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RESEARCH ON AUTOMATIC GRINDING PLATFORM FOR RARE EARTH INGOT CASTING

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Preliminary Note – Prethodno priopćenje

Aiming at the problems of low grinding efficiency and difficulty in ensuring grinding uniformity of rare earth metal ingots, a rare earth metal ingot grinding system was designed. Based on Creo software and ANSYS/Workbench software, the kinematics analysis, modal analysis and transient dynamics analysis were carried out on the walking mechanism and flipping mechanism of automatic displacement platform of grinding system. The results show that the rare earth metal ingot grinding system has good stability and is beneficial to improving the grinding quality.

Keywords: rare earth metal, ingot casting, automatic grinding, modal analysis, flipping mechanism

INTRODUCTION

Rare earth elements are widely used in the fields of metallurgy, military, petrochemical, glass ceramics, agriculture and new materials. [1] The molten salt electrolytic preparation of rare earth metal ingots, the surface layer of oxidation and impurities need to be polished. [2] At present, metal ingots are polished by traditional manual polishing method, which is inefficient and difficult to ensure the uniformity of polishing, and the metal dust generated by polishing is very harmful to human body. [3]

After investigation, the technical research of grinding robot began in 1970. [4] Subsequently, Japan, Germany, Switzerland and other developed countries developed a variety of automated and intelligent grinding and polishing equipment, among which the industrial robots produced by ABB of Switzerland have the most widely used applications, but at present there is less research on grinding robots and related equipment for rare earth metal ingots. [5]

Therefore, for a rare earth production line, an automatic grinding system for rare earth metal ingots has been developed. The system is composed of an automatic grinding and shifting platform and a six-axis industrial robot. The automatic grinding and shifting platform mainly consists of walking mechanism, rotating mechanism, turning mechanism and lifting mechanism, and cooperates with the six-axis industrial robot equipped with floating spindle and grinding wheel to finish the surface grinding of rare earth metal ingots. The kinematic and transient dynamics analysis of the automatic grinding and indexing platform is carried out by Creo and ANSYS/ Workbench. It is of great practical significance to actively explore the kinematic and dynamics characteristics of the grinding system of rare earth metal ingots, in order to improve the grinding accuracy of rare earth metal ingots.

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AUTOMATIC GRINDING PLATFORM FOR RARE EARTH INGOT CASTING

Rare earth metal ingots are trapezoidal and need to be polished on six sides. In order to realize automatic polishing, it is necessary to realize automatic clamping and turning action of the metal ingots by the indexing platform. At the same time, the automatic picking and discharging function is realized. The design of the grinding platform is shown in Figure 1.

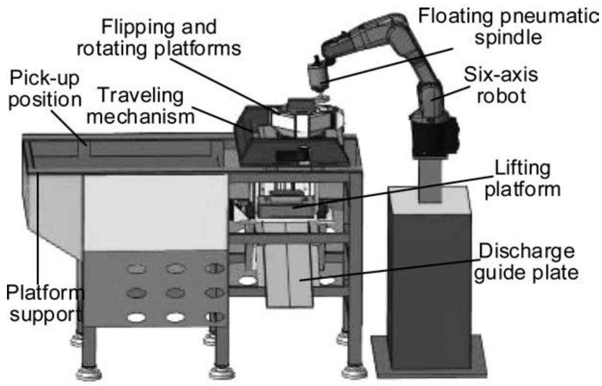

Figure 1 Automatic grinding platform for rare earth ingot casting

2 130 × 910 × 1 370 mm is the size of the platform support, and the maximum arm span of six-axis robot is 901 mm. the maximum speed of floating pneumatic spindle is 4 000 rpm, and the floating force is 35 N. in order to avoid the situation that the grinding amount is too much or not enough, the movement of walking mechanism, flipping mechanism and lifting mechanism

need high control precision, so the drive of each part is realized by servo motor and guided by THK high precision linear guide. Among them, the transmission of the walking mechanism uses the rack and pinion, and the lifting mechanism adopts the form of ball screw. There is a pneumatic swing table in the lifting mechanism, which can make the positioning platform of the lifting mechanism rotate 150 ° to complete the unloading of the finished ingot grinding products. The end of the six-axis industrial robot is a floating pneumatic spindle, which can realize passive submissive grinding and thus better control the grinding volume.

FLIPPING AND ROTATING PLATFORMS

The design of the flipping platform and the rotating platform is shown in Figure 3.

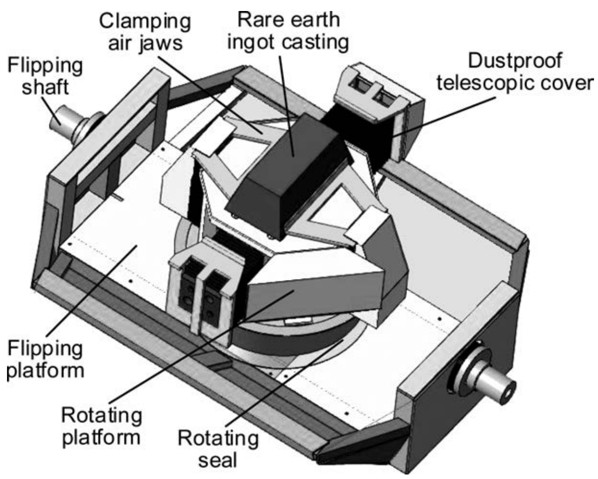

Figure 2 Flipping and rotating platforms

The rotary table is driven by a high precision pneumatic rotary indexing table, and the clamping and positioning of the ingots is realized by 2 wide air jaws. Since the working environment during grinding is very harsh and generates a lot of sparks and dust, [6] the pneumatic indexing table and the wide air jaws are sealed against dust using the rotating seal and the dustroof telescopic cover, respectively.

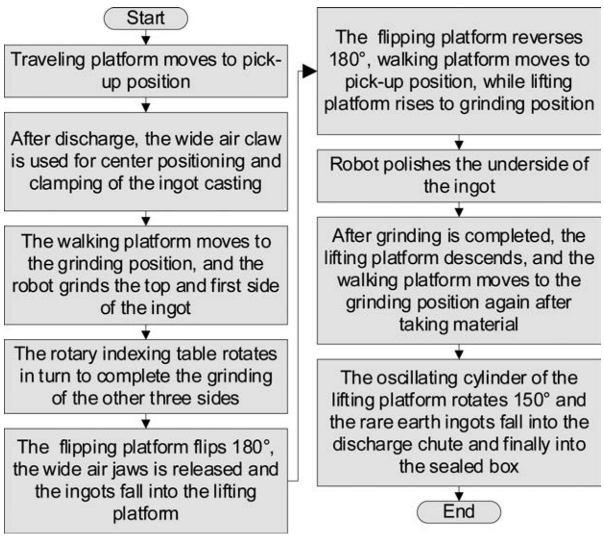

Figure 3 Workflow block diagram of the platform

WORKFLOW OF AUTOMATIC GRINDING PLATFORM

The pick-up position and grinding position are positioned with high-precision photoelectric sensors, and the rotating platform is equipped with pressure sensors to detect the metal ingots. The workflow of the automatic grinding platform is shown in Figure 3, where the pick-up position and grinding position are referred to Figure 2, and the location of the walking mechanism in Figure 2 is the grinding position.

MOTION ANALYSIS OF THE MECHANISM

According to the process flow and motion requirements of the automatic grinding platform, the servo motor operation modes of the walking mechanism, the tilting mechanism and the lifting mechanism are set in the Creo software, and the speed curve of the mechanism motion is derived, as shown in Figure 4.

In Figure 4, the maximum speed of the walking mechanism is 156 mm/s and the acceleration time is 2 s. The maximum speed of the flipping mechanism is 30 °/s and the acceleration time is 1 s. The maximum distance

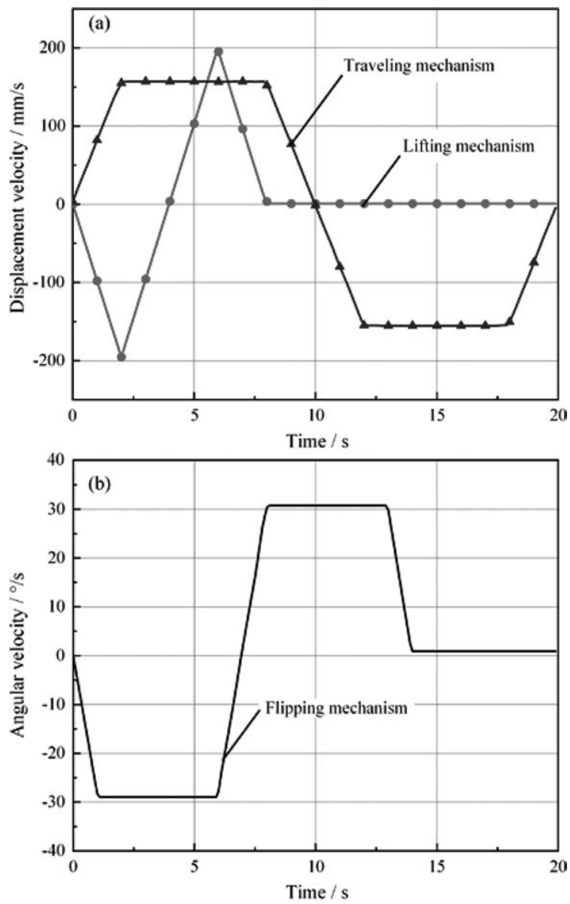

Figure 4 Velocity profile of the mechanism movement
(a) Displacement velocity; (b) Angular velocity

of the lifting mechanism is 400 mm and the acceleration time is 2 s. In Creo software - Application program - Mechanism module, add servo motors to the driving axes of the walking mechanism, the flipping mechanism and the lifting mechanism, and define the servo motors according to the mechanism motion law in the figure 5. Perform kinematic simulation analysis, and the analysis results are shown in Figure 5.

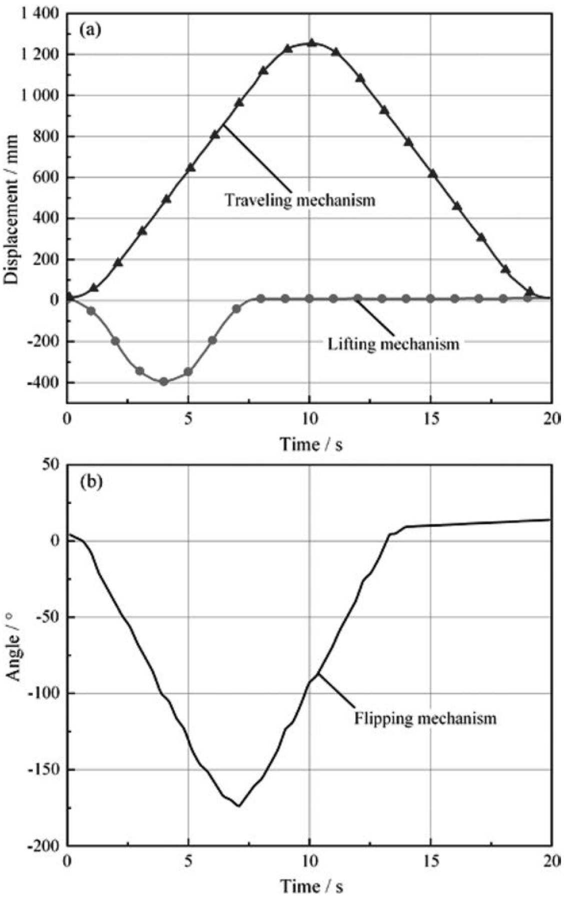

Figure 5 Displacement curve of mechanism movement
(a) Displacement; (b) Angle

Figure 5 shows the motion displacement curve of the mechanism, positive and negative indicate the direction. The maximum displacement of the walking mechanism is 1 188 mm, and the total time of the picking process and feeding process is 20 s. The maximum rotation angle of the flipping mechanism is 180 °, and the total time of the movement is 14 s. The maximum displacement of the lifting mechanism is 400 mm, and the total time of the rising process and the falling process is 8 s.

MODAL ANALYSIS AND TRANSIENT DYNAMICS ANALYSIS OF AUTOMATIC GRINDING PLATFORM

Modal analysis is the solution of structural vibration system by structural dynamics method. [7] The modal analysis of walking mechanism and flipping mechanism is carried out by ANSYS/ Workbench, and the analysis results are listed in Table 1. Among them, the first, third and sixth orders are local modes, and the second, fourth and fifth orders are overall modes.

Table 1 **Natural frequency of mechanism**

Order	1 st	2 nd	3 rd	4 th	5 th	6 th
Frequency/Hz	125,9	145,3	154,8	161,8	250,1	284,7

The modes of each order of the walking mechanism and the flipping mechanism can be divided into the overall mode and the local mode, and it can be seen from Table 1 that the frequency oscillations of each order differ greatly. Therefore, the transient dynamics of the braking process of the flipping mechanism is analyzed by the reduction method, and the solution with reasonable accuracy is obtained when the integration time step is taken 20 times the intrinsic frequency of the highest order mode.

$$ITS = \frac{1}{20f}$$

Where *ITS* is the integration time step and *f* is the frequency. According to the modal results, the mode that contributes most to the overall response of the flipping mechanism is the sixth-order mode with an intrinsic frequency of 284,7 Hz. The integration time step of the transient dynamics of flipping mechanism is 1,8 × 10^{-4} s. The torque curve required to flip the mechanism is obtained from the maximum angular acceleration of the flipping mechanism, as shown in Figure 6. In this case, the braking process is 1,3~2,3 s.

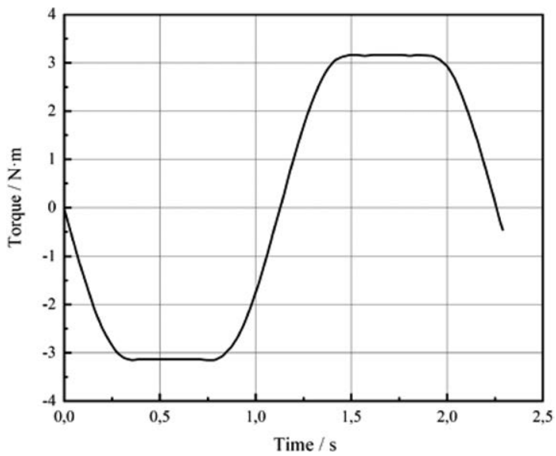

Figure 6 Torque curve of flipping

Based on the obtained torque curve the required torque for the braking process is added at the flipping axis of the flipping mechanism. Add gravity to the whole mechanism, where the direction of gravity is the positive direction of X. Add a fixed constraint to the travel mechanism.The overall deformation nephogram of the braking process of the flipping mechanism is shown in Figure 7. Figure 8 shows the response curve of the overall deformation displacement of the braking process.

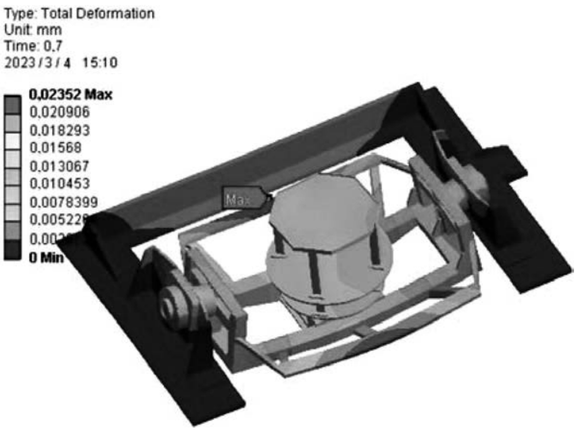

Figure 7 Deformation nephogram of whole

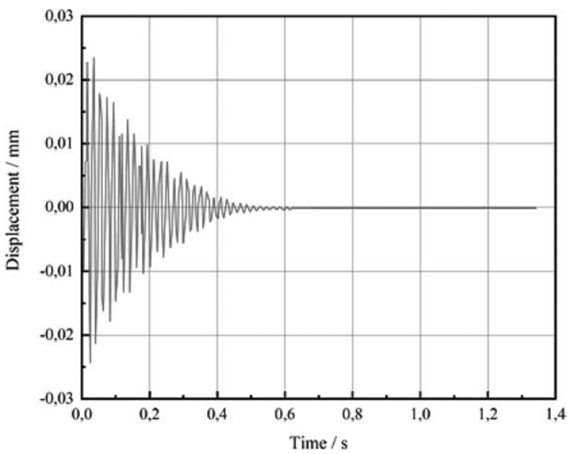

Figure 8 Response curve of displacement

According to Figure 7, when the flipping mechanism is braked quickly, the whole part of the rotating mechanism in the flipping mechanism has a tendency to change in the X positive direction, and the middle of the side support of the flipping mechanism is deformed most seriously, with the maximum deformation displacement of 0,0235 mm. Figure 8 shows the response curve of the overall deformation displacement of the braking process. After the rapid braking of the flipping mechanism, the mechanism shakes slightly, and the most serious position of the shaking is the middle of the support on both sides of the flipping mechanism, but it decays rapidly, and after 0,6 s, the shaking stops.

CONCLUSION

In this paper, a automatic grinding system for rare earth metal ingots is designed, and the kinematic analysis of the walking mechanism, flipping mechanism and lifting mechanism of the grinding system is carried out to obtain the motion displacement curve and torque curve of the mechanism, which shows the high accuracy of the mechanism motion position, smooth starting and braking process, and verifies the reliability of the automatic grinding system for rare earth metal ingots; through the modal analysis and transient dynamics analysis, it is shown that the vibration of the flipping mechanism of the grinding system can be quickly attenuated, which can effectively improve the grinding accuracy of rare earth metal ingots, and also provides a reference for the control parameters of the grinding system.

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Note: The responsible translator for English language is W. H. Zhen -Henan Xinxiang College, China