Design and research of impact test bed

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Abstract

Honeycomb materials have many advantages, including their lightweight, stability of plastic deformation, and high energy absorption capacity. In recent years, the industry has been widely concerned with honeycomb materials increasingly used in automotive, aerospace, engineering, and construction. However, the research on crashworthiness and energy absorption of honeycomb materials under impact load has been booming.

The crashworthiness of the honeycomb specimen is tested by adding a drop hammer to the honeycomb specimen by drop hammer, which is simple in principle and easy to realize. It is the main experimental method to study and analyze the crashworthiness of honeycomb specimens. The main execution mode of the same type of test bed is pneumatic, high cost, a large area of occupation, and inconvenience in maintenance and repair. Most of them are T-groove guideways of cast iron, which have high precision and stiffness, but they are cumbersome. Some drop-weight release mechanisms use mechanical stroke switches and complex structures.

This project aims to set up an impact experiment system with a simple structure, low cost, and precise transmission according to the specific situation and research needs. The research contents of this design mainly include the following aspects :

1) studying the impact dynamics and the basic theory of impact and establishing the mathematical model of impact test;

2) Complete the overall design of the drop hammer impact Test bed according to the test target. Then, several implementation schemes of the drop hammer impact Test bed are compared, and the optimal scheme is selected according to the advantages and disadvantages of these schemes. Then the whole experiment platform is divided into several parts with the idea of modularization, including the design of the drop hammer device, the base design, the design of the lifting mechanism.

3) For the key automatic release mechanism in this design scheme, a release mechanism implementation principle is put forward, and the final design scheme is determined through the analysis of the principle. The three-dimensional model of the release mechanism is built and checked.

4) The control scheme is put forward according to the experimental flow of the test rig and the corresponding control requirements. Through the analysis and understanding of the control scheme, the I / O points, input and output equipment controlled by PLC are determined. Then the control flow of the control system is determined according to the input and output equipment, and the PLC trapezoid diagram and PLC program language are written accordingly. Finally, the hardware selection of the control system is completed according to the requirements of the overall scheme.

Keywords: honeycomb material; drop hammer impact test rig; automatic release mechanism; PLC control servo motor

Contents

Chapter 1: Introduction

1.1 The social context, purpose and significance of the project study

1.1.1 The social context of the project research

A porous material is a network structure formed by the regular or irregular arrangement of holes that penetrate or close to each other. Honeycomb materials, in the traditional sense, are a kind of porous materials, but due to domestic and foreign research in recent years. The study and creation of honeycomb materials, now what we call the meaning of honeycomb materials, has significantly changed [2] . For example, Liu Peisheng defined honeycomb materials in his work as follows: continuous solids are arranged in two dimensions as polygons
The pores are correspondingly present in columnar partitions, similar to the hexagonal nests of honeycombs so this two-dimensional porous material can be used
Figuratively referred to as "honeycomb material"[3].

As scholars at home and abroad pay more and more extensive attention to honeycomb materials, many different definitions of honeycomb materials have emerged, but their central descriptions are almost the same as Professor Liu Peisheng.

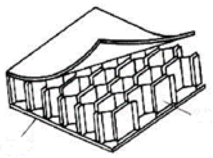


Figure 1-1: schematic diagram of honeycomb structure materials

The advantages of honeycomb specimens are obvious: lightweight, impact resistance, energy absorption, and economy. Hence the honeycomb material. In recent years, it has also become a new type of green material that is emerging in developed countries to save resources, protect the ecological environment and have low cost. Moreover, for honeycomb structural materials used in the aviation and automotive industries, crash resistance is one of the most important indicators of performance.

Figure 1-2 honeycomb explosion-proof tire damaged by external force

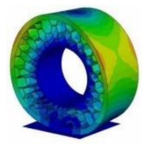


Figure 1-3 honeycomb tire

Impact testing machine (English name: impact testing machine) refers to the application of impact test force to the specimen Material Test bed for impact testing. The impact Test bed is divided into manual pendulum impact Test bed, semi-automatic impact Test bed, and so on.

Digital display impact Test bed, microcomputer controlled impact Test bed, falling hammer impact Test bed and non-metallic impact Test bed, etc. By replacing the hammer body and the specimen base, it is possible to test the simple support beam and the cantilever beam. Among them, the falling hammer impact Test bed adds instantaneous impact force to the honeycomb specimen through the falling hammer of the free fall so as to test the impact resistance of the honeycomb specimen, the principle is concise and easy to achieve, and it has become the main experimental method for the study and analysis of the impact resistance of the honeycomb specimen.

1.1.2 The purpose and significance of the project research

At present, the main execution mode of the same type of Test bed is pneumatic. Its advantage is precise and smooth loading. Its disadvantage is high cost and large area. In addition, the pneumatic Test bed must have intricate power devices and gas pipelines. Maintenance and repair is very inconvenient. The general drop hammer also needs to use the guide rail limit when falling, and most of its guide rail part uses a T-slot guide made of cast iron, which is a bit of high precision and stiffness, but it is very bulky. There are also some drop hammer release mechanism control parts that use mechanical stroke switches, the degree of automation is low, the structure is complex, and the position and height of the heavy hammer lift, the position and height of the release mechanism to perform the release action are determined by the stroke switch, if you want to adjust the position of the stroke switch, it is very troublesome.

The purpose of this project is to build a set of impact experiment systems with simple structure, low cost and accurate transmission according to the specific situation and research needs.

1.2 Research status in related fields at home and abroad

1.2.1 Study of impact Test bedes

1.2.2

The research needs of impact Test bedes come from the demand for strength tests of materials because of the leading nature of the industrial revolution, so foreign countries started very early in this regard, from the earliest simple structure of gravity Test bed to the most advanced pneumatic catapult impact Test bed abroad are ahead of the domestic. And according to the degree of automation, the Test bed can be divided into three generations. The first generation of automation is low, is to spring, rubber and other elastic components as the source of impact of the mechanical impact table; the second generation, because of the development of automation technology, has a certain automation performance, high precision, stable performance, is to combine hydraulic and pneumatic control with building the impact Test bed; 20 At the end of the century, on the basis of the current development of information technology and electronic integration technology, the third generation of impact Test bed was developed, the third generation of impact Test bed can adjust the impact energy by changing the counterweight and increasing the height, which can realize a high degree of automatic control of the impact process and can be realized after the impact process is completed

Now shock data collection and analysis. For example, the ZCJ series impact tear testing machine developed by MTS in the United States and the SM produced by [AVCO] A series of impact testing machines, the EPS series produced by Ito Seiki Co., Ltd. in Japan, and the ASQ series impact testing machine produced by Yoshida Seiki Co., Ltd. are representative products. Subject to technical strength, rush imported from abroad.

The price of the Test bed is very high, and the entire test maneuver is hundreds of thousands of dollars.

In recent years, benefiting from the development of domestic technology, many domestic impact Test bedes have also appeared in China, such as the TestStar series of electronic universal testing machines of Shenzhen Wan testing equipment Co., Ltd.

Figure 1-4 U.S. MTS Company ZCJ2000 Drop Hammer Punch Test Machine

Figure 1-5 Deep Zhen Wan test company DIT shock drop Hammer punch test machine

1.2.3 Study on collision resistance and energy absorption characteristics of honeycomb specimens

Since the 1960s, researchers at home and abroad have promoted the study of honeycomb materials because of the demand for materials with small specific gravity, specific strength and higher stiffness, such as the Apollo lunar spacecraft and other aerospace projects that have made extensive use of hive materials.

Most of these studies are aimed at the energy absorption of honeycomb structures for the impact resistance when receiving out-of-plane impacts, and most of the research objects are honeycomb sandwich structures.

As early as 1961, McFarland began doing a lot of research on honeycomb materials. In 2005, Xia Lijuan and Yu Yin and others optimized the design of the thickness of each part of the honeycomb specimen sandwich board under many working conditions. Also, in 2005, Yamashita and Gotoh abroad also faced the shape and surface of the cells of honeycomb materials under external shock loads. The thickness of the plate has been studied a lot, and the above is the impact resistance of the honeycomb specimen to the honeycomb material when it is subjected to external impact load research. Because the energy absorbed by honeycomb materials when they receive extra-surface shock is much higher than the energy absorbed by receiving internal shock loads, most of the research on the impact resistance and energy-absorbing characteristics of honeycomb materials is also limited to the situation of receiving off-plane impact loads.

However, in recent years, the crash resistance and energy absorption characteristics of honeycomb materials when receiving shock loads in the surface have also been paid more and more attention by many industry researchers.

In 1988, Klintworth and Stronge were established under conditions where honeycomb materials were subjected to in-plane shock loads.

Basic theoretical mode. In 1994, Papka and Kyriakides used finite element simulation software ABAQUS to simulate the compression process of honeycomb materials under in-plane shock loads and compared them with experimental results. Domestic research on this project is much later. By 2005, Lu Wenhao and Bao Ronghao used theoretical analysis and finite element simulation

Method, the mechanical phenomena of honeycomb materials under dynamic shock loads were analyzed.

In summary, whether it is about the off-plane impact load or the in-plane impact load, scholars and experts at home and abroad have done a lot of research on the energy absorption and collision resistance of honeycomb specimens, and there is a lot of literature to be found in this regard. However, most of the above studies are based on finite element simulations and theoretical models to make process analysis, and the experimental results of impact loads on honeycomb specimens are not sufficiently studied.

1.3 The main research content of this topic

This project aims to build a set of impact experiment systems with a simple structure, low cost and accurate transmission for honeycomb materials according to the specific situation and research needs, and the research content of this design mainly includes the following aspects:

(1) Study impact dynamics and the basic theory of collisions, and establish mathematical models of impact tests

(2) According to the test objectives, the overall design of the falling hammer impact Test bed is completed. First, compare the implementation schemes of the drop hammer impact Test bed, and select the optimal scheme according to the advantages and disadvantages of these schemes. Using the idea of modularity, the entire Test bed is generally divided into several parts for design, including the design of the falling hammer device, the design of the base, and the design of the lifting mechanism

(3) For the most critical automatic release mechanism in this design scheme, a release mechanism execution principle is proposed, and the final design scheme is determined through the analysis of the principle. Build a 3D model of the release mechanism and check it;

(4) According to the experimental process of the Test bed and the corresponding control requirements, the control scheme is proposed, and then through the analysis and understanding of the control scheme, the input and output devices that need PLC control are determined so as to determine the number of I/O points required by the PLC. The control flow of the control system is then determined according to the input and output devices, and the PLC ladder diagram and PLC programming language are written accordingly. Finally, according to the requirements of the overall scheme, the hardware selection of the control system is completed.

Chapter 2: The overall design of the honeycomb specimen impact Test bed

2.1 How honeycomb specimen impact testing works

2.1.1 Basic concepts of impact dynamics

Impact motion is the movement in which the parameters of force, position, velocity, acceleration, etc. change dramatically in a very short period of time. The impact on the object will make the object have a great acceleration in a short period of time, and for the human body, the impact will cause damage to the instrument. Therefore, in this design, because the main test mode is impact, safety factors must be taken into account, considering the impact of the impact on the surrounding environment and people, and measures must be taken to isolate and absorb the impact energy.

Shocks can be divided into three types according to the time domain waveform characteristics according to the excitation parameters:

(1) Pulsed shock. This shock is an impact that is instantaneously changed by a great change in the excitation parameter, from the equilibrium position to the maximum instantaneously, and back to the equilibrium position. Idealized pulse-type shock waveforms include semi-sine waves, trapezoidal waves, triangular waves, and sawtooth waves. This kind of impact mostly occurs in the collision, drop and so on of the goods in the process of transportation, loading and unloading

(2) Step impact. This shock is also instantaneously changed from the equilibrium position to the new position by a great change in the excitation parameter in an instantaneous time. The idealized step-type impact process takes only microseconds to milliseconds. The most classic example of this kind of impact is when a multi-stage rocket is separated, because the front stage is abandoned, the mass is instantaneously reduced, and a step impact occurs

(3) Complex shock, also known as transient vibration. The reciprocating oscillation of this shock waveform is difficult to express mathematically. In fact, most of the indirect (transmitted through skins, partitions, brackets, etc.) of aircraft, missiles and instrumentation equipment inside the ship is a complex impact.

2.1.2 A mathematical model of a drop hammer impact

According to the principle of the falling hammer impact Test bed and the requirements of the falling hammer scheme, it is necessary to measure the instantaneous impact force, instantaneous speed, instantaneous displacement and impact energy to analyze the experimental results of the honeycomb specimen being impacted. Moreover, because the impact force of the impact test is very large, the damage to the specimen is large, and the damage to the contact sensor will also be very large, so the sensor measurement method must be non-contact.

Based on the above requirements and analysis, the acceleration measurement is finally selected as the key measurement, and according to the acceleration, the instantaneous impact force, instantaneous velocity, instantaneous displacement and impact energy can be obtained.

Among them, the instantaneous impact force is:

$$P(t) = M\,[g + a(t)] \quad (2\text{-}1)$$

Where P(t) – instantaneous impact force (N) ; M – weight weight (kg);

a(t) - measured instantaneous acceleration (m/s2); g - gravitational acceleration (m/s2).

Regardless of the friction of the guide column and lifting mechanism, the acceleration of the impact of the entire drop hammer on the honeycomb specimen can be reduced to freedom Falling body movement, the instantaneous contact speed between the falling hammer and the honeycomb specimen can be calculated according to the free fall. In fact, according to the research of researchers at home and abroad, in the falling hammer impact experiment, the impact of friction on the test results is minimal, and it can be omitted. Therefore, the friction force is omitted during the calculation of the above instantaneous impact force, and the entire impact model is simplified to free fall motion.

Therefore, the acceleration measure of the last measurement is integrated once and twice, respectively, and the corresponding instantaneous velocity and instantaneous displacement are obtained.

The instantaneous speed is

$$V(t)= v(0) + \quad (2\text{-}2)$$

The transient displacement is

$$s(t)= \int_0^t dx \int_0^x a(t)dt - s(0) \quad (2\text{-}3)$$

where v(0) – initial impact velocity (m/s);

s(0)—Initial compression displacement(m);

v(t)—Transient velocity (m/s);

s(t)—Transient displacement(m).

Combined (2-2) and (2-3) to obtain the load-displacement journey P(s). The load-displacement curve P(s) is integrated to obtain the impact energy absorbed by the specimen; the impact energy is:

$$E = \int_0^{\Delta L} P(s)ds \quad (2\text{-}4)$$

Eventually, the impact energy loaded onto the honeycomb specimen is

$$E' = Mg\ (H + \Delta L) \qquad (2\text{-}5)$$

Wherein, H is the distance between the bottom surface under the hammer and the bottom surface on the specimen, and the ΔL is the length of the specimen destruction, where Δ L is generally negligible.

2.1.3 How the test system works

The falling hammer impact Test bed generally includes the base, the upper platform, the lifting beam, the support mechanism, the guide mechanism, the release mechanism, the falling hammer mechanism and so on.
It works as:

Lifting stage: through the motor or other power source to provide power to the lifting mechanism, driving the lifting mechanism to lift, the lifting mechanism rises at the same time to drive the release mechanism and the falling hammer mechanism to rise together, the falling hammer device and the counterweight added to it thus obtain sufficient gravitational potential energy.

Release stage: the release mechanism is opened, the falling hammer device does a vertical downward free fall operation because of the role of the guide mechanism, and the hammer head impacts the honeycomb specimen placed on the base.

2.2 Design and implementation of Test bedes

2.2.1 System Requirements

According to GB/T6803 for the technical regulations of the ordinary falling hammer material testing machine and the realistic needs of the falling hammer testing machine, there are the following requirements for the system as a whole:

First, sufficient strength and stiffness must be guaranteed. In the lifting stage, it is necessary to lift the falling hammer to a high place, and there are high requirements for the strength and stiffness of the lifting beam, roller screw and other parts, especially the two brackets and blocking blocks of the release mechanism withstand the weight weight and the gravity of the hammer head on almost all the falling hammer devices in the lifting stage, and the requirements for strength and stiffness are very high; in the release stage, the block block of the release device is absorbed by the electromagnet, the decoupling is opened, and the falling hammer device and the hammer head move from the falling body. The honeycomb specimen on the hammer head impact base also has a high demand for the strength and height of the base due to the destructive nature of the impact process;

Second, the support guide mechanism should be perpendicular to the base, and the support guide mechanism should be parallel to ensure that the hammer body can do free fall movement, and the hammer landing point is just concentrated on the honeycomb specimen. This places very high demands on manufacturing precision.

Third, the rigidity and inertia of the base must be guaranteed. Theoretically, the base should be an infinitely large rigid plate, so the base must have very high rigidity and very high strength. Due to the destructive nature of the impact process, it should be ensured that the falling hammer impact will not interfere with and destroy the data acquisition system around the testing machine, in addition, taking into account the service life of the testing machine

It should be ensured that the base does not crack after multiple impacts and that the base does not dent.

Fourth, considering the service life of the testing machine and the accuracy of the test, the hammer body of the falling hammer should ensure that it will not cause obvious deformation after multiple punches, so the hammer body should ensure a very high hardness, and the hardness value should reach 50HRC or more.

Fifthly, security must be guaranteed. In order to prevent the honeycomb specimen from popping out and injuring people during the impact process, a protective device should be provided around the testing machine, and a safety yellow line should be set up, requiring the surrounding personnel to be outside the safety yellow line;

Sixth, in the impact process, the falling hammer changes greatly in the state of motion in a very short period of time, so in order to ensure the accuracy of the collected data, it is necessary to ensure that the speed of the data collection process is fast enough, and there are also high requirements for the sampling rate and sampling accuracy.

2.2.2 Choice of system design scheme

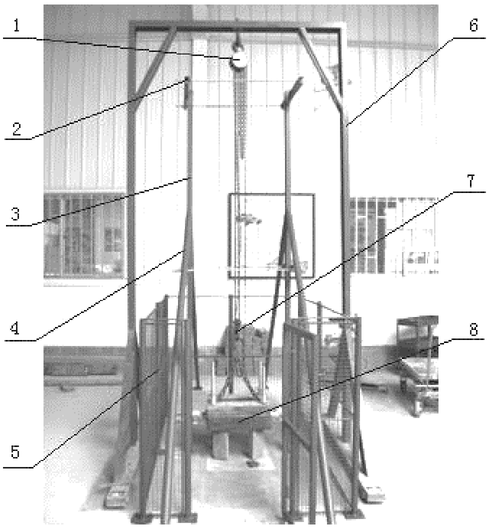
In general, the power source currently widely used in the drop hammer impact Test bed is divided into four types: 1) hand pull hoist type. By pulling the hoist by hand, the lifting mechanism drives the release mechanism and the falling hammer mechanism to lift, this kind of square

The degree of automation is low, and it requires high labor intensity, in addition, the transmission is not precise, it is impossible to accurately calculate the lifting height of the lifting mechanism, and it is impossible to accurately predict the size of the final instantaneous impact energy;

2) Motor win-up type. Through the hoist, the lifting mechanism drives the release mechanism and the falling hammer mechanism to lift. This equation does not set the starting position of the shock, and it is also impossible to accurately measure the height of the lift, and it is impossible to finally instantaneous shock energy

3) Hydraulic or pneumatic. The advantage of hydraulic pump or air pump as a power source is that the realization of the impact Test bed is simple and efficient, the transmission is precise, but the cost is high, the footprint is large, in addition, the hydraulic or pneumatic Test bed must have intricate power devices and pipelines, maintenance and repair is very inconvenient.

4) Servo motor type. The kinetic energy of the servo motor is converted into the gravitational potential energy of the heavy hammer by using the servo motor as the power, plus the transmission mechanism such as the timing belt and the roller screw. This method is simple and efficient to perform, and the loading and transmission are smooth and precise. In addition, the servo motor has overload protection.



1-Hand pull hoist 2-lead screw structure 3-rail 4-rail support

5- Guardrail 6- Gantry 7-Decoupling 8-Hammer Diagram

Fig. 2-1 Hand-pulled hoist type falling hammer impact Test bed

In general, the currently widely used guiding mechanism of the falling hammer impact Test bed is guided by V-groove and channel steel or through the combination of groove and guide wheel. The biggest disadvantage of this kind of guidance method is that it is not suitable for the test of the large impact force brought by the large mass falling hammer, because the greater the weight of the falling hammer, the higher the height of the lift, the greater the instantaneous impact force caused by the fall, when the above two types of guiding mechanisms are used, once the instantaneous impact force exceeds the limit that the guide mechanism can withstand, the channel steel or guide wheel may jump out of V Type grooves and grooves, leading to the destruction of the Test bed. There is another guiding mechanism on the market is to use the guide column and the drop hammer device and the through hole on the lifting device to achieve the directional function, this guide device guidance is precise, economical and practical, and will not be affected by too large instantaneous impact and damage or affect the guidance accuracy, as long as the use of suitable surface processing technology, friction can also be completely controlled within the acceptable range.

In summary, the use of servo motor as the power source, the selection of roller screw transmission, the selection of the guide column as the guiding mechanism, this scheme can ensure the efficient and accurate loading and accurate guidance of the impact Test bed, and there is no safety threat when the impact test machine works, the footprint is not large, the cost is not high, and it is the best design scheme.

2.2.3 The design of the heavy hammer

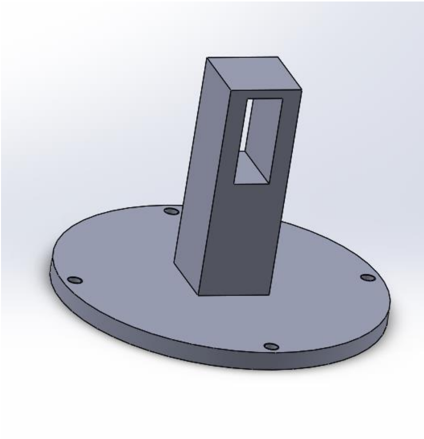
The impact process is a free-fall process, and the impact energy finally concentrated on the honeycomb specimen comes entirely from the kinetic energy converted by the gravitational potential energy of the falling hammer device and the counterweight falling from a certain height. According to the law of conservation of mechanical energy, when the falling height is fixed, the instantaneous impact speed is certain, and the impact energy is completely determined by the mass and gravity of the falling hammer device. For the design requirements of the honeycomb specimen impact Test bed, this energy must be adjustable and adjusted as accurately as possible in the largest range. Therefore, the impact Test bed must be able to adjust the falling hammer device as a whole at the same time

Mass and height of drop hammer lifting, the former is very simple to achieve, can be achieved by changing the counterweight added to the drop hammer device

Realization, such as by increasing or subtracting steel plates or replacing steel plates of different thicknesses, and the latter needs to be realized according to the cooperation of roller screws and lifting devices, the motor is transmitted to the ball screw through the transmission mechanism, the lifting beam and the ball screw are lifted, when the motor stops running, the ball screw and the lifting beam are self-locking, theoretically the lifting beam can stay at any position on the roller screw, which can change the starting position of the free fall movement of the heavy hammer. However, due to the consideration of the venue and the real sense, the lead screw can certainly not be extended indefinitely, so the change in impact energy needs to be achieved by changing the counterweight added to the falling hammer device.

Considering the size and stability of the actual testing machine, a thick steel plate is finally used as a counterweight loading plate, which has a cuboid protrusion in the center, and its lower part acts as a guiding fixture for the counterweight steel plate through the central rectangular through hole of the counterweight steel plate, and its upper part acts as a "handle" connected to the release mechanism The shape matches the release device, as shown in Figure 2-2. A slightly thinner steel plate is also used to thread into the loading plate, and there are through holes at both ends to match the guide pillars, which serve as a guide mechanism for the falling hammer to fall straight down, as shown in Fig. 2-3. Finally, a threaded hole is opened in the center to connect with the three-jaw chuck below, which is designed to enable quick change between different hammer heads, as shown in Figure 2-4. The specific assembly drawings are shown in Figures 2-6.

In the overall material selection of the falling hammer device, considering the great energy erupted during the impact process, it will also have a great destructive effect on the hammer body, so it must be required that the falling hammer device has sufficient impact toughness and strength. To ensure the impact toughness is to ensure that after experiencing multiple heavy hammer impact processes, the entire falling hammer device can still have a good enough quality, and there will be no obvious cracks on the surface; the guarantee strength is to ensure that after experiencing multiple heavy hammer impact processes, the hammer body can still maintain a relatively good shape and not significant deformation, so as to ensure the accuracy and repeatability of the test. Among the conventional material selections, cast iron and steel are the most commonly used materials. However, although cast iron has relatively good hardness and tensile properties, the biggest defect of cast iron is that it is a brittle material, which does not have good impact toughness and cannot withstand too much impact. The steel has good enough impact toughness, but its surface strength can not meet the design requirements of the testing machine, ordinary steel in the heat treatment after the can improve its surface stiffness, but due to the heat treatment process, its impact toughness is inevitably destroyed. Therefore, ordinary cast iron and ordinary steel cannot meet the design requirements of the testing machine. In addition to ordinary steel and cast iron, the most widely used material is alloy steel, of which alloy tool steel can perfectly meet the design requirements of the impact Test bed for the hammer body. Alloy tool steel is a kind of tool steel formed by fusing with alloying elements such as chromium, molybdenum, tungsten and vanadium on the basis of carbon tool steel. Due to the addition of alloying elements, the hardenability, hardenability, wear resistance and toughness of alloy tool steel have been greatly improved. Among them, the alloy tool steel with medium carbon content (carbon mass fraction 0.35%~0.70%), after quenching, the hardness is slightly lower, but it also reaches HRC50~55, and the toughness is good. Therefore, the alloy tool steel with medium carbon content was finally selected as the hammer body material, which has good impact toughness and good surface strength degree of quality.



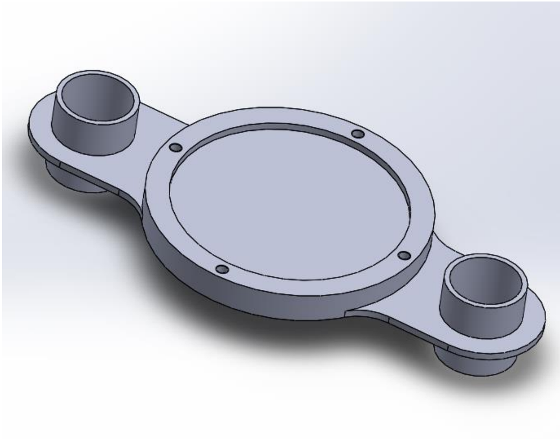
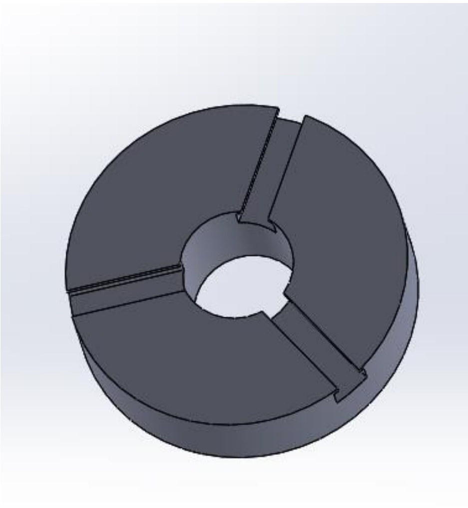


Fig . 2-2 Drop Hammer Counter weight Loading Board

Fig. 2-3 Guide Flat Table



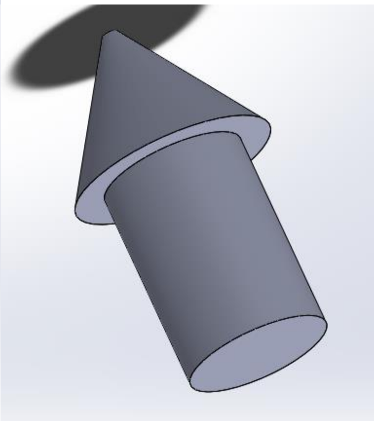
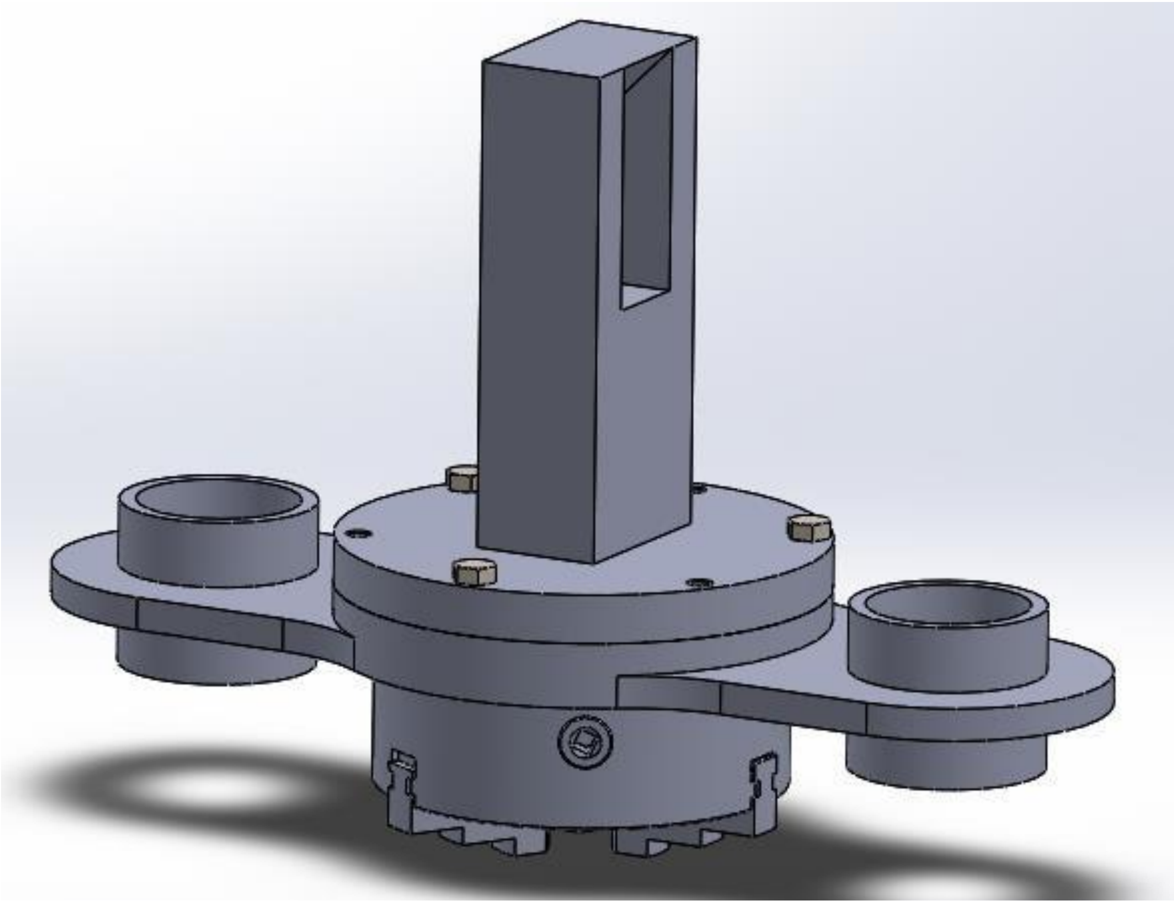


Figure 2-4 Three-jaw chuck

Fig. 2-4 Hammer head illustration



2.2.4 Design of the base

According to the third clause of the overall design principle of the system described earlier: The rigidity and inertia of the base must be guaranteed. Theoretically, the base should be an infinitely large rigid plate, so the base must have very high rigidity and very high strength. Due to the destructive nature of the impact process, it should be ensured that the falling hammer impact will not interfere with and destroy the data acquisition system around the testing machine, in addition, considering the service life of the testing machine, it should be guaranteed that the base will not crack after multiple impacts, and the base will not be dented.

Therefore, the design of the base is designed in accordance with the above design principles, in order to achieve high rigidity and inertia, the scheme used is reinforced concrete as the base, and the concrete grade adopts C30 (theoretical compressive strength fck = 20.1Mpa, tensile strength fct = 2.01Mpa, modulus of elasticity Ec = 30000Mpa). In addition, in order to prevent the vibration of the impact process from having a destructive effect on the surrounding area, the base should be separated from the surrounding area by using an isolation buffer substance. At the same time, because reinforced concrete is not suitable for excessive direct impact, a 5cm thick steel plate is buried in the center of the reinforced concrete base to withstand the kinetic energy impact of the free fall from the falling hammer device. In addition, a piece of steel plate is buried on each side of the base, which is firmly connected with the support guide column by welding, as shown in Fig. 2-6. This three pieces of steel

There is enough clearance in the middle of the plate to prevent the middle of the bearing steel plate from vibrating straight after withstanding the impact of the falling hammer device The connection to the two columns connecting the steel plates affects the verticality of the columns and thus undermines the accuracy of the entire Test bed system.

In order to be able to better cooperate with the honeycomb specimen and to achieve maximum protection for the entire Test bed, a honeycomb specimen placement station was finally designed in the center of the base. The portion of the upper honeycomb specimen that is in direct contact is set up as a replaceable part, which extends the life of the entire base by replacing the part, as shown in Figure 2-7.

The main support of the column is to play a supporting role, supporting the weight of all parts in the upper part of the entire Test bed, including the upper platform, servo motor and transmission mechanism. In addition, it should also play a role in correcting the verticality of the guiding mechanism. The guiding column mainly plays a guiding role, limiting the lifting beam and the falling hammer device all moving on the vertical surface to ensure that the falling hammer can do free fall movement. At the same time, the support and guide column determines the effective height of the entire impact Test bed, the higher the support and guide column, the higher the effective lifting height of the Test bed, and the higher the impact energy that can be applied to the honeycomb specimen on the base, but if the support and guide column is too high, the deflection will make the verticality of the entire guide column be destroyed, so that the stability of the entire Test bed is greatly reduced. The accuracy of the Test bed's test results is questionable. In summary, the design of the support and guide column needs to have sufficient stiffness, and at the same time not too high, with a moderate length. According to the design requirements and actual situation of the Test bed, the height of the final design support guide column is 3m. From this, the maximum instantaneous impact velocity and maximum impact energy of the entire Test bed can be derived:

$$E = MgH \quad (2\text{-}7)$$

$$v = 2Hg \quad (2\text{-}8)$$

Medium E above - Maximum impact energy (J) of the Test bed;

M - Weight weight (kg);
H – maximum rail height (m);
g – gravitational acceleration (m/$s2$).

For the material selection of supporting the guiding column, the above analysis has shown that the supporting and guiding columns must have a very high strength, while taking into account the cost factors, among the widely used materials, alloy structural steel can best meet the material needs of supporting the guiding column. In order to maintain good verticality, the steel plate embedded in the support guide column and the base adopts a welded fixing method, and the support guide column is welded with round steel around the periphery to ensure its verticality. In order to ensure that the fit between the column and the through hole does not cause too much friction and thus affect the falling process of the falling hammer device can be simplified to free fall movement, the surface of the supporting guide column and the surface of the through hole are chrome-plated.

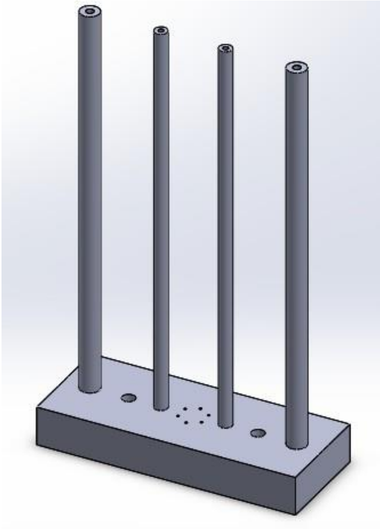


Fig. 2-6 Base

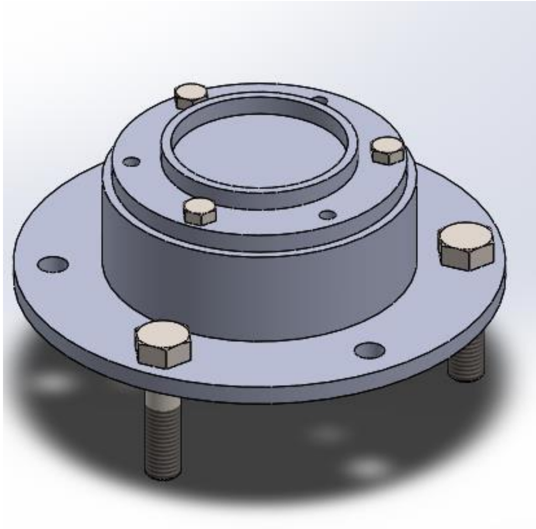


Fig. 2-7 Specimen placement table

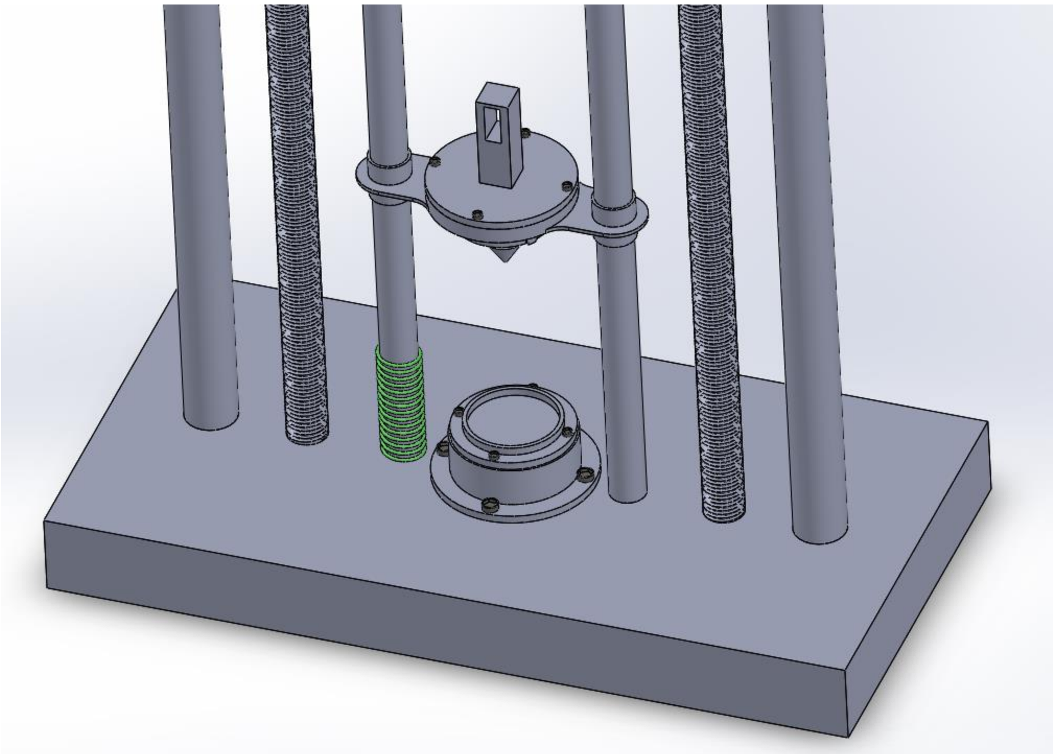


Figure 2-8 Base assembly drawing

2.2.5 Enhance the design of the mechanism

According to the previous scheme selection, the working principle of the lifting mechanism is: through the servo motor to drive the timing belt rotation, the same step belt and the roller screw through the gear, the synchronous belt rotation to drive the roller screw rotation, through the servo motor forward reversal to change the forward and reverse of the roller lead screw, and the roller lead screw with the lifting beam, the forward and reverse of the roller lead screw and change the rise and fall of the lifting beam.

The lifting mechanism is mainly divided into two parts: lead screw and lifting beam

Because the lead screw can also play a slight support role in supporting the guide mechanism while being transmitted, and the lead screw

The weakening effect of the upper slot on the lead screw is relatively large, so the size of the lead screw is as large as possible. The lead screw selected for this design is a DFU10020 roller screw with an outer diameter of 10cm, a lead of 20mm, and a bead diameter of 0.925mm.

The lifting beam is mainly mated with lead screws, and its shape is a roller screw mating pair on both sides plus a through hole in the inner mating with the guide column. In addition, in order to cooperate with the release mechanism, two threaded holes are pre-opened at the corresponding position on the lifting beam, and the two threaded holes of the release mechanism are bolted with the hinge hole, which can firmly connect the two parts together. The stage in which the lifting beam works is the lifting stage, in this stage, the lifting beam needs to bear all the weights that will apply impact force to the specimen on the base, including the falling hammer device and counterweight, in addition to the additional force exerted on the lifting beam caused by the acceleration of the lifting stage, it can be said that the lifting beam needs to bear a lot of force, which puts forward very strict requirements for the material selection of the lifting beam, High-strength materials must be used to ensure that the lifting beams during the lifting stage will not be deformed or otherwise fail due to excessive force. Therefore, the final choice is low-alloy high-strength structural steel, which can fully meet the load requirements of lifting beams within the scope of system design. In addition, in order to reduce friction with the supporting guide column, the inner wall of the through hole is chrome plated.

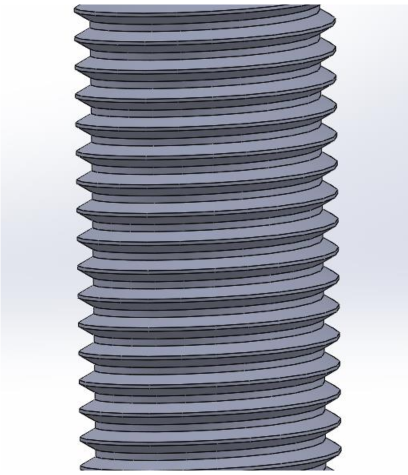


Fig. 2-9 Lead screw

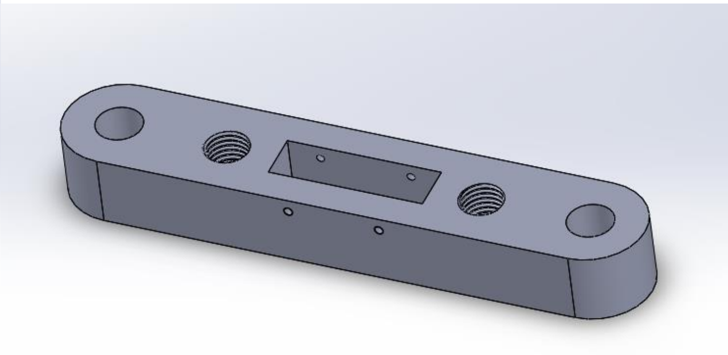


Fig. 2-10 Lifting beam

2.2.6 Establishment of an overall model of the overall design

According to the above analysis of each module, a three-dimensional model of each module has been established, and the three-dimensional model of each part is assembled using Solidworks software to obtain the overall model as shown in the figure.

Figure 2-11 Overall scenario 3D model

2.3 Summary of this chapter

Through the analysis of the system requirements, the optimal design scheme is finally selected. Using the idea of modularity, the basic introduction of each module was made, and the specific scheme was designed, the most suitable materials were selected, and the corresponding three-digit model was established on the basis of the design scheme. This chapter establishes the overall structure of the honeycomb specimen falling hammer impact Test bed, and completes the design of the mechanical part of most of the impact Test bed.

Chapter 3: Design of Release Mechanisms

3.1 Principle of release mechanism design

The release mechanism is the most important mechanism of the falling hammer impact Test bed, which plays a very important role in both the lifting stage and the release stage. In the lifting stage, the release mechanism is connected to the falling hammer device and counterweight, and the upper lifting device needs to play a role in transmitting the lifting force; in the release stage, it is a key stage to test whether a release mechanism can meet the system design requirements. When the release signal from the control part is transmitted, the release action needs to be completed quickly in a very short period of time, and the free fall movement process of the falling hammer device cannot be interfered with and the accuracy of the test can be affected.

At present, the mainstream release mechanism on the market is about two types: mechanical decoupling and automatic decoupling.

The design scheme of mechanical decoupling is simple in principle and has certain feasibility. It is mainly to design the mechanical decoupling into a ring structure, which is stuck at the interface by a pin or hook to form an effective decoupling that can withstand the load. When released, the pin is pulled by hand, the interface is quickly disconnected, and the decoupling is opened instantaneously to complete the release action. This design scheme is simple and efficient, first of all, in the case of the strength of the pin, the lifting stage can indeed steadily complete the whole set of lifting actions; in the release stage, as long as the overhead can be smoothly pulled, the release mechanism can be accurately disengaged and released the falling hammer structure. But the disadvantages of this scheme are also obvious, because the height of the test machine will not be infinitely high, so want to increase the final impact energy, to the falling hammer device is the most feasible program, but when the counterweight is too high, the falling hammer mechanism is too heavy, the friction at the interface will be too large, mechanical decoupling in the release must require a lot of force to pull the pin, this action first of all the labor intensity requirements are very high, when the friction is too large, It is difficult for manpower to pull the pin, and secondly, the role of manpower on the release mechanism will change the initial state of the falling hammer mechanism, and the stability is very poor.

The principle of automatic decoupling is more complex, and it can achieve a considerable degree of automation and automatic decoupling action. At present, most of the automatic decoupling on the market is controlled by adding a power source to control the opening and closing of the decoupling device. These applied power sources are usually hydraulic or pneumatic sources that require an external pipe to control the decoupling action by the hydraulic cylinder or cylinder action. This device is indeed able to automate, but its structure is complex and not simple and efficient enough.

Therefore, a simpler and more efficient design scheme for automatic release device is proposed. The body of the grappling hook is an inverted A-bracket, and the upper end of the bracket is mounted with rolling bearings, which cooperate with the sliding block between them to reduce friction. The block prevents the lower end of the bracket from falling apart and automatically falling off due to the supports closing in the middle. Above the block is an electromagnetic clutch, when it conducts electricity, it can adsorb the iron block, so that it is detached from the two rolling bearings, the lower end of the bracket is also separated, the falling hammer device is released to fall, and the release mechanism completes the release action. This method abandons the additional hydraulic and pneumatic power source, simple and efficient, easy to control, in addition, because the use of blocking blocks is iron, not easy to deform, there will be no accidental release Like, safe and reliable

3.2 Release mechanism design scheme

According to the design principle of the automatic release mechanism, the proposed design scheme of the release mechanism is as follows:

Because there should be no interference with the support guide columns on both sides, the shell of the release mechanism cannot be too wide, and the release mechanism that is too small is doomed to be unable to withstand too much lifting load, so the shell of the lifting mechanism is set to a rectangle. Because it is necessary to connect and cooperate with the lifting beam, the threaded hole is set in the two corners of the lifting mechanism, and the threaded hole on the lifting beam is concentric, and the hinged hole with the size M48 is bolted together, and the lifting beam and the release mechanism are firmly fixed together, because the M48 large-size bolt is selected, The relative strength is much higher and can withstand a considerable degree of lifting load. In addition, a 5 cm diameter through hole is opened in the center of the lower end of the release mechanism , with a pin with a diameter of 5 cm, and a hole with a diameter of 5 cm on the two brackets is concentrically fitted, and the pin is used as a shaft to make the two brackets stable enough to rotate the pin when opening and closing. The upper end of the two brackets has a 2 cm diameter through hole mated to a 2 cm diameter pin and a rolling bearing with an inner diameter of 2 cm. Because space in the lifting mechanism is limited and the two rolling bearings do not need to be subjected to dynamic loads, rolling ball bearings are selected. A block block should also be designed between the two rolling bearings to prevent the movement of the upper end of the bracket inward rotation when subjected to a force applied by the lifting load.

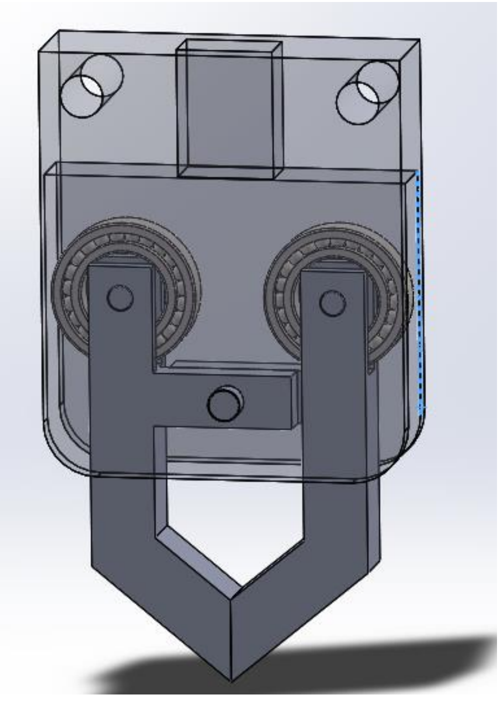


Figure 3-1 Automatic release mechanism 3D model

3.3 Checks by the release agency

Through the simulation check function in solid works, the strength of the release mechanism can be checked. The release mechanism will be installed Fitted, and then secured by fixing the two threaded holes of the release mechanism, the material is selected as alloy steel. Calibration is carried out after applying a limit force of 1000 N.

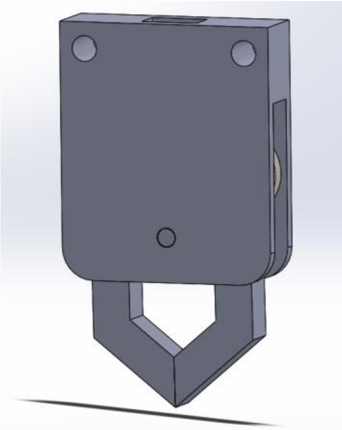


Figure 3-2 Prepare the setup before the release machine is checked

The check results are as follows:

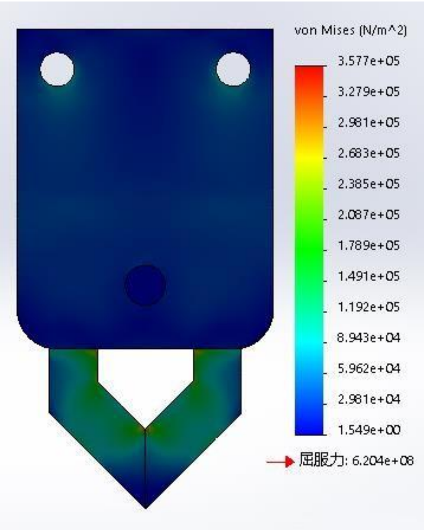


Fig. 3-3 Release machine overall strain diagram

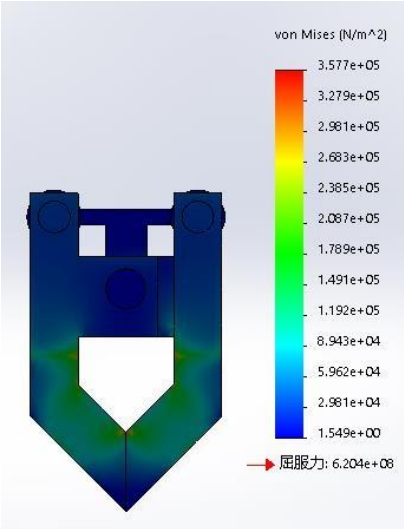


Fig. 3-4 Release machine structure Internal strain gauge

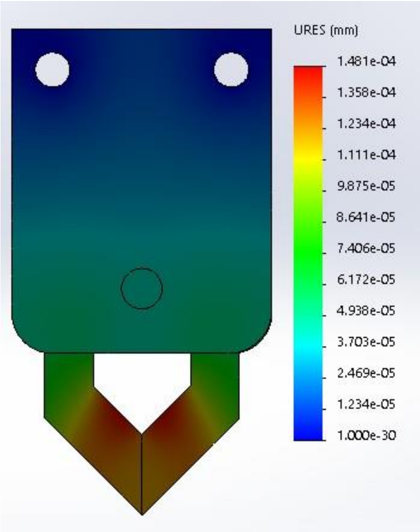


Fig. 3-5 Release machine structure overall displacement diagram

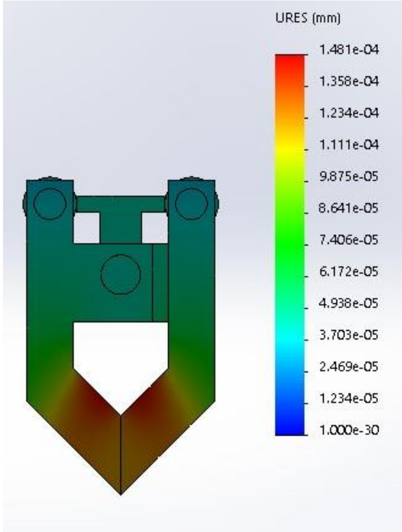


Fig. 3-6 release machine The internal parts of the structure are shifted

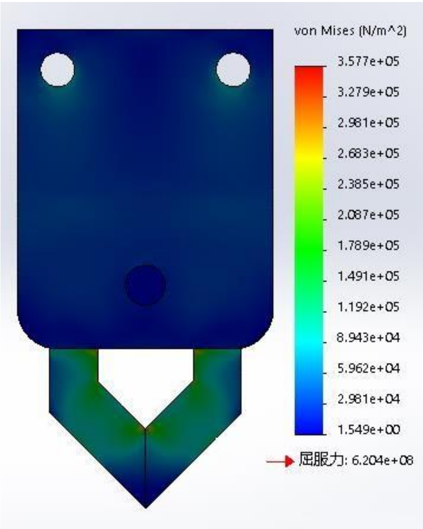


Fig. 3-7 Stress diagram of the whole body of the release machine

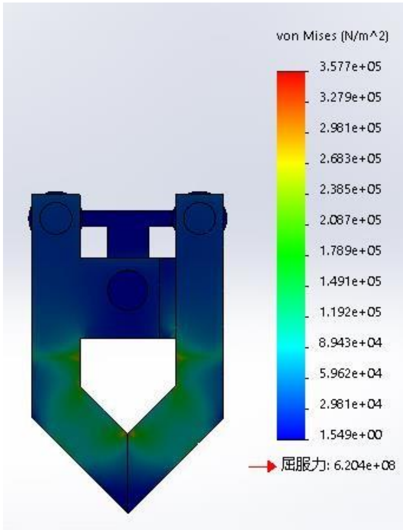


Fig. 3-8 Release machine Construct internal stress maps

As shown in Figure 3-5 , the final check result is a maximum displacement of 1.48×10^{-4} mm, which fully meets the system design requirements.

Chapter 4: Control System Design of Impact Test bed

4.1 System control principle and test process analysis

According to the system requirements, in the process of completing an impact test, the servo motor needs to make fast forward rotation, slow forward rotation, rapid reversal, slow reversal action, and each action needs to ensure certain accuracy while performing. Therefore, it is particularly important to choose the appropriate control method.

The full name of the PLC is the programmable logic controller. It is a digital operation motor system for the automatic control of industrial production in an industrial environment. PLC through the digital or analog input device to detect the external input signal, through its internal programmable memory to perform operations, sequence control, timing, counting and other operations, and finally through the digital or analog output equipment to control a variety of equipment in industrial production, to achieve the purpose of highly automated control of the production process.

(1) High reliability. Since most PLCs use monolithic microcomputers, the degree of integration is high, coupled with the corresponding protection circuits and self-diagnostic functions, which improves the reliability of the system.

(2) Programming is easy. The programming of the PLC mostly uses relay control ladder diagrams and command statements. Because ladders are visually simple, they are easy to master, easy to use, and can be programmed without even computer expertise.

(3) Flexible configuration. Because the PLC has a building block structure, the user can flexibly change the function and scale of the control system with a simple combination, so it can be adapted to any control system.

(4) The input/output function module is complete. One of the biggest advantages of PLCs is that there are corresponding templates for different field signals (such as DC or AC, switching, digital or analog, voltage or current, etc.) that can be used with the industrial field Devices such as pushbuttons, switches, sensing current transmitters, motor starters, or control valves are connected directly and connected to the CPU motherboard via a bus.

(5) Easy to install. Compared with computer systems, the installation of PLCs requires neither a dedicated machine room nor strict shielding measures. When used, the detection device only needs to be properly connected to the I/O interface terminals of the actuator and PLC to operate normally.

(6) Fast running speed. Since the control of the PLC is performed by the program control, both its reliability and operating speed are incomparable to the relay logic control.

Therefore, the choice of PLC control servo motor is an efficient and feasible solution.

The control of the servo motor can be achieved by connecting the PLC - servo controller - servo motor.

4.1.1 Drop Hammer Lift Phase

In the drop hammer lifting stage, the operation sequence of the test machine is to first lift quickly, and then slowly lift when it reaches a certain height litre. A proximity sensor can be used to detect whether the lifting beam is approaching a preset height and used as an input signal to enter the PLC , and a servo motor rotary encoder can be used to precisely control the lifting height of the falling hammer when the target lifting point is reached.

In addition, the finite bit protection function must be used to input the limit signal into the PLC as an input signal via the limit sensor, and when the lifting device is lifted beyond the allowable distance range, it can be stopped in an emergency.

4.1.2 Downward drop hammer phase

When the drop hammer has been lifted to a predetermined lifting point, the electromagnetic clutch is opened by PLC control to prevent the block from being adsorbed, and the bracket of the automatic release mechanism is opened to complete the release process.

When the drop hammer test is completed, after 30s of buffering, the lifting beam automatically descends, and the action sequence of the testing machine is first rapid descent, and slowly descends when it reaches the base. The same is the use of a ranging sensor to measure the height of the drop hammer lift, and as an input signal input to the PLC, when reaching the base near the use of servo motor rotary encoder will slowly lower the lifting beam to the starting point, reach the starting point after shutting down the motor, an impact test completed

The descent process must also be protected by a limited position, in case the falling process of the lower lifting beam cannot stop causing damage to the base and the lifting beam itself.

4.2 Control design of the drop hammer test platform

4.1.1 PLC wiring diagram design

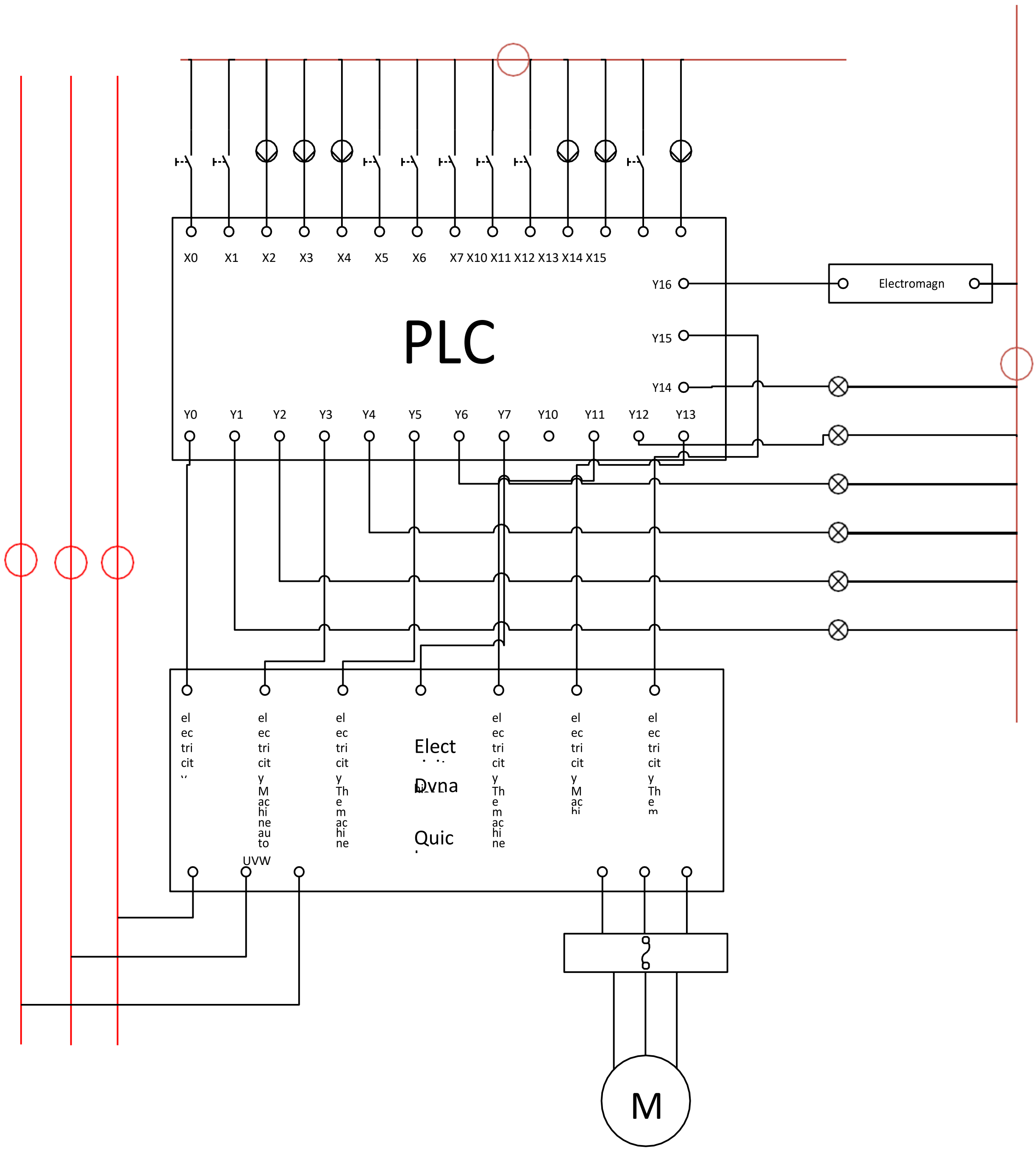


Figure 4-1 PLC wiring diagram

4.2.2 I /O address distribution

Based on the analysis and understanding of the system requirements, combined with the requirements of the 8-bit PLC hardware, the following I/O is designed

Address allocation schemes.

Table 4-1 I/O Address Assignment Table

serial number	address	function	serial number	address	function

1	X0	Power-on button	1	Y0	Motor switches
2	X1	Auto experiment button	2	Y1	Power on LED
3	X2	Proximity sensor 1	3	Y2	High-speed automatic lift indication lamp
4	X3	Proximity sensor 2	4	Y3	The motor automatically rotates at high speed
5	X4	Distance sensor 3	5	Y4	Low-speed automatic lift indication lamp
6	X5	Auto drop button	6	Y5	The motor automatically rotates at low speed
7	X6	Auto boost button	7	Y6	High-speed automatic landing indication lamp
8	X7	Manually control the boost button	8	Y7	The motor automatically reverses at high speed
9	X10	Manually control the landing button	9	Y10	Low speed automatic landing indication lamp
10	X11	E-stop button	10	Y11	The motor automatically reverses at low speed
11	X12	Limit sensor 1	11	Y12	Manually raise the LED
12	X13	Limit sensor 2	12	Y13	The motor is constant speed forward rotation
13	X14	Release the button	13	Y14	Manually lower the LED
14	X15	Distance sensor 4	14	Y15	The motor is reversed at constant speed
			15	Y16	Release mechanism release

4.2.2 PLC ladder design

The ladder diagram designed according to the requirements of the control system and the I/O address allocation scheme is:

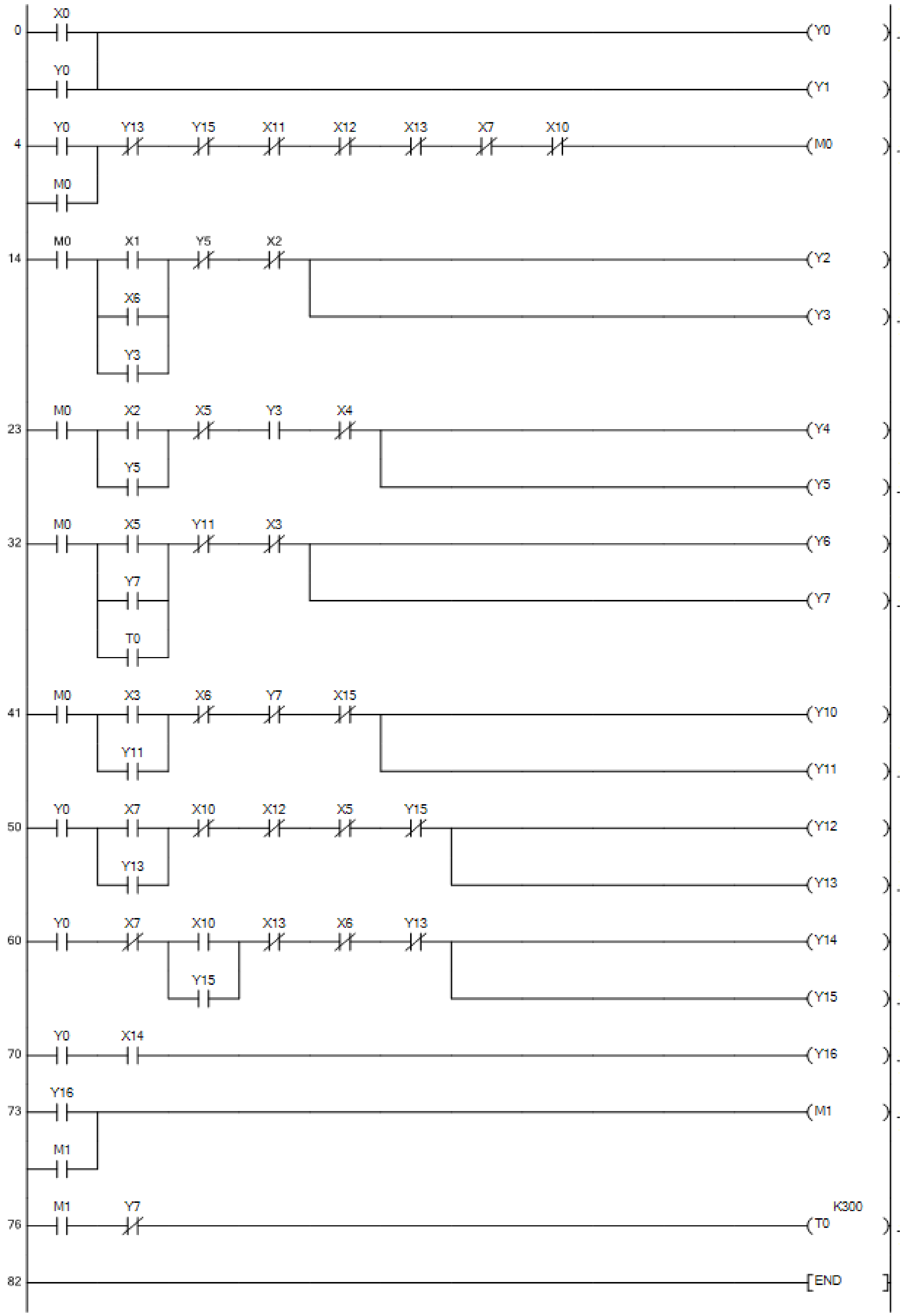


Figure 4-2 Ladder diagram

The entire control process is as follows: when the power button is pressed, the signal input is obtained at the X0 position, and Y0 and Y1 are the same
When turned on, the power signal light is on, the servo motor starts, and Y0 is self-locking; when the motor starts, the automatic state virtual contact M0 opens and locks itself; when it enters the automatic state, press the automatic automatic test button switch, X1 gets the signal input, Y2 and Y3 turns on, the motor rotates at high speed, and the high-speed forward indicator light is lit, Y2 is self-locking; when it reaches the vicinity of proximity sensor 1, proximity sensor 1 signals, X2 There is a signal input, at this time the motor high-speed forward stop, Y4 and Y5 are turned on, the motor is low-speed forward rotation, the low-speed forward transmission indicator light is lit; when the specified position is reached, sensor 3 emits a signal The X4 has a signal input and the motor stops turning forward. At this time, press the automatic release button, X14 has a signal input, the electromagnetic absorber is opened, the block is absorbed, the two brackets of the automatic release mechanism are opened, the falling hammer is released, the automatic release mechanism performs the release action, and the virtual contact M1 work begins to time; when the timing is completed T0 When there is a signal output, the Y7 is turned on, the motor is reversed at high speed, the high-speed reverse signal light is lit, and the virtual contact M1 is disconnected, the timer is reset, and when the lift beam falls near proximity sensor 2, Y10 and The Y11 turns on, the Y6 and Y7 disconnect, the motor reverses at low speed, the lifting beam slowly descends, and when it reaches near sensor 4, the X15 has a signal input and the motor stops reversing to complete an experiment.

In addition, in order to ensure the safety of the test, the scheme also designed two limit switches, when the automatic control system is out of control, the limit switch sends a signal, M0 virtual contact power off, exit the automatic control state.

When replacing the hammer head and resetting the automatic release mechanism, sometimes it is also necessary to manually control the lifting and lowering of the lifting beam, X7 and X8 correspond to the manual control button, when the manual lift button is pressed, X7 has a signal input, Y12 and Y13 are turned on, The motor is constant speed forward, and the constant speed forward indicator light is lit; when the manual landing button is pressed, the X10 has a signal input, Y14 and Y15 are turned on, the motor constant speed is reversed, and the constant speed reversal indicator light is lit. The X10 and X7 are interlocked, and the Y13 and Y15 are interlocked to prevent the motor from turning on at the same time. At the same time, when X7 or X10 is turned on, M0 is powered off and exits the automatic control state.

4.2.3 PLC programming

```
LD X0
OR Y0
OUT Y0
OUT Y1
LD Y0
OR M0
ANI Y13
ANI Y15
ANI X11
ANI X12
ANI X13
ANI X7
ANI10
OUT M0
LD M0
LD X1
OR X6
OR Y3
ANB
ANI Y5
ANI X2
OUT Y2
OUT Y3
LD M0
LD X2
OR Y5
ANB
ANIX5
AND Y3
ANI X4
OUT Y4
OUT Y5
LD M0
LD X5
OR Y7
OR T0
ANB
ANIY11
ANI X3
OUT Y6
OUT Y7
LD M0
LD X3
OR Y11
ANB
ANI X6
ANI Y7
ANI X15
OUT Y10
OUT Y11
LD Y0
LD X7
OR Y13
ANB
ANI X10
ANI X12
ANI X5
ANI Y15
OUT Y12
OUT Y13
LD Y0
ANI X7
LD X10
OR Y15
ORB
ANI X13
ANI X6
ANI Y13
OUT Y14
OUT Y15
LD Y0
AND X14
OUT Y16
LD Y16
OR M1
OUT M1
LD M1
ANI Y7
OUT TO
K300
END
```

4.3 Control circuit hardware selection

4.3.1 PLC selection

PLC selection is mainly divided into three steps:

(1) Analysis of the subject of the charge and submission of control requirements

The steps are a detailed analysis of the process characteristics and working characteristics of the controlled object, an understanding of the working mode of the controlled object, an understanding of the method and characteristics of the electromechanical and hydraulic cooperation of the work of the controlled object, the determination of the purpose and workflow of the controlled object, and the determination of the control mode and control scheme of the controlled object.

(b) Determine the input/output equipment of the PLC and determine the number of I/O points

The steps are an analysis of the objective workflow and control scheme of the controlled object, to determine all the input devices required by the system (e.g. buttons, sensors, limit switches, position switches, transfer switches, etc.)in addition to determining the specific output devices (e.g. contactors, solenoid valves, Signal indicators and other actuators, etc.)By determining the input and output devices of the PLC. It is possible to determine the number of I/O points of the PLC.

(3) Select the PLC model

Through the analysis of the above control scheme, by querying the selection manual and other information, it is possible to determine the model of the PLC, the power supply and so on.

Based on the previous analysis, it is determined that the PLC is connected to the servo controller to control the servo motor. The input device of the PLC is mainly two distance sensors, two proximity sensors, two limit sensors and 8 buttons, with a total of 14 input points. The output equipment is mainly the servo controller of the servo motor, 7 indicator lights and electromagnetic absorbers, with a total of 15 output points.

Due to the large number of Mitsubishi PLCs studied at the undergraduate level, they were selected in the Mitsubishi PLCs, of which the F series in the Mitsubishi PLCs has the characteristics of miniaturization, generalization, and low price, and by selecting the appropriate number of I/O points, the final choice Choose the FX2N-32MR-001 PLC. Its relay output and input are 16 points and the output is 16 points. Its power input type is: AC power input, rated voltage ac100~240V Through analysis, the FX2N-32MR-001 PLC fully meets the design requirements of the control system.

4.3.2 Sensor selection

1） Proximity sensor optional

In the traditional relay automatic control system, the contact detection method such as the limit switch can detect the proximity and contact of the object under test, so as to work through the electric shock opening and closing control system of the relay. It is suitable for PLC control

The system is made by proximity sensors with similar functions. Proximity sensors can detect without touching the object being detected. The object under test is close to and this information is converted into a signal input into the PLC.

Proximity sensors can be divided into many categories depending on how they work. There are capacitive proximity sensors, inductive proximity sensors, photoelectric proximity sensors, Hall sensors, pyroelectric sensors and eddy current sensors.

Because the design is a falling hammer lifting mechanism, the running speed is faster, and the volume is larger, the use of capacitive proximity sensor, inductive proximity sensor or Hall sensor is likely to not play the effect of these three sensors, and pyroelectric sensor is not suitable for this design, the industrial environment site is divided into surround and photoelectric sensor anti-environmental interference ability is too poor. Therefore, the eddy current sensor was finally chosen.

The working principle of the eddy current sensor is: after the power is turned on, the sensor sensing surface generates an alternating magnetic field, when there is a metal object close to this magnetic field, the eddy current generated in the metal absorbs the energy of the oscillator, and the amplitude of the alternating magnetic field on the sensing surface is attenuated. According to the size of this attenuation, the proximity of the metal object can be detected. The eddy current sensor studio is not affected by non-metallic factors in industrial environments such as dust and oil, and has the characteristics of low power consumption and long life, in addition to its relatively low cost.
After the above analysis, the linear proximity sensor can meet the system design requirements.

2） Distance sensors are available

There are different types of distance sensors according to different working principles, and there are basically four kinds. That is, ultrasonic ranging sensors, laser ranging sensors, infrared ranging sensors, Weibo radar sensors.

Among them, the current widely used are ultrasonic distance sensors and laser distance sensors. The former is more used in the fields of defense and medicine because of the higher accuracy of testing. Laser distance sensors are more used in the industrial field. For example, the XY positioning of tower crane crane, automatic control of target distance, monitoring of safe docking position of ships, and so on. Therefore, the laser distance sensor was finally selected as the distance sensor for this design. Because there is no standard model for laser ranging sensors, they are not selected.

4.4 Summary of this chapter

Through the analysis of the target control process of the entire Test bed system, the control mode and control scheme of the Test bed system are proposed. Through the analysis and understanding of the control scheme, the number of I/O points and input equipment and output equipment controlled by the PLC were determined. The control flow of the control system is then determined according to the input and output devices, and the PLC ladder diagram and PLC programming language are written accordingly. Finally, the appropriate PLC model and sensor were selected according to the requirements of the overall scheme.

Conclusion

Honeycomb materials have the advantages of light weight, stable plastic deformation and good energy absorption performance, and have been gained by the industry in recent years

It is widely concerned and increasingly used in the fields of automotive, aerospace and engineering construction. Research on the crash resistance and energy absorption properties of honeycomb materials when subjected to impact loads has also been booming.

This design enables experimental studies of the impact resistance of honeycomb specimens by building a simple and easy-to-implement drop hammer impact Test bed. This design mainly does the following work:

（1） Study impact dynamics and the basic theory of collisions, and establish mathematical models of impact tests

（2） According to the test objectives, the overall design of the falling hammer impact Test bed is completed. First, compare several implementation schemes of the falling hammer impact Test bed, and select the optimal scheme for the advantages and disadvantages of these schemes. Then adopt the modular idea to build a model of the falling hammer impact Test bed;

（3） For the most critical automatic release mechanism in this design scheme, a release mechanism execution principle is proposed, and the final design scheme is determined through the analysis of the principle. Build a 3D model of the release mechanism and check it;

（4） According to the experimental process of the Test bed and the corresponding control requirements, the control scheme is proposed, and then through the analysis and understanding of the control scheme, the number of I/O points and input devices and output devices controlled by the PLC are determined . The control flow of the control system is then determined according to the input input and output devices, and the PLC ladder diagram and PLC programming language are written accordingly . Finally, according to the requirements of the overall scheme, the hardware selection of the control system is completed.

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