New design deforming controlling system of the active stressed lap

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ABSTRACT

A 450mm diameter active stressed lap has been developed in NIAOT by 2003. we design a new lap in 2007.This paper puts on emphases on introducing the new deforming control system of the lap .Aiming at the control characteristic of the lap ,a new kind of digital deforming controller is designed. The controller consists of 3 parts: computer signal disposing 、motor driving and force sensor signal disposing. Intelligent numeral PID method is applied in the controller instead of traditional PID. In the end , the result of new deformation are given.

Key words: the active stressed lap; deforming controller; force actuator; intelligent numeral PID; response speed

1. INTRODUCTION

NIAOT has successfully developed a polishing machine with the active stressed lap technology in 2003. The lap has been used to polish a ϕ 9l0mm,with F/2 paralboloidal mirror . Figure 1 is a picture of the lap polishing a mirror.

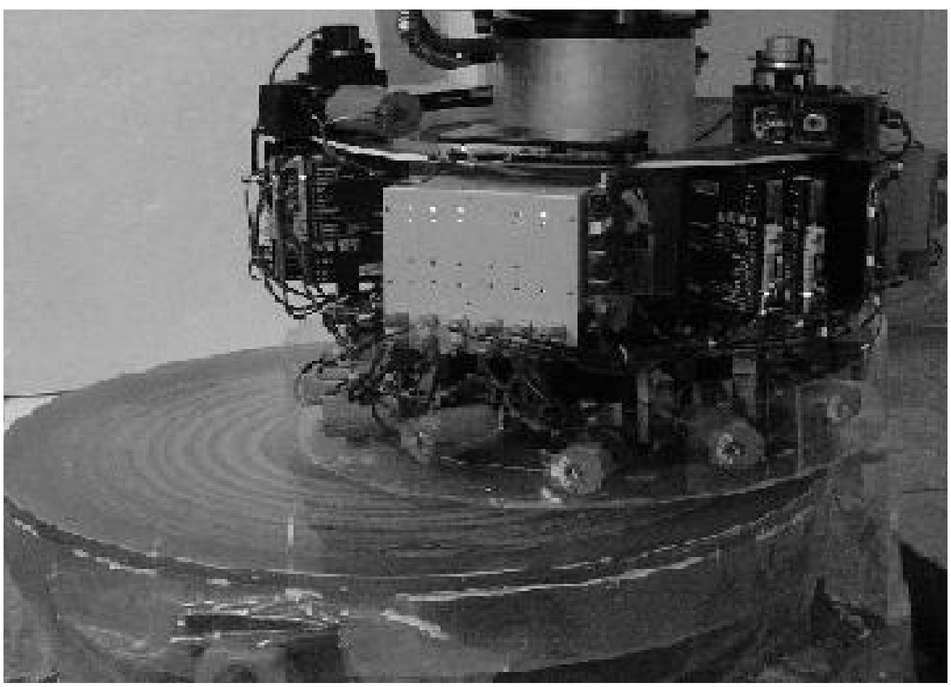

Fig.1 picture of the lap polishing a mirror

The result indicates the polishing efficiency and the accuracy are greatly improved. But during the procedure of the

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polishing , a few deficiencies of the deforming control system of the lap are found. One of the main shortcomings is that to improve the speed of rotation will cause the decrease of deforming accuracy because of the response slow speed of the deforming control system. In order to improve the performance of the active lap , the deforming control system is redesigned. Aiming at the control characteristic of the lap, a new kind of digital force controller is designed for the lap.

This article introduces the design of the digital controllers in detail. Section 2 briefly introduces the deforming technology of the active stressed lap. Section 3 introduces the design of the deforming control system. Section 4 introduces the hardware design of the digital actuator. Section 5 introduces the software design of the digital actuator.. In the end deforming experimental result of the new design is given in Section 6.

2. DEFORMING TECHNOLOGY

The active stressed lap technology is a new polishing technology. During the procedure of polishing , the active stressed lap can actively changed its shape and maintain an accurate fit to the mirror surface according to different lap position on mirror surface and different angle of lap Using the lap, so a aspherical mirror can be polished just like a spherical or a plane mirror. Compared with traditional polishing method, the active stressed lap has high polishing efficiency and natural smooth.

In figure 2 ,it can be seen that 12 force actuators are loaded on the back of the lap. In theory, according to any set of requirements of the off-axial aspherical surface, a set of corresponding force of actuators can be obtained. In this way, in the elastic limit scope of the material of the stressed lap to control the surface shape is transformed to control force of 12 actuators.

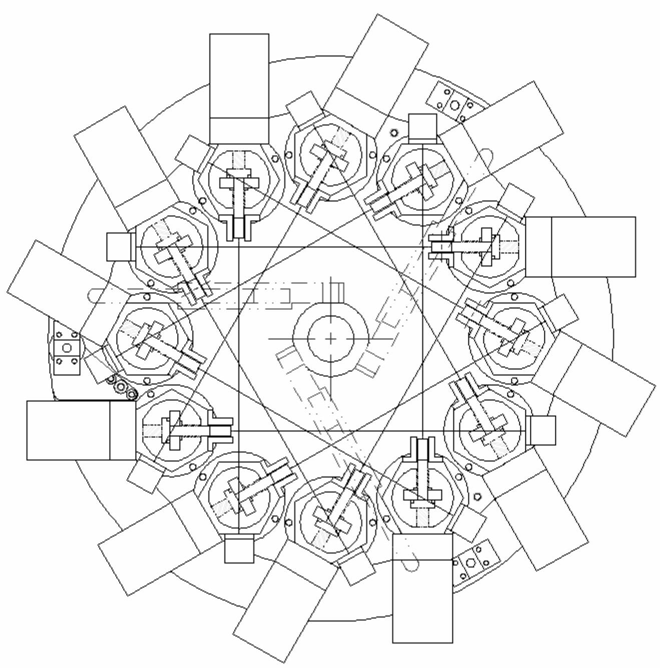

Fig.2 Deforming mechanical structure

The deforming control system of the lap is composed of 12 independent closed-loop control systems. These systems receive data form the control computer, then control the force actuator .In this way the required surface of the lap is obtained.

3. DESIGN OF THE CONTROL LER

The deforming control system mainly consists of three functions: computer signal processing、 motor driving and force sensor signal processing .In consideration of the requirements of the lap ,the deforming controller must also have fast response time、small size and light load.

Three functions are concentrated into a small PCB. The PCB is designed as a special controller for the active stressed lap. The controller uses a force and current double closed-loop control structure. The traditional speed loop is omitted in this controller. The control structure can be seen in Figure 3.

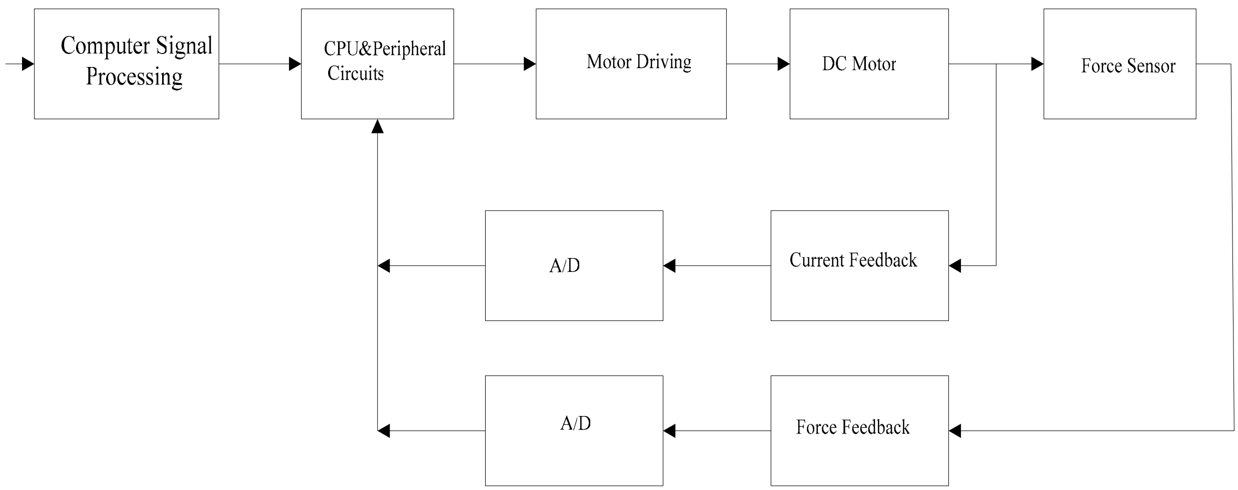

Fig.3 Control structure of system

4. HARDWARE DESIGN

For the polishing system bus is used can (Controller Area Network) bus, we select the microcontroller which is based on n a 16/32 bit ARM7TDMI-STM CPU with real-time emulation and embedded trace support as the CPU of the deforming controllers. The microcontroller is also combined with can-controllers and 10-bit ADC. It is suitable for the deforming controllers.

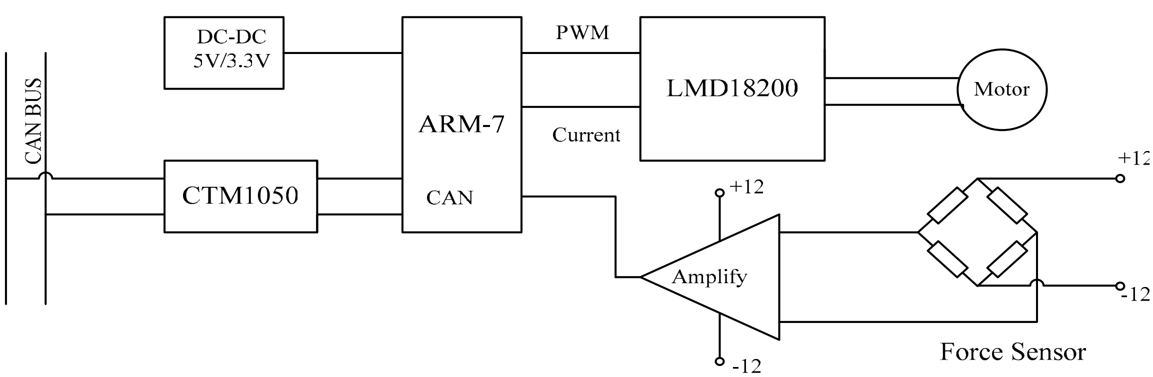

Fig. 4 Hardware theory sketch of the deforming controller

The motor driving part is based on the PWM outputs of microcontroller and LMD18200. The LMD18200 is a 3A H-Bridge designed for motion control applications. An innovative circuit which facilitates low-loss sensing of the output current has been implemented.

The signal of force sensor must be precision amplified and be transferred to microcontroller. The force signal and current signal must be A/D conversed by the 10-bit ADC of the microcontroller.

Figure 4 is the hardware theory sketch of the deforming controllers.

5. SOFTWARE DESIGN

The software design of controller mainly includes three parts. There are sending and receiving data through CAN bus、disposing force signal and intelligent numeral PID for the force and current feedback.

Figure 5 is the flow chart of the whole controlling system.

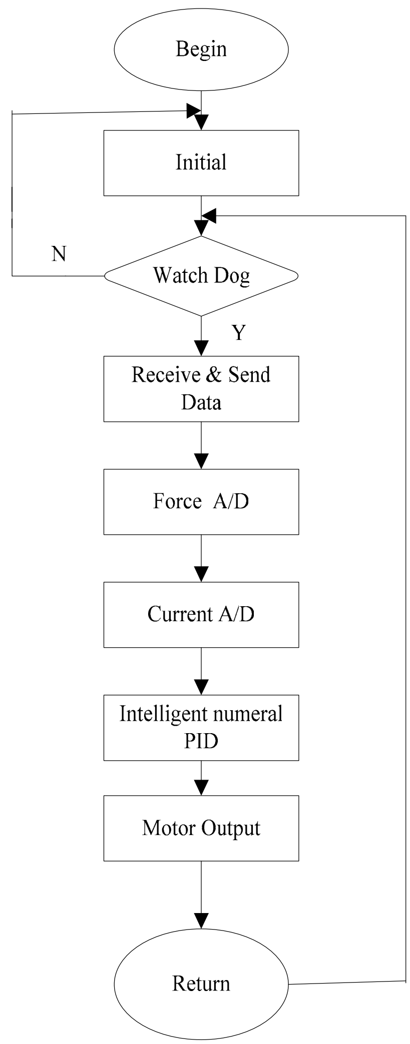

Fig.5 Flow chart of the whole controlling system

Among them , intelligent numeral PID algorithm is the most important part. Aiming at the characteristic of this system, integral partition PID algorithm is applied to replace the traditional PID. It can ensure the control accuracy 、avoid the oscillation system and speed up the response time.

Concrete steps are as follows:

1. According to the actual situation , set a fixed value X , $X > 0$;

2. When $|e_k| > X$, PD algorithm is selected.

3. When $|e_k| \le X$, PID algorithm is selected.

Figure 6 is the float chart of intelligent numeral PID algorithm.

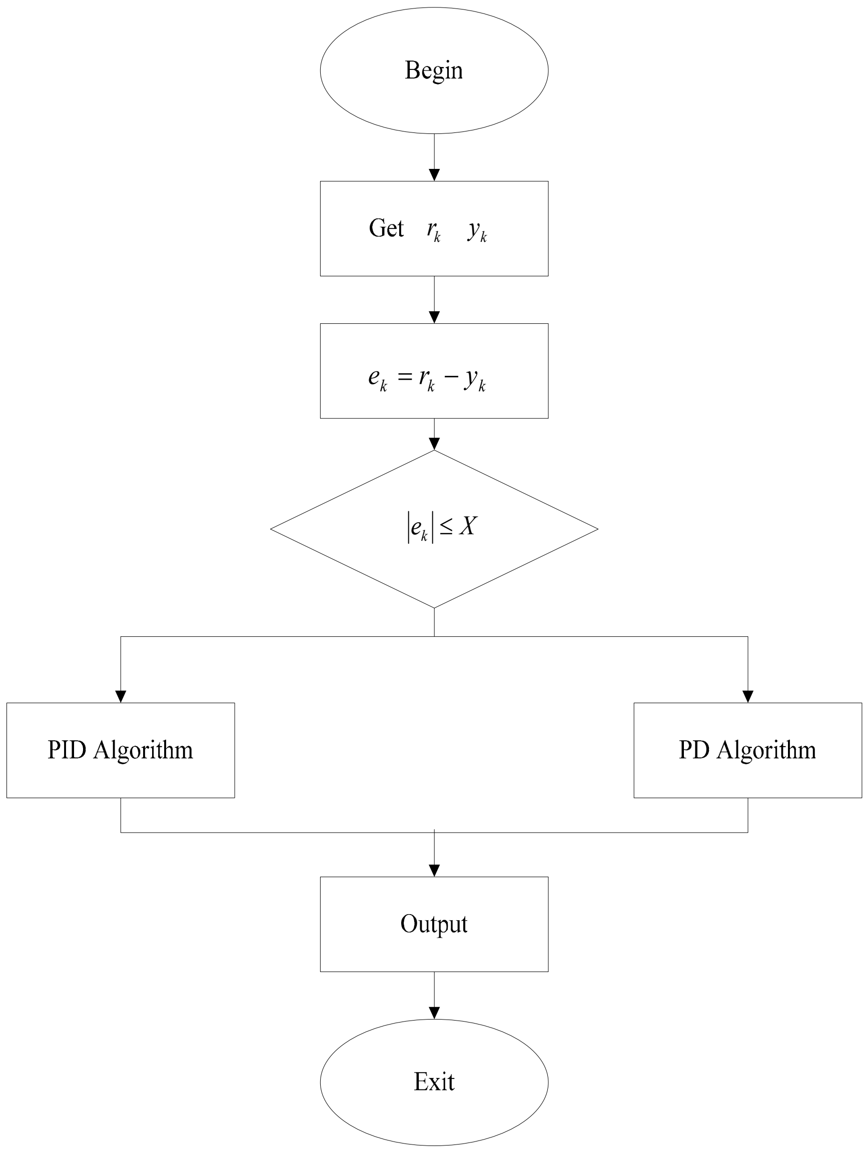

Fig.6 Float chart of Intelligent numeral PID algorithm.

6. DEFORMING EXPERIMENTS

In order to test the performance of the new deforming controller, deforming experiments are made. In order to easily making experiments, we design a simple deforming actuator. Figure 7 is its photo. Using it, we measure the response speed of the new controller.

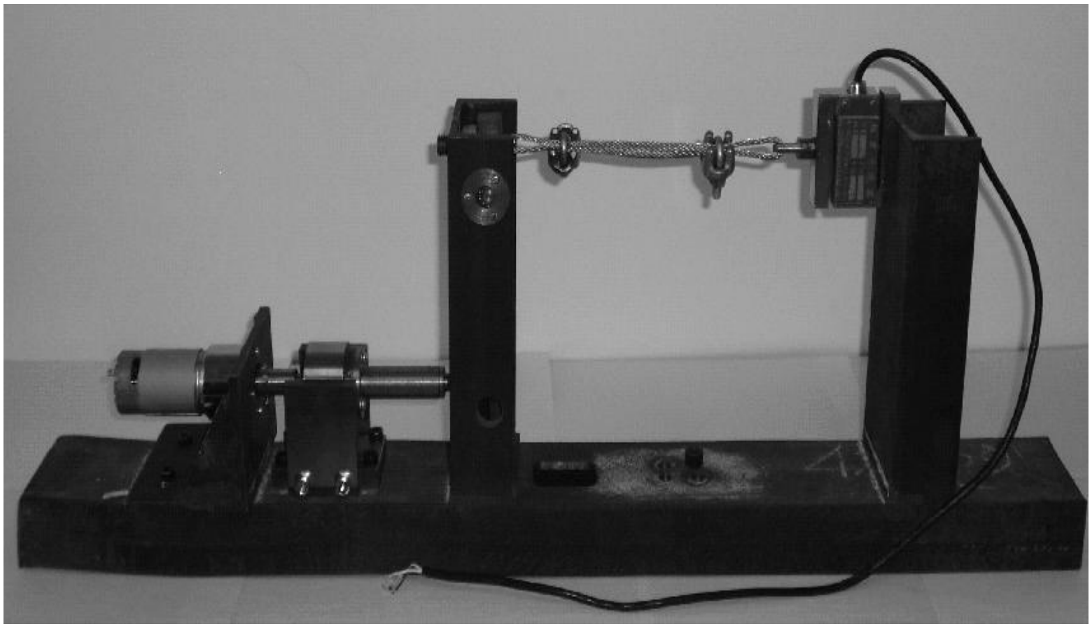

Fig.7 Photo of simple deforming actuator

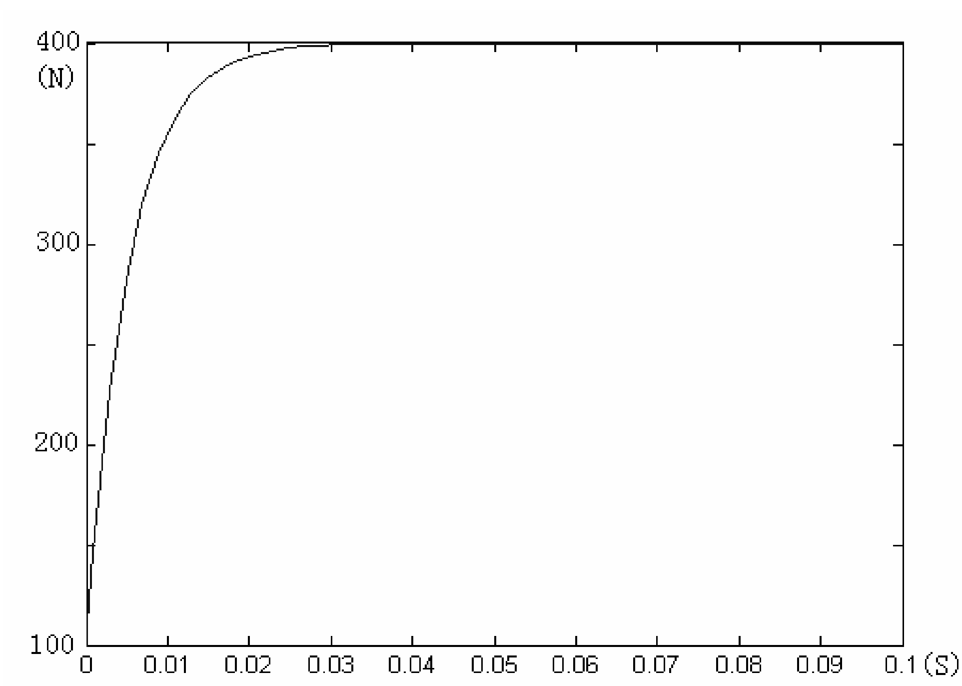

Fig.8 Step response

The line in Figure 8 is a simulated step response of the system. On the base of step response experiment, the sine response is tested. The two lines in Figure 9 represent given sine value and measured sine value.

From Figure 8 and Figure 9, it can be seen the response speed has been quickened largely.

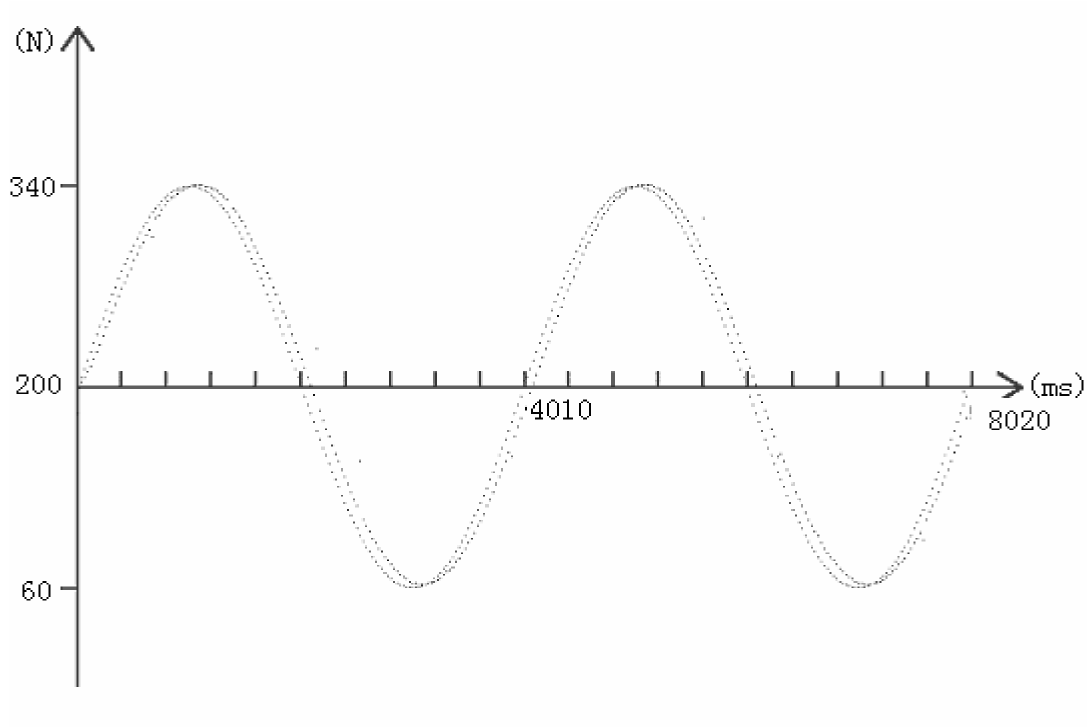

Fig.9 Sine response

CONCLUSION

After redesigned, the response speed and accuracy of new deforming controller have been largely improved. The new design makes the controlling structure simpler、the volume of the lap smaller and the weight of the lap lighter. It can be easily installed on the back of the active stressed lap. The new structure makes the lap is more transplantable.

The new deforming controller will improve the polishing efficiency of the active stressed lap. With the new design ,the active stressed lap can polish the bigger diameter, faster focus ratio and higher precision astronomical mirrors.

We will go on developing this technology of the active stressed lap and contribute to the development of the next generation's telescope.

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