapon station combat sequence is described as is straightforward, it reduces the circulation of information between the sensor and the shooter, the target is confirmed that closely tracking the target distance obtained by laser range finder, azimuth data and pitch angle is automatically increased by the fire control computer, without manual intervention, the operator only need to open the weapons and launch insurance operation, can greatly improve the operation level of the intelligent system.

5.2 Modularization

With the changing demand of the battlefield, the vehicle mounted top weapon station will pay more attention to modular design, which includes modularization of system structure and modularization of hardware and software. The modularization of the system structure requires the system to have an open structure, which ensures that the system is easy to increase the function module, easy to upgrade and technical transformation. It is the basis of the diversification of fire allocation and the guarantee of the ability of multipurpose combat in the weapon station. The modularization of hardware and software focuses on the centralization of functions, often using general task modules to cover the functions of each subsystem or subsystem [13]. The Swedish TRACKFIRE mounted top weapon station is a typical weapon system designed with modular design [14], [Fig. 3](#) is its modular configuration diagram. According to the different operational requirements, the user can choose the appropriate weapon, view sight, missile box module and general frame for rapid assembly.



Fig. 3 TRACKFIRE weapon station modular configuration diagram

6. Summary

To sum up, taking the typical remote control weapon station of foreign equipment as an example, this paper summarizes the development status and characteristics of remote control weapon station in recent years, probes into its future development trend, and sums up the basic working principles and key technologies of remote control weapon station based on this. The work done in this paper has certain theoretical significance and technical reference value for the analysis, development, design, upgrading and upgrading of remote control weapon stations in China.

References

- [1] Xu Zhenhui, Mao Baoquan, Zhao Junyan: Function Amalgamation Design Method of Remotely-Operated Weapon Stations (ROWS), *Journal of Academy of Armored Force Engineering*, Vol. 24 (2010) No. 1, p. 53-57.
- [2] Ren Yongliang, Fan Dapeng: Influence of Telecontrol Weapon Station Development on National Firepower Control, *Ordnance Industry Automation*, Vol. 27 (2008) No. 10, p. 11-14.
- [3] Liu Yu: New application of electro-optical technology in light weapons, *Journal of Applied Optics*, Vol. 27 (2006) No. 4, p. 289-292.
- [4] Wu Xinjie: Application of Sound Survey Technology in Counterambush System, *Modern Electronics Technique*, Vol. 31 (2009) No. 1, p. 4-10.
- [5] Xue Hanjie: Double-Motor Anti-Backlash Driving Technology and Its Application in NC Machine Tool, *Aeronautical Manufacturing Technology*, Vol. 28 (2009) No. 17, p. 84-89.
- [6] Zhao Guofeng, Chen Qingwei, Hu Weili: Adaptive Control of Dual-motors Driving Servo System with Backlash Nonlinearity. *Journal of Nanjing University of Science and Technology(Natural Science)*, Vol. 31 (2007) No. 2, p. 187-192.
- [7] Gawronski W, Beech-Brandt J J, Ahlstrom H G, et al: Torquebias profile for improved tracking of the deep space network antennas, *IEEE on Antennas & Propagation*, Vol. 42 (2000) No. 6, p. 35-45.
- [8] Gong Jun, Lu Guolin: The Application & Development of Brushless DC Motor in the Industry. *Small & Special Machines*, Vol. 25 (2000) No. 5, p. 16-19.
- [9] Ma Xiaojun, Yuan Dong, Zang Kemao: Research on Situation and Development of Digital All-electrical Gun Control System of Tank. *Acta Armamentarii*, Vol. 33 (2012) No. 1, p. 69-76.
- [10] Zhang Pengjun, Bo Yucheng: The Application of Fuzzy Control for Smallarms Control Servo System of Remort Turret. *Journal of North University of China(Natural Science Edition)*, Vol. 28 (2007) No. 12, p. 19-22.
- [11] Zhang Wei, Chen Yuzhong, Hu Yongming: Active Disturbance Rejection Control of Remotely Operated Weapon Station. *Journal of National University of Defense Technology*, Vol. 33 (2011) No. 1, p. 44-46.
- [12] Mao Baoquan, Wang Fan, Xu Li: PID Controller of Robot Weapon Station Servo System Based on Fuzzy-Neural Network. *Ordnance Industry Automation*, Vol. 29 (2010) No. 9, p. 75-79.
- [13] Ji Bin, Mao Baoquan: Pilot Design of Weapon System Man-Machine Interface for Weapon Station. *Ordnance Industry Automation*, Vol.28 (2009) No. 7, p. 89-93.
- [14] Chen Zhanfeng, Mao Baoquan, Shao Yi: Application of CAN Bus in Data Transmission of Remote Control Weapon Station. *Journal of Gun Launch & Control*, (2008) No. 3, p. 41-44.