**Design of Automatic Loading and Unloading Device for the Fine Blanking of Thick Materials Based on the Humanoid Feeding**

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**Abstract.** In view that there is a high market demands on the precision stamping processing of thick plates and the loading & unloading of thick blank plates in current fine blanking industry of thickness materials are commonly implemented through the manual operation, a complete set of automatic loading and unloading device for the fine blanking of thick materials based on the humanoid feeding is designed. This device mainly consists of hydraulic press, unstacking device, alignment device, humanoid loading device, discharge device for the finished product, humanoid unloading device, etc. It realizes the automatic stacking, automatic unstacking, automatic alignment, automatic loading, automatic oiling, automatic feeding, automatic stamping, automatic discharge of stamping wastes, automatic discharge of the finished stamping products and automatic collection of waste plates, etc., and also basically realizes the automation of the whole process flow of the precision stamping processing of thickness plates.

**Introduction**

The rapid development of modern stamping technology makes it constantly expand the scope of application. The manufacturing of structure parts for all kinds of electromechanical and household electrical appliances by using the stamping technology for thick plates not only can realize the high quality, high efficiency and low consumption, but also can reduce the weight of products, improve the service life of the parts and decrease the production cost. In the batch production of products such as the automobile, tractor, motorcycle, agricultural machinery, engineering and construction machinery, instrument and apparatus, various home appliances and hardware, etc, the plate parts and three-dimensional parts with thickness within 4 -20mm can be manufactured with the stamping processing method for thick plates instead of the casting, forging, powder metallurgy and cutting processing methods, which not only can obtain the excellent economic benefits, but also can bring the significant comprehensive social benefits including the energy conservation, environmental protection, etc. Therefore, thick plate stamping technology is becoming more and more attractive as the main development direction and new field of modern stamping technology[1].

At the same time, stamping production technology is also developing towards the direction of high speed, automation and flexibility with the development of modern manufacturing technology. Manual operation, manual feeding and conveying production mode in traditional stamping production has been unable to meet the needs of the high-speed development industries such as the automobile, electronics, machinery, household appliances, national defense, etc as well as the increasingly fierce international competition demands. In the stamping production, the use of robots instead of manual operation to form automated production units or flexible automated production lines is an effective way to achieve the high-efficiency, high-speed and high-quality stamping production, and also an important development direction of modern stamping production technology[2].

At present, China's modern plate stamping technology is constantly developing towards the direction of thick material, precision, automation and intelligentization. Therefore, in view of the current situation that the loading and unloading of thick blank plate in the precision stamping industry is commonly implemented by the manual operation, an automatic loading and unloading
device for the precision stamping of thickness materials based on the humanoid is designed and developed through cooperation with a company specialized in the stamping of precision parts.

**Overall Scheme Design and Workflow**

**Design of Overall Scheme**

The automatic loading and unloading device for the precision stamping of thickness materials based on the humanoid mainly consists of humanoid loading device, humanoid unloading device, unstacking device, alignment device, oiling device, hydraulic press, waste discharge device, discharge device for the finished products, etc. The schematic working diagram for the complete machine is as shown in the Fig.1.

![Schematic working diagram for the complete machine.](image)


**Workflow**

The humanoid loading device will grab one thick plate from the unstacking device and place it in the alignment device, and the alignment device will be used to complete the alignment of the thick plate. The humanoid loading device will grab one aligned thick plate from the alignment device and push forward the thick plate at a set step into the hydraulic press, and the oiling device will be used to oil and lubricate the thick plate. The lubricated thick plate will enter into the space between the upper and lower die of the hydraulic pressure. One end of the stamped thick plate will stretch out from the discharge end of the hydraulic press, and the humanoid loading device will clamp the extension end of the thick plate, while the humanoid loading and unloading device will move up and down synchronously with the upper and lower die in the hydraulic press. This will be proceeded in turn until completing the total stamping process. The stamped waste plate will be moved from the humanoid loading device to the waste plate collecting device; the waste materials resulting from stamping will be discharged from the hydraulic press by the waste collection device and collected in the waste box of the waste collection device, while the finished products resulting from stamping will be discharged from the hydraulic pressure by the discharge device for the finished products and collected in the box for the finished products of the discharge device for the finished products.

**Process Flow**

Fig.2 shows the process flow diagram for the stamping automation production of the whole thick plate.
Design and Workflow of Each Mechanism

Design and Workflow of the Humanoid Loading and Unloading Device

The humanoid loading device and humanoid unloading device designed in this project have the same structure, and they mainly consists of tooling equipped with six-dimensional force sensor, industrial robot and double material detection device. This kind of humanoid loading and unloading device can simulate the actions of hands, and also has the functions such as the automatic loading and loading, double material detection, automatic feeding, and synchronous upward and downward movement of the tooling at the end of industrial robot with the die during the stamping of plate.

The human loading device and unloading device are symmetrically arranged at both sides of the hydraulic press. Fig.3 shows the schematic structure diagram for the humanoid loading and unloading device.

Design and Workflow of Tooling.

Tooling is an end actuator mechanism of robot and mainly used for grabbing plate\cite{3} and completing related actions. As the grabbed plate is thick plate which has a high load, the electromagnetic chuck with a higher adsorption capacity and stability is used to grab materials, and it is arranged on the support made of high-strength alloy. Two electromagnetic chucks are symmetrically arranged on the support made of high-strength alloy, and reversible plate clamping mechanism is installed at both sides of the support made of high-strength alloy. Six-dimension force sensor is installed between the tooling and the end of the industrial robot, so as to detect the load size, judge whether the plate is absorbed in place and whether the plate is dropped during handling, detect the different sizes of forces and moments along different directions during the up & down of plate with the stamping die, tail wraps after stamping, etc and then transfer the signal of force and moment to the robot control system. The robot will adjust the position and posture of the tooling according to the applied multi-dimensional force, which makes its clamped plate move up and down synchronously with the die of hydraulic press. In addition, after completing each stamping of workpiece, the robot tooling will clamp the plate to feed materials for a step towards the direction of the hydraulic press, so as to achieve the purpose of simulating the artificial production action and process of the stamping plate.

Design and Workflow of the Double Material Detection Device.

In order to prevent the robot grabbing double materials, the double material detection device is designed and installed on the tooling of robot for purpose of double material detection. This double material detection device mainly consists of connection parts, sensor, spring and electromagnetic chuck. After grabbing of workpieces by the robot, the electromagnetic chuck will closely absorb the plate under the regulating effect of spring to make sure that the sensor is vertical and close to the plate. The sensor is the ultrasonic wave sensor. The thickness of grabbed materials is detected through the ultrasonic wave and compared with the preset plate thickness, so as to detect whether it is the double materials and transmit the judgment result into the robot controller\cite{4}\cite{5}.

Design and Workflow of Unstacking Device

The unstacking device consists of ground rack of unstacking trolley, movable unstacking trolley, first plate detection sensor for detecting the stock of thick plates in the unstacking trolley and...
magnetic splitter for magnetic splitting of thick plate; the ground rack of unstacking trolley is installed at the front side of the hydraulic press, and the magnetic splitter is arranged at both sides of the ground rack of the unstacking trolley. The unstacking trolley can move along the ground rack of the unstacking trolley, and the unstacking trolley motor is provided on the unstacking trolley to provide power for it. The first plate detection sensor is installed on the body of the unstacking trolley.

In order to guarantee the continuous product, two independent unstacking devices are designed and symmetrically arranged at both sides of the humanoid loading device for purpose of alternate use. Fig.4 shows the schematic structural diagram for the unstacking device.

![Diagram](image)

3.1 Industrial robot; 3.2 Six-dimensional force sensor; 3.3 Tooling; 3.4 Double material detection device

**Figure 3.** Schematic structural diagram for the humanoid loading and unloading device.

4.1 First plate detection sensor; 4.2 Ground rack of trolley; 4.3 Magnetic splitter; 4.4 Trolley body; 4.5 Driven wheel; 4.6 Driving wheel; 4.7 Motor

**Figure 4.** Schematic structural diagram for the unstacking device.

**Design and Workflow of Alignment Device**

In the stamping production of plate, the position accuracy of plate in the die must reach ±2mm, while the stacking accuracy of plate can only reach ±5mm. In order to guarantee the speed and accuracy of the humanoid loading device in the grabbing and releasing of materials, accurate placement of plate in the die of hydraulic press and a certain degree of accuracy, a set of gravity alignment device is designed to realize the alignment positioning of the plate. This alignment device includes a main body of the alignment platform which has a rectangular platform face fitting the thick plate, and the alignment platform face is used to undertake the thick plate falling under its gravity. The rectangular platform face inclines towards one of its angle, and a blocking part is installed on the lowest corner of the rectangular platform face to prevent the occurrence of deviation of thick plate when it falls. Several rolling balls are arranged on the upper face of the rectangular platform, and the rolling ball is used for the rolling support the dropped thick plate. Several areas of the gravity alignment device can be adjusted through the movable plug to make the alignment device fit different plate dimensions.

**Design and Workflow of the Automatic Oiling Device**

In the stamping processing of the metal plate, there is a certain contact state of a certain pressure between the die and plate and high-temperature contact area extremely occurs in the processing. Therefore, in order to decrease the temperature of the contact area, improve the quality of stamping products and enhance the anti-rust performance of products, lubricating oil shall be used in the stamping process to sufficiently lubricate the plate.

This oiling device consists of supporting plate, oiling nozzle, nozzle bracket, oiling roller, oil box and oil pump. The supporting plate is horizontally arranged at the feeding end of the hydraulic device and extends to the front end of the hydraulic press device along the feeding end; the oiling
nozzle is installed on the supporting plate through the nozzle bracket and is located above the supporting plate, and oiling nozzle exit faces towards the supporting plate; there is a clearance between the oiling nozzle and supporting plate to let the thick plate pass through, and oil box is arranged at the bottom of the supporting plate; oiling roller is arranged in the oil box, and at least part of roller surface of the oiling roller is exposed out of the upper surface of the supporting plate; the inlet of oil pump is connected through with the oil box, while the outlet of oil pump is connected through with the oiling nozzle through the pipeline. Fig.5 shows the schematic structural diagram for the oiling device.

Work Flow of Hydraulic Press

The hydraulic press is equipped with upper die holder and lower die holder; the upper die holder is equipped with upper die plate, while the lower die holder is equipped with the lower die plate. The assembly of the upper and lower die plate can complete the blanking of thick plate, while the separation between the upper die plate and lower die plate can generate a spacing where the thick plate can pass through. The hydraulic press is equipped with oil pressure sensor to trig the blanking signal and oiling sensor to trig the oiling signal. Fig.6 shows the schematic structural diagram for the hydraulic structure.

Design and Workflow of Waste Discharge Device

Wastes resulting from stamping will be retained on the surface of the lower die plate after completing each stamping of plate, and damage will be caused to the die in the next stamping if the wastes are not taken out in time or not clean. In order to avoid damage during the stamping of die, a set of waste discharge device is designed to guarantee complete discharge of wastes.

This waste discharge device mainly consists of waste discharge bracket, waste collection and discharge device, waste weighing device and waste collection device.

Waste discharge bracket is arranged at one side of the hydraulic press and close to the hydraulic press device. Waste collection and discharge device mainly consists of the waste discharge cylinder and the waste pickup claw connecting with the piston rod of the waste discharge cylinder, and the waste pickup claw can do straight line motion with the stretching of the piston rod of the waste discharge cylinder, so as to pick up the waste resulting from the stamping of the hydraulic press device and discharge the pickup waste into the waste weighing device. The waste weighing device mainly consists of waste boxing cylinder, waste weighing platform and waste weighing sensor. The waste weighing platform is connected with the piston rod of the waste boxing cylinder and can do straight line action with the stretching of the piston rod of the waste boxing cylinder, and the waste
weighing platform can receive the wastes picked up by the waste discharge device. Waste weighing sensor is installed on the waste weighing platform to measure the weight of wastes dropped onto the waste weighing platform. The waste collection device consists of waste baffle and waste collection box. The waste baffle is vertical to the upper side of the waste weighing platform, and the clearance between its lower end and the upper surface of the waste weighing platform is not larger than the minimum thickness of wastes. The waste collection box is located below the waste weighing platform to receive the wastes blocked by the waste baffle and dropped onto the waste weighing platform. Fig.7 shows the schematic structural diagram for the waste discharge device.

Design and Workflow of Device for Pickup and Placement of the Finished Products

After completing each stamping of plate, the finished products after stamping will be retained on the formwork surface of the die and shall be taken out in time.

This device for the discharge of the finished products mainly consists of the bracket for discharge of the finished products, pickup and placement device for the finished products, detection device for the finished products and collection device for the finished products. The device for the discharge of the finished products is arranged at another side of the hydraulic press device and also close to the hydraulic press device; the pickup and placement device for the finished products mainly consists of the finished cylinder and the finished product pickup frame connecting with the piston rod of the finished cylinder, and the finished product pickup can do straight line motion with the stretching of the piston rod of the finished cylinder, so as to pick up the finished products obtained from the stamping of hydraulic press device and discharge the picked finished products into the finished product detection device. The finished product detection device mainly consists of the finished product detection frame and the finished product detection sensor installed on the finished product detection frame. The finished product detection frame is arranged below the finished product pickup frame and make the finished products dropped from the finished product pickup frame pass through its frame, and the finished product detection sensor is used to detect the finished product passing through the finished product detection frame. The finished product collection device mainly consists of the belt conveyor and the finished product collection box; the belt conveyor is arranged under the finished product frame, and the conveying belt on the belt conveyor is used to undertake the finished products dropped from the finished product frame and deliver the finished product into the finished product collection box; the finished product collection box is arranged under the front end of the belt conveyor and is used for receiving the finished products dropped from the belt conveyor. Fig.8 shows the schematic structural diagram for the finished product pickup and placement device.

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7.1 Waste discharge bracket; 7.2 Waste boxing cylinder; 7.3 Waste discharge cylinder; 7.4 Waste baffle; 7.5 Waste pickup claw; 7.6 Waste weighing platform; 7.7 Waste collection box; 7.8 Weighing sensor

Figure 7. Schematic structural diagram for the waste discharge device.

8.1 Bracket for discharge of the finished product; 8.2 Collection box for the finished product; 8.3 Belt conveyor; 8.4 Finished product detection frame; 8.5 Finished product pickup cylinder; 8.6 Finished product pickup frame; 8.7 Finished product detection sensor.

Figure 8. Schematic structural diagram for the finished product pickup and placement device.
Summary

This set of equipment has simple principle, reasonable design, clear structure, convenient operation, safety and reliability. It can fit the stamping production of plates with thickness of 8-12mm, and the stamping production rate can reach 8 times/minutes; the production line basically realizes the full automation, and reduces the labor intensity and production risk of workers under the premise of reducing workers. Meanwhile, as this set of equipment uses the industrial robot, it has a high degree of flexibility and breaks the barriers of the conventional stamping automation production line, such as the single product, long cycle for replacement of production line and high cost. The replacement of the product line can only be achieved by replacing a set of tooling, so it has a higher flexibility and saves a lot of time and costs for the enterprises.

References


