Overall Framework Design of Integrated Manufacturing Center of Underground Laser Rapid Prototyping for Aeroengine Components Based on Cloud Computing and Internet of Things

Xiaodong Lv*
College of Aeronautical Manufacturing Engineering, Xi’an Aeronautical Polytechnic Institute, Shaanxi, China

*Corresponding author email: dxl_118@163.com

Abstract. This paper displaces an antiaircraft defence multi component integrated aeroengine manufacturing system which is designed for fast supply and timely repair of aeroengine in wartime. The robust control architecture is based on the global control of cloud computing and super expansion of the neural terminals of the Internet of things by fog computing. In order to improve the purpose of the whole system, we set up a system which can produce a variety of aeroengine components by the fog computing node with high autonomy. This relatively independent production system can receive intermittent commands from the cloud processor. For most of the time, each relatively independent laser rapid manufacturing unit runs the manufacturing task in the weak command environment. It only needs to send a decision from the cloud processor on the model and quantity of the aeroengine to be produced, and mark the changed parts with special requirements. Command encapsulation and encryption are carried out at the interface of the middle layer, and then sent down to the physical layer and the fog computing layer to realize macro command decryption and the production sequence of this batch of aeroengine production tasks configured to different number of laser manufacturing units.

1. Introduction
The underground manufacturing center is not easy to demolish and rebuild as the above ground buildings. It often involves the re networking and adjustment of the underground hydrology, pipeline system, electric power, gas transmission system and other systematic networks. In wartime, the air domination is a crucial factor to determine the direction of the war, and the aeroengine is the core part of the combat helicopter, so it is very important to maintain the wartime manufacturing capacity of the aeroengine, and the underground manufacturing center is undoubtedly a good choice. Through the fog calculation, the production sequence of each component in the helicopter can be rationally allocated and the manufacturing time can be optimized as a whole. The machine time of each laser rapid prototyping equipment can be allocated, so that the manufacturing time of the whole batch of aeroengine can be minimized. If the shielding measures are taken on the surface and the anti detection bunkers are arranged scientifically, the existence and stable operation of the underground manufacturing center in wartime is very possible. Compared with the above ground manufacturing centers, the underground constructions have higher concealment and anti Strike ability. However, due to the difference of temperature, humidity, dust, poor air circulation and other environmental factors,
people will feel uncomfortable at varying degrees, so we should try to improve the automation and remote control stability of the equipment in the underground constructions \cite{3,4}.

The main work of this paper is to introduce a kind of operation mode of aeroengine underground manufacturing center based on fog calculation. The core technology is the equipment communication in the shielding state of underground signal. \cite{5} So far, the advanced optical fiber technology is undoubtedly a good option to solve such problems. \cite{6,7}

2. Raw Design of Laser Rapid Producing Based on Cloud Computing and Aeroengine Database

There we explore a new mode designed for war time aeroengine in emergency. Each alloy component producing file stems from the aeroengine database and encoded in the middle-link-layers finally reaches the rapid laser producing unit. The network nodes in the upper layer of the rapid laser manufacturing unit complete the task distribution through fog computing. The task distribution of fog computing is based on the manufacturing time of each aeroengine component in the cloud database and the remaining time of the existing tasks carrying on each rapid laser manufacturing unit. Considering the manufacturing time of each aeroengine component recorded in the cloud database, the remaining machine time of each rapid laser manufacturing unit and the total number of rapid laser manufacturing units, optimize the configuration and minimize the manufacturing time of the whole batch of aeroengine. Overall framework is shown in figure 1.

Figure 1. Rapid laser producing mode supported by Cloud computing and aeroengine database.

2.1. Cloud Processing, Middle Layer Fog Calculation and Rapid Laser Manufacturing Unit

The cloud processor issues the macro instructions of the whole batch, the fog processor issues the tasks, the rapid laser manufacturing unit executes the specific task menu and feeds back the execution progress to the central control center. See figure 1 for classification details.
### Table 1. Cloud database output and online supervision of user terminal.

| Transmission mode       | Functions undertaken                                                                 |
|-------------------------|---------------------------------------------------------------------------------------|
| Cloud processing WiFi, Satellite, Cable, Optical fiber | Mobilize the aero-engine parts library in the cloud database and issue the manufacturing quantity and detail fine-tuning instructions |
| Fog calculation WiFi, Cable, Optical fiber          | Read the style and quantity instructions of the whole batch of aeroengine, optimize the resource allocation, and assign the parts manufacturing tasks of each rapid laser manufacturing unit |
| WiFi, Optical fiber      | The task progress is fed back to the general control system through optical fiber, and the manufacturing task instructions of aeroengine components to be executed are read by WiFi and fibre channel |

### 3. Fog Processor and Optical Fiber, WiFi Wireless Signal Communication in Underground Channel

The characteristics of underpass communication are as follows:

- Optical fiber is the main communication link, and it can extend almost infinitely.
- WiFi is the secondary communication link, but the coverage radius can be extended appropriately.
- The power line is connected in parallel with the optical fiber, which can provide auxiliary power for the rapid laser manufacturing unit.

For detailed description, the communication parameters of underground channel are shown in table 2.

### Table 2. Communication between fog computing processor and rapid laser manufacturing unit.

| Value                         | Whether there is expansion space |
|-------------------------------|---------------------------------|
| Length of underpass        | 2000m                           | No                           |
| Number of rapid laser manufacturing units | 30                             | Yes                          |
| Network packet generation speed | 2package/s | No                            |
| Radius of WiFi coverage    | 50m                             | Yes                          |
| Radius of optical fiber coverage | No limit       | Yes                          |

### 4. Results

Signal shielding, high security, unmanned operation room and remote control manufacturing are the biggest advantages of mature underground laser rapid manufacturing center. In wartime, the unmanned manufacturing center has a greater advantage than the manufacturing plant that needs to be equipped with manpower, because it will not occupy the already tense staffing. At the same time, the laser rapid prototyping unmanned manufacturing center has more difficulties in design and manufacturing than the factory workshops which need to be equipped with traditional artificial ground construction, because the fog calculation must provide accurate process control, positioning control, automatic navigation configuration of the material transport car between the equipment in the manufacturing center, etc.

The morphology of raw material powder is shown in figure 3. Furthermore, two examples of surface morphology of laser rapid prototyping products after polishing are shown in figure 4 and figure 5.
5. Conclusions

This paper briefly introduces the organic combination strategy of absolute autonomous single component local rapid laser cell manufacturing mode and relatively macro guidance of cloud processor, and describes a production example of weak command autonomous fog computing production and distribution system for manufacturing aeroengines on rapid laser forming units. If the fast laser production equipment is idle, once the mass aeroengine production task is distributed on the system, it will immediately enter the state of full speed autonomous operation. If there are unfinished jobs running at full speed, the newly assigned tasks will not affect the progress of the previously issued jobs and will be put into the waiting state. So this is a relatively independent manufacturing system.

- avoid excessively unnecessary network attacks;
- only the cloud processor sends out macro instructions, informing the model, quantity and local modification details of the aeroengine to be produced, then the fog computing terminal can execute the distribution of production tasks;
- different from the traditional structure set cloud computing as the core, the central of the system is the fog computing part of the terminal expansion location;
- simplified three-tier structure effectively eliminates redundant data.

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