Research on the Integrated Support of Equipment under Green Ecological Concept

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Abstract. In the context of the country’s great efforts to build a socialist ecological development, the weaponry and equipment, as an important part of the development of the national defense, are becoming more and more important in the direction of green ecological environment. The article analysed and discussed several key ways of implementing green integrated support of equipment------green design for equipment, green manufacturing for equipment, and green maintenance for equipment, which promotes coordinated and continuous development of military, environment and economy on the basis of expounding the connotation of green ecological environment and equipment integrated support.

1. Introduction

With the widely spread of sustainable development ideas, Environment protection has increasingly attracted people’s attention. Green, as a concept, is gradually popularized in production and life. Green appliances, green food and green buildings have reduced environmental pollution and saved resources while meeting the needs. Weapons and equipment are an important part of the development of the national defense. Attaching importance to the green guarantee of equipment is conducive to promoting the coordinated development of military, environment and economy, and is of great significance to the promotion of social and ecological civilization construction and the development of the army itself.

2. The connotation of Green ecological environment

The road of green ecological environment means that all social production activities of human beings should follow the rationality of ecology, conform to the law of ecology, give priority to ecological capital and benefits, and realize the sustainable development of harmonious coexistence between man and nature. This is the inevitable choice for the long-term healthy development of human society. Since the 18th National Congress of the Communist Party of China (CPC), we have vigorously advocated the concept of green ecological development, which has significant improved the ecological environment and the quality of development. This has made positive contributions to healthy and sustainable development and the protection of the global environment and resources, reflecting the sense of responsibility and responsibility of a major country. With the goal of building a beautiful China, the 19th National Congress of the Communist Party of China (CPC) will comprehensively and systematically elaborate on green ecological development, which will become the fundamental idea for guiding China's long-term, sustainable and healthy development in the future.

As a public product of society, military equipment bears the same responsibility to society. A series of support activities such as intermediate repairs and overhauls of various equipment, maintenance of aircraft, the refueling, storage and transportation of incendiary agent and oxidants for rockets and
missile, etc. may cause serious pollution the surrounding environment; all kinds of decommissioned equipment will undoubtedly become members of industrial waste. The only way to solve the above problems is that military equipment must follow the path of sustainable development, fully consider the carrying capacity of resources and the environment, and pursue the sustainable and coordinated development of the comprehensive support of equipment, resources and environment.

3. The connotation of equipment integrated support

Equipment integrated support was proposed and applied by the United States in the 1960s. Mainly because after the Second World War, propelled by the advancement of science and technology, the technical performance of weaponry has become higher and higher, and its structure has become more and more complicated, resulting in more expensive and more expensive support costs. According to statistics, a third of America's annual defense expenditure after the 1970s was consumed on the use and maintenance of equipment. On the other hand, the status and role of equipment support in warfare are becoming increasingly prominent. Technological advancements and structural complexity have resulted in a strong guarantee for high-performance weaponry to develop operational capabilities. If the supportability of the equipment cannot be taken into account during the development and production stages, the weaponry is difficult to achieve their operational effectiveness despite the advanced technical performance. The main performance is low reliability, high failure rate, high demand for spare parts, and difficulty in use and repair. To this end, the U.S. military began to change equipment construction strategy, and began exploring the issues of equipment supportability at the stage of equipment development, considered equipment development and support equipment, and supportability and support resources construction simultaneously, and proposed the concept of “integrated support”. This idea is to pursue the overall operational effectiveness of weapons equipment, and to incorporate equipment supportability into the design of equipment, and to develop support elements and resources when equipment is developed. The delivery of easy support and support equipment and support resources hand over the troop simultaneously to make new types of equipment rapidly develop operational capabilities.

China introduced the concept of "integrated support" in the late 1980s, and successively formulated GJB1371 “Analysis of Equipment Supportability”, GJB3872 “General Requirements for Equipment Integrated Support” and other relevant standards. Of these, GJB3872 defines “equipment integrated support” as follows: in the full life cycle of equipment, to meet the requirements for combat readiness of the system, reduce the cost of the life cycle, comprehensively consider the equipment support, determine the support requirements, and performance support design, plan and develop support resources, and provide a series of management and technical activities timely to support resources required for equipment.
4. **Formation and realization of equipment green integrated support**

The 20th century was a period of rapid development of human material civilization, but it was also the period in which the ecological environment and natural resources were most seriously damaged. Environmental pollution and ecological imbalances have become a significant crisis in the 20th century and have become one of the main factors restricting the world economy, sustainable development, and threatening people's health. Under such circumstances, countries around the world have begun to study to reduce and avoid environmental pollution in the production process and protect the ecological balance; then they have proposed to save resources and sustainable development, and began to study non-polluting green products, green manufacturing, and green weapons. In today’s transition to informationization, we should take the opportunity of modernization of weaponry and upgrading of information technology to vigorously promote the construction of green equipment, which, on the one hand, plays an important supporting role in building a resource-conserving and environment-friendly society and promoting the adjustment of industrial structure and the transformation of development pattern, on the other hand, and is also an inevitable requirement for continuously upgrading the equipment modernization of the PLA and achieving the goal of building a strong military. Therefore, we should incorporate the new concept of green ecological development into all aspects of equipment green support.
4.1. Key points for implementing green integrated support

Green integrated support for equipment refers to a series of activities that use green standards and green technology to plan comprehensive support throughout the entire life cycle of the manufacture, use, and destruction of weaponry. The implementation of green comprehensive support should carry out environmental protection awareness throughout the entire equipment support work, and its main points include the following aspects.

4.1.1. Environmentally friendly and safeguard. In the R & D and design phases, it should be considered that the materials produce little or no pollution to the natural environment such as air and water. At the same time, the design should be humanized to minimize the damage to users or operators.

4.1.2. High-efficiency resources and low energy consumption. In the stages of processing, manufacturing, testing, packaging, and transportation, resource conservation and energy conservation should be considered to maximize resource utilization.

4.1.3. Excellent performance and cost saving. In the stages of equipment delivery, maintenance, warehousing and other stages, the human-oriented ergonomics concept must be reflected, which is convenient to use and will not cause harm to users; at the same time, it must have low energy consumption and low manufacturing performance during operation.

4.1.4. Recycling, safety standards. In the process of scrapping, dismantling, recycling and incineration or landfilling, the gas discharge, liquid discharge, and solid disposal should meet the requirements of environmental protection, and the requirements for reuse, remanufacturing, and recycling (referred to as 3R guidelines) as much as possible.

4.2. Ways to achieve green integrated support

To sum up, the realization of green integrated support of equipment must start from the source, from key links and from technology. The source and keys are mainly green design, green manufacturing and green maintenance.

4.2.1. Green design for equipment. The design phase of the product has a decisive effect on follow-up work. The research and practice of concurrent engineering in advance manufacturing technology show that about 83% of the life-cycle costs of product development and manufacturing are determined by the work in the product design phase, and cost required the initial phase itself accounts for less than 7% of the life-cycle costs of equipment products. Therefore, the follow-up process should be considered from the initial design phase.

Green design refers to the full consideration of impact on resources and the environment in the design of the product and its life cycle. While considering the function, quality, development cycle and cost of the product, all relevant design factors are optimized to make the overall environmental impact of the product and the manufacturing process minimize. The green design of equipment, also known as environment-oriented design, is a technology and method that considers environmental impacts systematically throughout the life cycle of equipment and integrates into the initial design process of the product. It mainly includes the following three aspects: (1) the design for maintainability is to extend the life cycle of the product and optimize the design plan. Because prolonging the life cycle of a product can reduce various disposals after the product is scrapped, thereby improving the utilization of resources and reducing negative impact on the environment. However, various disposals after scrapping depend on the ease of maintenance of the product. Therefore, the disassembly of the product must be considered at the design phase, especially the wearing parts should be easy to disassemble and repair. (2) For energy-saving design, the life-cycle saving problem should be considered in the design phase. Energy should be saved from the entire system planning and later equipment use stage. The research and production department can produce prototypes, and then use digital simulation tools to perform virtual operations in order to find deficiencies early and estimate their energy consumption indicators, so as to continue to improve, optimize the design, and achieve the desired goal. (3) Design
for disassembly, disassembly refers to the process of systematically removing its components from the assembly, and to ensure that the target components are not damaged. Disassembly is an important means to achieve an effective recycling strategy. Only in the initial stage of product design taking into account the disassembly problem after scrapping can achieve the final efficient recycling of products. The currently accepted guidelines are: reduce the amount of demolition work, such as the assembly of hazardous materials into sub-assemblies to facilitate disassembly and maintenance of waste; easy to disassemble, avoid embedding metal parts in plastic parts; product predictability, avoid parts contaminated and corroded; easy to handle, seal the toxic substances as far as possible, easy to grasp the surface; easy to separate, identify different materials with signs or colours; reduce diversity, and use standard parts as much as possible.

4.2.2. Green manufacturing for equipment. On the premise of meeting the requirements of product function, quality and cost, we consider systematically the impact of product development, manufacturing, use and activities on the environment, so that the product has the least negative impact on the environment and the highest resource utilization rate throughout the life cycle. The advanced manufacturing mode that comprehensively considers the product manufacturing characteristics and environmental characteristics is called green manufacturing. The advantages of green manufacturing include: the environment of manufacturing site is more safe and clean, and the health of producers is protected. The product has a very good humanized design quality, and the user is convenient to operate. The follow-up disposal cost has been reduced to achieve user satisfaction and social recognition. In short, green products are the products that use green materials, through green design and design processes, green packaging and circulation, and can finally be fully recycled and reused. Green manufacturing starts with the selection of green raw materials and the widespread use of green technology. On the one hand, the selection of green materials should have the greatest resource utilization and the smallest environmental impact at each stage of the life cycle of manufacturing, use and post-use disposal. The selection should follow: preferential selection of renewable materials, recycling materials as much as possible to improve resource utilization and achieve sustainable development; try to choose materials with low energy consumption and less pollution; try to choose materials and parts with good environment compatibility and try to avoid using toxic, harmful and radiation materials. The materials used should be easy to reuse, recycle, remanufacture or easy to degrade. On the other hand, the widespread adoption of green technology requires that while improving production efficiency, it must take into account the reduction or elimination of hazardous waste and other toxic chemicals, improve working conditions, reduce health threats to operators, and produce safe and environmentally friendly compatible products.

Meanwhile, strengthen the environmental assessment of the use of natural resources and the discharge of air, soil, water, and waste; determine the impact assessment of biodiversity, human health, and natural resources based on the relative scale of environmental load. Finally, green packaging is used when the product is offline, so that this circulation link also meets the requirements of saving and environmental protection.

4.2.3. Green maintenance for equipment. The goal of green maintenance is not only to achieve the physical goal of maintaining or restoring the specified state of the product, but also to achieve the sustainable development goal of minimizing the negative impact on the environment and the highest resource utilization rate in all activities from equipment maintenance to disposal. The implementation of green maintenance should run through the following basic points: establish and implement environmental criteria for fault definition. Take damage to the environment as the main criterion for equipment failure, and the fault harmful to the environment is an important object for prevention and elimination. Through various advanced manufacturing technologies, such as digital maintenance simulation, we discover, analyse and take measures to eliminate possible environmental damage in advance. Take environmental impact as the criterion for maintenance quality and acceptance. Strengthen the research on new technology and technology of green maintenance. Green maintainability design must be considered in the initial green design, that is, reducing the impact of
maintenance on the environment must be taken as the main goal when designing the maintainability of equipment.

It should also be grasped that because maintenance may cause damage to the environment, the cost of maintenance project and treatment means that may be increased in order to eliminate such damage is the additional cost to ensure green maintenance, which is the money that should be spent. When the costs of using new green maintenance techniques, new materials, and new technologies are basically equal to the costs of reduction of environmental governance and penalty, green repair new techniques, new technologies, and new materials are preferred to improve social benefits. When the additional costs due to green maintenance design and the reduced costs of environmental management and penalty are basically equal, the former is given priority over the latter.

Calculation of maintenance pollution cost

The additional costs of management and penalty due to pollution for certain maintenance:

\[ C = K \times W \] (1)

In the formula (1), C is the additional costs of management and penalty caused by pollution for maintenance, \( W \) is the maintenance cost without considering pollution for a maintenance, \( K \) is the pollution cost factor, usually from 0.1% to 5%. For example, the reference data obtained by a repair shop based on actual measurement are 0.4% for light pollution, 1% for medium pollution, and 3% for severe pollution. The average cost of management and penalty increased by pollution for each maintenance is:

\[ \bar{C}_i = \frac{\sum_{i=1}^{n} f_i c_i}{\sum_{i=1}^{n} f_i} \] (2)

In the formula (2), \( \bar{C}_i \) is the average cost of management and penalty increased by pollution for each maintenance, \( f_i \) is maintenance frequency of item \( i \)-th, \( c_i \) is the additional cost of management and penalty caused by pollution for the \( i \)-th maintenance, \( n \) is the total number of maintenance items.

5. Conclusion

Equipment green integrated support is a complicated system engineering. It is still in the preliminary stage. However, under the consensus of the development of the green ecological concept, all countries have paid attention to it, and it is in the ascendant. This is not only one of the problems to be solved in establishing a coordinated society in my country, but also a subject to be studied by workers engaged in this field in the 21st century.

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