Advances in Engineering Research, volume 103
Proceedings of the 3rd International Conference on Material Engineering and Application (ICMEA 2016)

Analysis on Development of Overseas Soldier Power

Yu-Lin ZHU[a*], Yang LIU, Li-Fu CHENG, Jun WANG, Xiao-Ming WANG, Hao ZHANG

63981 Unit of the PLA, Wuhan, China

[a]zhuyl_0731@163.com

*Corresponding author

Keywords: soldier power, individual soldier, development.

Abstract: With the growing popularity of soldier information equipment, the requirement for electric power supporting individual soldier combat increases. Now available power sources such as alkaline battery and lithium battery may not meet the demands any longer, and the contradiction between supply and demand is turning up. To solve this problem, Western countries are seeking innovation in the field of soldier power development. This paper mainly discusses the problems that the soldier power is facing and points out its development trend.

Introduction

Whether in conventional or future information battlefield, the individual soldier is regarded as a synthetic system integrating combat lethality, situational awareness, survivability and flexibility [1]. It is believable that the individual soldier will have a continuous enhancement of combat capability and play an more and more effective role in the future warfare. The U.S. military has defined the individual soldier as an unit or a node owning a variety of abilities to process battlefield information flexibly as required and perform various combat missions. As is well known, the soldier combat capability highly depends on not only their mentality and corporeity, but also the military equipments especially with information [1-3].

Besides the conventional weapons such as gun and ammunition, large numbers of electronic equipments are necessary for scouting, detecting and communicating in modern battlefield since they can improve the soldiers' situational awareness [2, 3]. Due to a mass consumption of electric energy for the running of equipments, a large amount of batteries need be carried, which greatly restricts personal flexibility and causes pressure to logistic supply [4-6].

The soldier's electric power has great effects on soldiers combat capability including combat lethality, situational awareness, survivability and flexibility, although it possesses no any execution. In modern warfare, soldiers' combat capability is closely related to soldier equipments which can't operate without continuous supply of electricity. The soldier power, providing energy for the combat equipments (such as rifle sight and strong light) and information equipments (such as night-vision scope, transceiver and GPS), is usually recognized as a basic factor of combat lethality and situational awareness [1-3, 5]. Also, it has close connection with the soldier flexibility.

Problems of the Present Soldier Power

Although its importance has been widely approved, the soldier power shows a poor condition of technology and falls behind with the requirement for soldier combat [1].

Its Energy Density Is Low, Resulting In Short Working Duration. Alkaline battery and lithium battery are used widely by the army in most countries. For example, the alkaline battery is used to provide energy to sight and night-vision scope, and the lithium battery is usually used in transceiver and display for helmet [4]. Due to their advantages of light weight, large capacity, long life, easy to carry and need no maintenance, these two batteries have huge amount and wide application range. However, with the increasing demand in soldier transceiver and helmet display, both alkaline and lithium batteries show poor capability because of their low energy density [7, 8]. That is to say, the supply fails to meet the demand. For example, the soldier transceiver in U.S. army is expected to work continuously for more than 24 hours. However, even if a standby battery is taken, the time can only prolong to 2 days. Therefore, charging the battery in fight gap is necessary which undoubtedly results a heavier psychological burden on the soldiers, especially when the fighting strength is great or the logistics supply is difficulty in some mountainous areas [3].

The Total Weight Is Great, Showing An Influence On The Soldier Flexibility. A recent survey shows that the burden of troops in Afghanistan and Iraq is far beyond the standard. For this reason, the soldier flexibility is inhibited seriously, consequently weakening the combat lethality. For instance, each rifleman in the U.S. Army infantry squad should take a package weighing 68 kilograms, including water, radio, battery and other supplies afforded for a few days [2]. The situation in British is not more optimistic than that in U.S. It is reported that the monitor, grenade shooter, minigunner and light support weapon shooter in an infantry squad should take 74, 65, 72 and 69 kilograms, respectively. That is, they all exceed the standard of 50 kilograms [5]. Although only a small part of the loads, the weight of soldiers' battery can't be ignored. Taking the U.S. for an example, a soldier in Afghanistan need consume 88 AA batteries during a 5-days task [1]. It means that, the total weight reaches about 3 kilograms, very close to the mass of M4 carbine. Undoubtedly, it makes the serious situation even worse especially for the overwhelmed soldiers.

The Quantity Is Large, Increasing Pressure on Logistics Supply. The alkaline battery widely used in battlefield has low energy density and is non-rechargeable so that its amount is enormous, resulting much pressure on logistics supply. As reported, every U.S. soldier in Afghanistan consumes average 88 AA batteries during a 5-days task. That is, a battalion needs about 35200 batteries totaled over one ton. For another example, a Canadian soldier in Afghanistan need carry 40 standby batteries during a 3-days task. Consequently, a complete combat group composed of 1000 soldiers needs 65000 batteries. That is to say, all the 2800 Canadian soldiers in Afghanistan require 750000 batteries within 6 months, weighing about 14 ton. Such a great logistics pressure has drawn much attention of western countries.

The Cost Is High, Causing an Economic Criticism. Although an unnoteworthy equipment, the battery accounts for a high proportion of war spending due to its large consumption. According to the investigation from U.S. Army, an soldier expends averagely 65000 dollars on battery each year. In contrast, a M4 carbine which can be used for several years costs only 3000 dollars. It is estimated roughly that 1.3 billion dollars are spent on battery for all the over 20000 soldiers in Afghanistan. Apparently, this consumption has made the military uneasy. The situation of the Canadian Army is not more optimistic since millions of dollars need be devoted to the soldier power every year. From the above analysis, it is revealed that the expenditure on battery is huge for the Army in western countries, and thus they have to address the conflict between soldier power requirement and actuality.

Solutions for the Problem of Soldier Power

America, Britain and other western countries have been paying close attention to the soldier power issues in Iraq and Afghanistan. In order to meet the growing demand for individual soldier power, these western countries are actively developing novel power sources and studying in energy-saving technologies.

Tab.1 Properties of some overseas soldier powers [2]

Countries	Soldier equipments	Soldier Powers	Output power /watts	Continuous working time /hours	Weight /kilograms
America	Land Warrior	Lithium battery	20	12	0.97
		A1 methanol fuel cell	30	48	1.0
		Solar cell	62	Under sunshine	1.14
Britain	Future Integrated Soldier Technology	A2 fuel cell	150	12	3.6
		Solar cell	204	Under sunshine	0.49
Israel	Project Anog	Fuel cell	20	72	4.0
Germany	Future Infantryman	Methanol fuel cell	200	96	4.0
Australia	-	Vibration energy collector	-	Unlimited	4.0
Canada	Bionic energy collector	Solar cell	6~12	Unlimited	0.65

Solar Cell

The U.S. Army is cooperating with the solar experts at Massachusetts Institute of Technology (MIT) to develop a fiber with photoelectric effect, which can be used to make up tent, combat uniform, knapsack and other equipments [7]. The equipments made from this fiber can convert solar energy into electric energy, consequently supplying power for individual communication, monitoring and other actions [9, 10].

Israel Defense Forces (IDF) are developing a compact solar panel based on special design, which owns a maximum power output of 30 watts and can charge multi batteries simultaneously. This solar panel has sockets matching various chargers and can be fully charged under the sun for 2~3 hours. Particularly, its weight and folded size are only 1.5 kg and 0.50.3 m respectively, indicating a good portability for the infantry.

Australia is developing a lightweight solar panel that can be put on outside the combat uniform, bulletproof vest, helmet radio and knapsack. This wearable solar panel is expected to solve the problem of excessive combat load from large amounts of battery.

Fuel Cell

Hydrogen fuel cell has numerous advantages including safe, environment-friendly and high fuel utilization rate [11]. The fuel cell produced from liquefied petroleum gas by American Voller Corp has entered the demonstration stage. Typically, the VE10M fuel cell customized according to military requirements owns a power output of 10 watts, and can charge equipments such as sight and transceiver. The American MTI Corp is developing a novel methanol cell which can support 72-hours task with a half weight of the lithium battery.

Fig.1 Optical images of AMI300W propane fuel cell, UltraCellXX55W methanol fuel cell andProtonex300W methanol fuel cell

The German SFC Corp developed a methanol cell system weighing only one kilograms and affording a maximum power output of 40 watts at the rated voltage of 14 V. Especially, it can reduce more than 20% of the power load on the premise of power supply for 72-hours task. At present, this fuel cell system is in testing phase.

Traditional High-Energy Battery. The research in traditional chemical battery has never been terminated. By preparing high energy density materials for chemical battery, the soldiers load would be decreased largely on the premise of adequate power supply. The U.S. Army Research Laboratory has been developing a new material which can increase the energy density of battery by 30%. This is unimaginable because the energy density increased only 1% per year in the past. Recently, the researchers in U.S. Army Research Laboratory obtained a stable power output by adding additives into the electrolyte to accelerate its reaction with electrode.

The French army and the Canadian army also tend to use traditional methods to solve the problem of individual power consumption. As an example, the French Saft Corp is making great efforts to develop military lithium battery with high reliability, light weight and long duration, which can be widely used for electronic equipments including communication, global positioning system, thermal imaging and laser pointer. Besides, the Canadian army is also seeking technical measures to tap the potentials of traditional alkaline and lithium battery, so as to address the current urgent need.

Fig.2 Image of flexible lithium battery settled into bulletproof vest

Energy-Saving Technologies. To solve the individual energy problems, both developing new sources of supply and reducing consumption are needed. Western countries are developing new equipments which are conducive to improving the utilization rate of electric energy. The American PPI Corp developed a guide rail which could centrally supply electricity for sight, tactical light and other electronic equipments to reduce power consumption. This device is specially designed for M4/M16 rifle and can support 4 kinds of electronic equipment for 24 hours continuously. More importantly, it is user-friendly and can display residual power exactly. The American Cynetic Designs Corp developed a novel inductive charging communication system which could charge the soldiers battery pack with wireless. Two inductors are applied in this system: one is on the soldiers back armor, the other is installed on the back of the seat and connected with the main power of the vehicle. When soldiers sit down, the inductor on soldiers back will be connected to the vehicles central battery pack and begins to charge. It should be pointed out that this central battery pack can not only be used as an main power supply for the integrated soldier system, but also be connected to the auxiliary power supply directly. Most importantly, sensing technology can be used for wireless data transmission besides wireless power transmission.

In order to meet the requirement of power supply for the British Army, the Lincad Corp developed a FAST CHARGER that can charge four batteries at a time. Particularly, only half of traditional charging time is needed for this charger, thus it will improve the charging efficiency as well as reduce the individual burden largely. The FAST CHARGER supports general AC power grid and has a power output of 2000 watts, with a dimension of 440 mm 400 mm 310 mm. In addition, it has a power management system, which can ensure reliable power supply in most severe conditions.

Conclusion

The problem of soldier power has been completely unmasked during the wars in Iraq and Afghanistan. On the one hand the demand for power is continuing, on the other hand the traditional alkaline and lithium batteries are in short supply. As technology progresses, New power technologies such as Solar cell and fuel cell are expected to solve the issues of individual soldier power. However, due to its large consumption, weak resistance against environment influence and so on, quite a long time is indispensable to solve the power problem completely.

References

[1] M. Yang, X. Q. Pei, J. L. Zheng. Novel technologies on soldier power, Chinese Journal of Power Sources, Vol. 40 (2016), pp. 477-480.

[2] L. Cheng, Q. Sun. The research progress and challenge of soldier power system, National Defense Science and Technology, Vol. 35 (2014), pp. 26-31.

[3] L. Y. Lu, T. Zhang, S. J. Huang. Analysis of military application status and prospect for battery energy storage system, National Defense Science and Technology, Vol. 35 (2014), pp. 20-25.

[4] W. H. Pu, J. G. Ren, C. R. Wan, et al. Development of Li-ion batteries for military fields and its negative electrode materials, Battery Bimonthly, Vol. 33 (2003), pp. 249-251.

[5] K. Liu, Q. R. Zhang, J. S. Xiao. Application analysis of the military fuel cell, Journal of Wuhan University of Technology, Vol. 30 (2008), pp. 749-752.

[6] J. Y. Wang. Review of fuel cell for overseas dismounted soldier, Chinese Journal of Power Sources, Vol. 35 (2011), pp. 746-747.

[7] X. Q. Zhang, Y. H. Li, C. Zhang. Research progress on solar cell, Materials China, Vol. 33 (2014), pp. 436-441.

[8] M. A. Green, K. Emery, Y. Hisikawa, et al. Solar cell efficiency tables, Progress in Photovoltaics: Research and App1ication, Vol. 20 (2012), pp. 12-20.

[9] K. Miyake, Y. Uetant, T. Selek, et al. Development of next generation organic solar cell, Sumitomo Kagaku (2010).

[10]J. Zhao, Y. P. Zeng. Advances in novel high-efficiency solar cell research, Physics, Vol. 40 (2011), pp. 233-240.

[11]F. Q. Kong, X. Q. Zhang. Application progress of rare earth hydrogen electrode material, Chinese Rare Earths, Vol. 37 (2016), pp. 123-128.