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# Research on Potential Application of FDM 3D Printing Equipment Rush Repair Support

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**Abstract:** According to the characteristics and application of 3D printing technology, the problems to be faced in the process of equipment maintenance and rush repair are analyzed, and the advantages of 3D printing technology for equipment maintenance and rush repair are summarized. Moreover, the phenomenon analysis, finite element analysis and analysis optimization are carried out in combination with the vulnerable parts in large engineering equipment. To provide data samples based on FDM 3D printing technology in equipment maintenance and rush repair, explore potential applications.

**Keywords:** 3D printing technology, Equipment maintenance, Rush repair finite element analysis.

## 1. Introduction

3D printing technology breaks the traditional manufacturing techniques of turning, milling, planing, grinding, etc., and is a rapid prototyping technology for parts using additive manufacturing technology [1]. It is a kind of three-dimensional design data model, after flake and data, with metal powder and plastic and other raw materials, combined with laser sintering, melting accumulation and other means, from the bottom to the top of the material layer by layer, has achieved the physical effect of data model. Because of its technical characteristics, it has both the production speed, the processing range is wide, the complex production capacity is strong, the raw material utilization rate is high, the finished product quality is good, the operation of the hand is fast and the equipment is easy to carry. In this study, FDM printing equipment was selected to manufacture the designed equipment by melting and stacking raw materials and the temperature difference between sprinkler head and baseboard. Compared with traditional metal 3D printing, FDM 3D printing has significant advantages in production cost, production speed and processing accuracy, which opens a new situation for the efficiency, quality and cost in the process of equipment emergency repair, opens up a new way, and strongly enhances the improvement of equipment emergency repair logistics capability. It has unimaginable potential in both military and civilian applications and fills the gap in the manufacturing field. Therefore, in recent years, the potential of 3D printing has been deeply explored, and remarkable results have been shown, which has had an important impact on the maintenance and rush repair of equipment, and formed a new development road.

## 2. Application of 3D Printing Technology in The Field of Emergency Repair and Support of Military and Civilian Equipment

With the innovation of key technologies and raw materials of 3D printing technology, 3D printing technology has occupied a place in the field of equipment rush repair and support. The US was the first to incorporate 3D printing technology. Following the launch of the first 3D-printed gun in 2012, key components of the F-35 fighter jet have been used at a high quality level in prototypes and even in large launch vehicles. On the basis of the successful production of more than 5M titanium aircraft metal, we have gradually applied it to the main bearing components of fighter jets and airliners. In 2012-2013, the United States proposed two mobile expeditionary laboratories, which firstly opened the first step in equipment maintenance and realized the 3D printing technology to quickly manufacture suitable replacement parts in time and on the spot under the environment of equipment rush repair. At the same time, the transformation has aroused the attention of our country, accelerated the development of 3D printing key technology, as well as deepening the common application of equipment rush repair.

From a macro perspective, 3D printing technology has made great breakthroughs in the innovation of key technologies and raw materials, and has even made some achievements in some fields, showing a good development trend on the whole. However, 3D printing technology rarely analyzes complex parts in complex environment, which needs to be explored and studied.

## 3. Problems Faced by Equipment Maintenance and Emergency Repair

With the assignment of tasks and work, it is inevitable that equipment cannot work normally due to component damage and failure when using equipment and maintaining support. At present, the maintenance of equipment mainly adopts the combination of replacement repair and original repair, and the emergency repair of equipment mainly adopts the way of replacement repair. Although this way of equipment maintenance can quickly repair equipment, has achieved the effect of functional recovery, but there are still some drawbacks:

The proportion of spare parts is unreasonable. Equipment is composed of several parts. In the maintenance of equipment, especially in the process of rescue repair, it occupies a large amount of backup space, which generates great pressure on the support force. It is often impossible to predict damaged parts during equipment rush repair, which results in the duplication of all replacement parts[1].

The production cost of some parts is high. The large quantity of equipment spare parts and low manufacturing

efficiency result in the high processing cost of replacement parts. At the same time, each part has its own validity period. Once the life of scrapping and equipment upgrading is reached, the original parts need to be scrapped, causing a waste of resources.

Spare parts require high production technology. The core parts of the equipment and the parts with strict coordination, the equipment spare parts first put forward high technical requirements. Modern equipment often presents the characteristics of high professional technology and high quality requirements, which puts forward higher requirements for the maintenance process. On the basis of high-level manufacturing technology, it also needs the requirements of special personnel, professional equipment and professional tools, which is almost difficult to achieve the maintenance of equipment with limited time.

# 4. Feasibility of 3D Printing Technology for Equipment Maintenance and Rush Repair

Reduce production costs. First of all, 3D printing technology avoids the waste of raw materials in reducing material manufacturing. Meanwhile, through structural optimization, the effect of raw material replacement is realized, which greatly reduces the loss and waste in the production process. Through the establishment of equipment parts database, it is no longer necessary to prepare all kinds of parts during equipment rush repair. The demand for equipment spare parts is greatly reduced, and the pressure on equipment support force is greatly reduced.

Shorten the manufacturing cycle. The parts with complex processing technology and high difficulty in equipment parts often require dozens of processing by traditional processing methods. And because of the gap of artificial technology, processing efficiency and manufacturing quality can not be in a stable state. When 3D printing technology is used to manufacture equipment parts, parts under complex process can be completed in a few hours at the fastest by calling part data in the database. This processing method is portable, anytime and anywhere, and truly realizes free production. In the case of production cycles, parts with complex manufacturing processes are the most iconic.

Improve the level of maintenance equipment construction. Modern equipment presents the characteristics of high technology, intelligence, precision and so on, so the maintenance process is extremely demanding, and some parts need to prepare the corresponding maintenance tools, but often the maintenance technology is unable to adapt to the upgrade speed of equipment research and development, which seriously restricts the ability of equipment maintenance support. If this problem can be solved, it will greatly promote the process of equipment maintenance support.

The use of "humanized" operation. For the 3D printing system optimization, the maintenance personnel easy to understand, easy to operate. Modern 3D printer presents the characteristics of portability, modularization and universality, which is more friendly to the operator and the operating environment, and better realizes the comprehensive equipment repair.

Increase opportunities for component structure optimization [2]. Due to the lag of R&D technology and production technology, some equipment is prone to problems such as unreasonable design of equipment parts, inconvenient installation and operation, and unable to meet current needs. Adhering to the principle of reasonable cost and excellent technology, we can carry out damage analysis and fault diagnosis for vulnerable parts and optimize and upgrade equipment[3].

# 5. Analysis and Optimization of Equipment Wearing Parts Based on FDM 3D Printing Technology

## 5.1. Selection of wearing parts

Toggle is a key part of large engineering equipment to play a role, because of its role and installation position, it is easy to damage the side wall of the left groove and rupture of the right protruding part, which has become an unstable factor affecting the normal work of engineering equipment. Therefore, in the process of equipment maintenance and rush repair, this part often becomes the part that needs to be replaced. Therefore, this part is selected as the optimized part of this analysis. The toggle is shown in Figure 1.

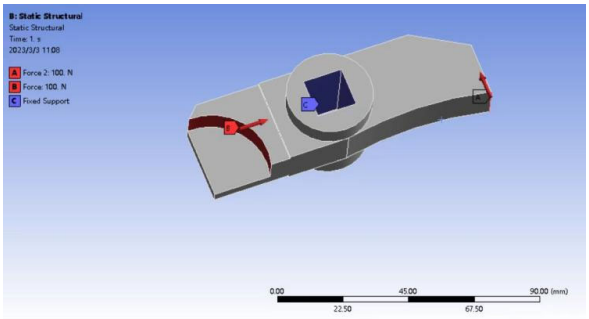


**Figure 1**. Toggle 3D model

## 5.2. Analysis of wearing parts

Aiming at the vulnerable parts -- toggle in the process of equipment maintenance and rush repair, the physical data of the toggle is converted into a three-dimensional model, and then the non-metallic parts are prepared by using FDM 3D printing equipment[2]. At the same time, in the selection of printing raw materials, non-metallic materials are selected to replace the original metal materials. On the basis of realizing the original functions, the internal structure is optimized to highlight the advantages of 3D printing technology. The toggle is based on FDM 3D printed parts, as shown in Figure 2.

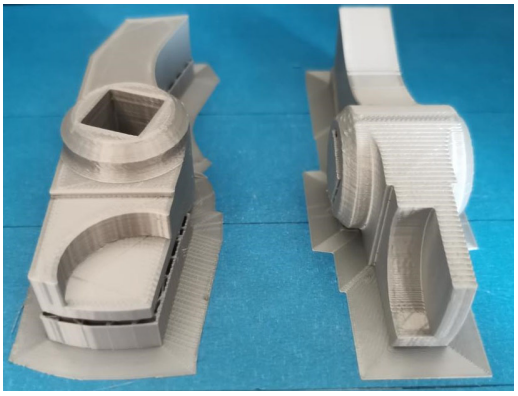

**Figure 2**. Toggle based on FDM 3D printing parts

In this analysis, the static analysis was carried out by

ANSYS WOEKBENCH, a finite element analysis software, when the layout of the toggle part was the same as its constraint and force. Combined with the results of static strength and modal analysis, the stress concentration points of the vulnerable parts of the toggle are analyzed and an optimization scheme is proposed. The results of undulator statics analysis are shown in Figure 3.

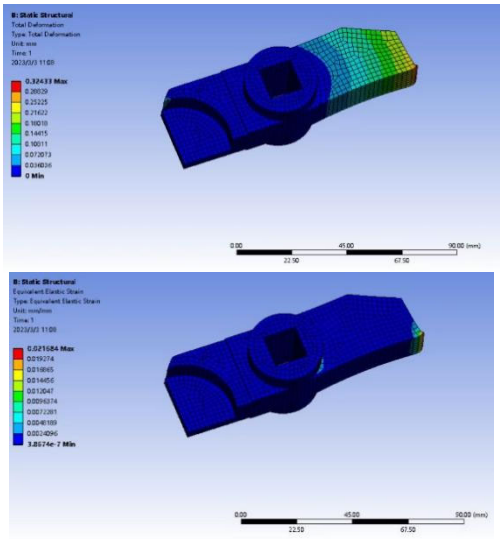

**Figure 3.** Results of toggle statics analysis

In the static stress analysis, the maximum stress acceptance point is located on the right side and contacts with the mechanical needle, and the maximum single deformation is 0.02mm. In the modal analysis, the area prone to deformation is also the right area, which is prone to point fracture. But in the lower left corner of the left side wall, there is a deformation that is also of interest.

Through the analysis, it can be concluded that the areas where the toggle is prone to fatigue failure are the left side wall joint and the right side contact Angle, which are the positions that need to be solved and optimized in the future.

## 5.3. Optimization scheme of wearing parts

### 5.3.1. Replace raw materials

Now the original part of the tosser is made of alloy steel material. The material of this 3D printing is plastic filament-like material, which is easy to cause material damage and fracture and cannot achieve satisfactory results. Therefore, in the selection of 3D printing raw materials, carbon fiber, Kraft and mixed ceramic materials can be selected for multiple optimization. Among them, carbon fiber materials have excellent performance in cost, processing technology and finished product properties, so it is recommended to use carbon fiber materials for raw material optimization.

### 5.3.2. Structure optimization

To optimize the structure of the stress concentration part of the toggle, through the way of topology optimization, the stress distribution can be rationalized design, honeycomb type, turtle type and other structure types can be optimized, so as to reduce the stress concentration and increase the life of parts.

### 5.3.3. Strengthen civil-military integration

For some parts, the processing is difficult, the processing cycle is long and the processing efficiency is low. Only relying on single processing and production cannot meet the needs of equipment maintenance and rush repair. Therefore, it is necessary to strengthen the integration of military and civilian to realize the situation that the military is the main body and the civilian is the support, so as to relieve the pressure of preparation. At the same time, grasp the core technology, break through the technical difficulties, and form the state of "having a ready mind".

# 6. Summary

With the increasing demand for equipment maintenance and rush repair, 3D printing technology is gradually mature. 3D printing technology has taken a place in the field of equipment maintenance and rush repair, and has emerged in the research and development of equipment maintenance. It is believed that with the upgrading and strengthening of 3D technology, it will explore a greater prospect in the field of equipment maintenance and rush repair in the future.

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