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Development of a Multifunctional Automated Production Line for Enhanced Efficiency and Quality in Chip Manufacturing

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Abstract: Chip manufacturers predominantly employ a semi-automated approach in the production of chips, characterized by low efficiency and a high error rate. The objective of this study is to develop fully automated production equipment capable of handling various chip types. This includes the automatic programming of printer chips, automated laser marking, and visual inspection of chip appearance. Furthermore, the study conducts finite element analysis on the components subjected to significant force.

Keywords: Chip, Program burning, Automation equipment, Finite element analysis.

1. Introduction

In recent years, the chip industry has maintained rapid development in China. Chip Program burning, as an important part of the chip industry and throughout the entire development process, has become an important factor restricting the development of the chip industry. The purpose of designing a chip is to require the chip to achieve the required functions, but there will always be certain problems in the programming and manufacturing of the chip, resulting in defects in the produced chip, which may eventually affect its normal operation.

The chip industry has entered a stage of rapid development, and companies specializing in chip research and development continue to appear. Most of the international high-end chip testing and manufacturing equipment companies are located in developed countries such as Japan andthe United States. These companies have advanced test technology and manufacturing equipment. After each batch of chips is designed and manufactured, they directly use the designed automatic test equipment to conduct design verification and functional analysis of the product. When the chip passes the functional standard test, the The testing procedures and equipment are continuously optimized, and finally large-scale mass production testing is realized. Compared with these countries, the chip testing industry started late in china. Although companies have begun to do related R&D and design, the versatility and test quality lag behind them, and they are far from meeting the needs of chip manufacturing in china.

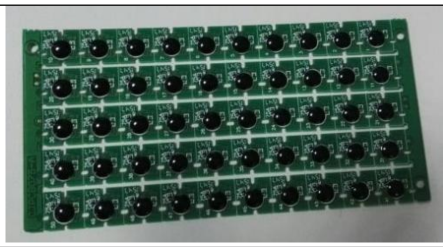
At present, the chip manufacturers mostly use semi-automated mode for manufacturing chips in china. A single person operates a single semi-automated device to burn and write the chip. The quality of the chip is tested manually. The efficiency is very low and the error rate is high. There is relatively little research on chip Program burning and testing automation equipment. Only in some larger companies, there are automated production lines for a single chip. This subject aims to build a simple automated production line compatible with multiple chips, including automatic Program burning of printer chips, automatic laser marking and visual inspection of chip appearance.

2. The Overall Design of Equipment

2.1. Demand Analysis

The specifications and dimensions of the chips that need to be burned are shown in the table below. The automation equipment needs to be compatible with chips with a length of 40mm to 110mm and a width of 40mm-110mm. The chip program is automatically program burning, automatic laser marking and visual inspection of the chip appearanc. These three links are connected into a complete automated production line.

Table1. The chip specification parameter

NO.	Item	parameter	
1	Dimensions (mm)	Length: 40-110 Width: 40-110	
2	Number of chips	A whole chip contains 50 chips	
3	Weight	≤20g	

2.2. The Overall Process of the Equipment

According to the process requirements of the chip, the automated equipment completes the chip feeding, program burning, laser marking, visual inspection, cutting and other process processes. The overall equipment design is shown in Figure 1. The specific process is as follows:

1) Chip feeding station: manually place the chip in the compatible board, and place the compatible board at the Turntable B;

2) Chip program burning station: the turntable rotates one station, the Chip program burning machine presses down to burn the program into the chip, and the turntable rotates another station after burning;

3) Six-axis robotic arm handling station: The six-axis robotic arm grabs the tooling plate that has been burned, rotates the compatible board that needs to be rotated, and then places the compatible board to laser the marking machine turntable loading station;

4) Laser marking station: the turntable B rotates one station, and the laser marking machine marks the chip. After the marking is completed, the turntable rotates another station;

5) Four-axis robotic arm handling station: The four-axis robotic arm picks up the finished compatible board and puts it on the turntable C, and the turntable rotates one station;

6) Visual inspection station: the upper and lower cameras inspect both sides of the chip at the same time to determine whether the chip meets the requirements, and upload the photo results to the host computer. After the inspection is completed, the turntable rotates another station;

7) Four-axis robotic arm handling station: The four-axis robotic arm picks up the finished compatible board and puts it on the cutting conveyor line.

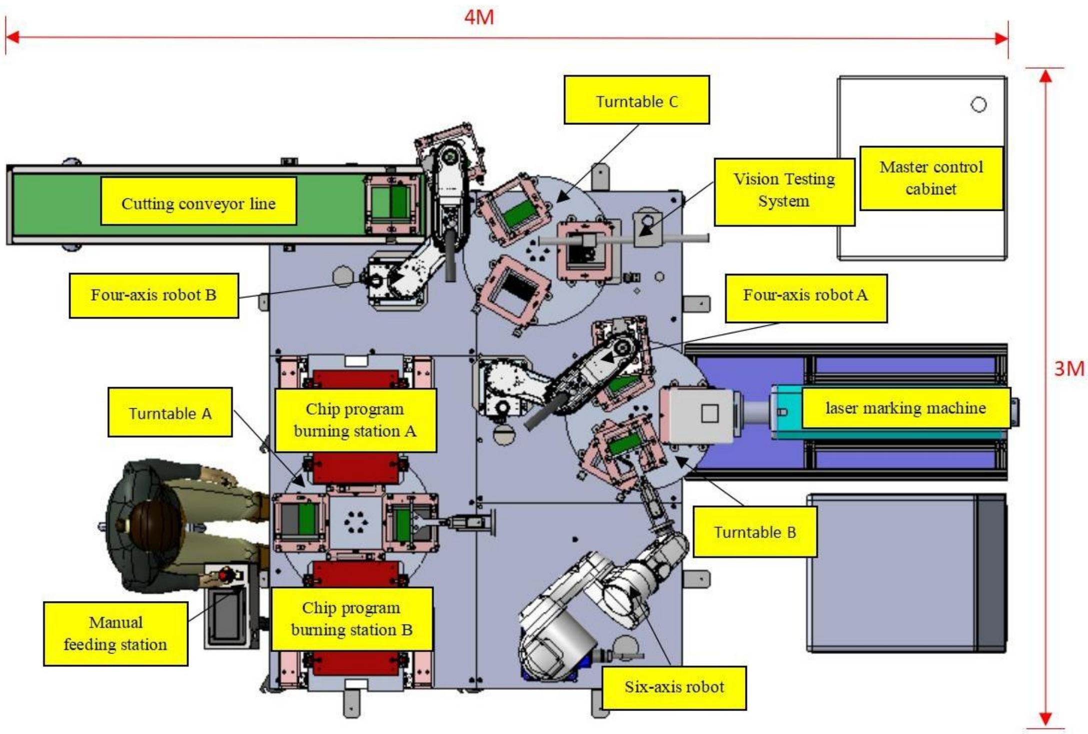


Figure 1. Overall design of equipment

3. Each Station Design of Equipment

3.1. Compatible Tooling Board Design

In order to be compatible with a variety of chip sizes, a compatible tooling board is designed. The compatible board positioning plate is manually opened, and the chip positioning hole is placed in the positioning pin of the tooling plate. The positioning plate of the tooling plate uses the spring force to position the chip and manually pull up and press it. Block and rotate 90°to make the pressure block press the chip to ensure that the chip cannot move up and down.

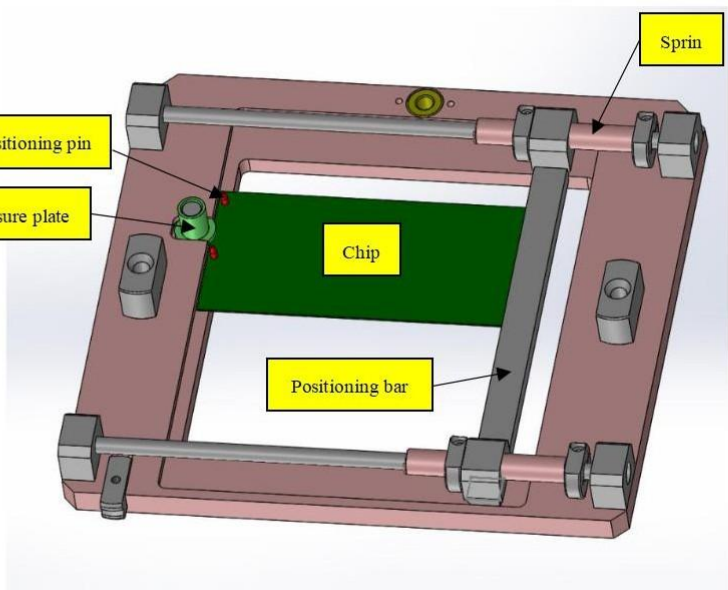
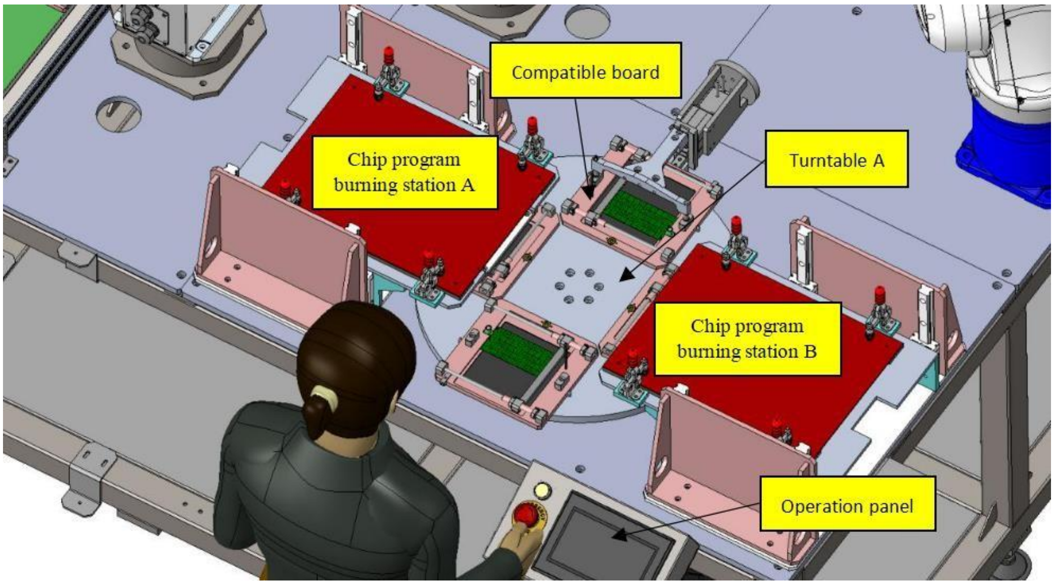


Figure 2. Compatible tooling board design

3.2. The Design of the Chip Program Automatic Burning Station

The program burning unit is composed of two machine, a four-station turntable, a compatible tooling board, and a control system. Place the chip in the tooling plate manually, and place the tooling board on the turntable. The tooling plate is positioned by positioning pins; the cam divider is used to locate the turntable, and the turntable rotates one station (90°); Electric cylinder drives down The mechanism drives the needle plate on the main board to press down according to the designated stroke of different chips, and burn the program into the chip. After burning, the turntable rotates one station again;



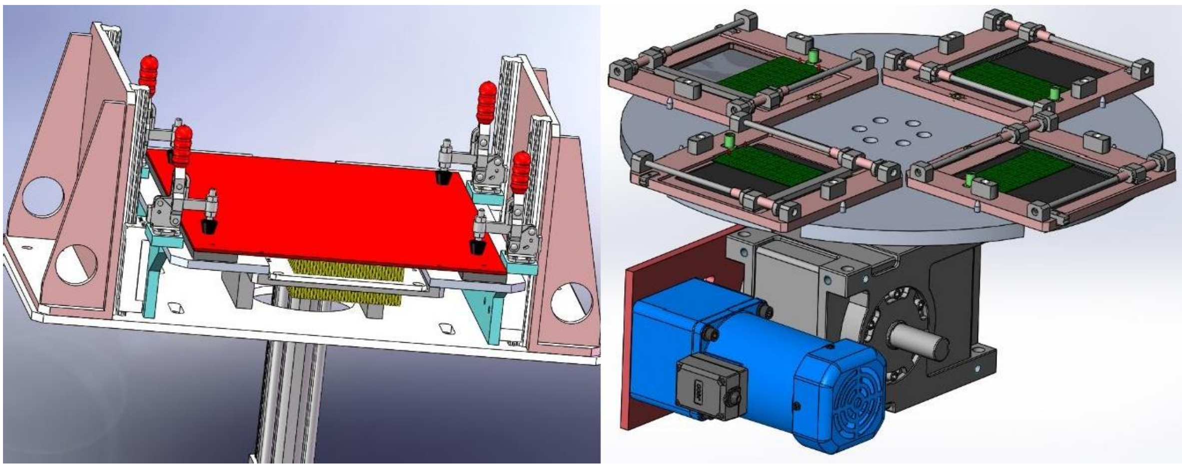


Figure 3. Design of the chip program automatic burning station

3.3. Robot Fixture Design

The fixture of the six-axis robot and the four-axis robot are the same. The compatible board is dragged by the lower jaw, and the positioning pin of the upper jaw locates the compatible plate. The electric gripper clamps the compatible plate. The fixture design is shown in Figure 4. The six-axis robot moves the compatible board from turntable A to turntable B, the four-axis robot A moves the compatible board from turntable B to turntable C, and the four-axis robot B moves the compatible board from turntable C to the cutting conveyor line.

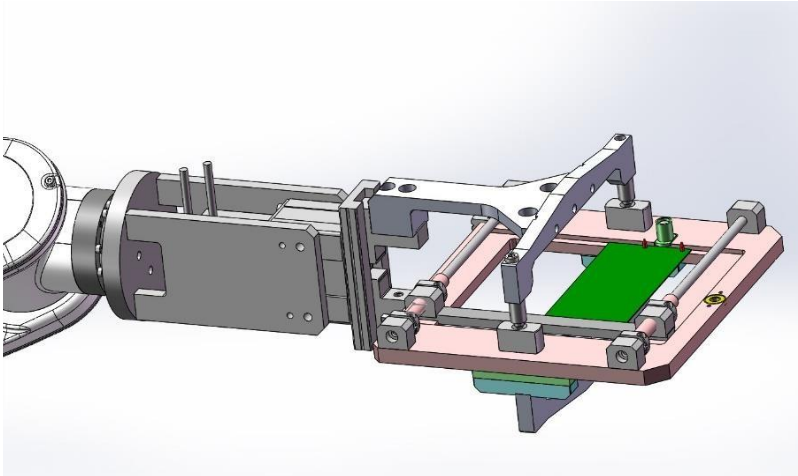


Figure 4. Robot fixture design

3.4. Laser Marking Station Design

The laser marking station consists of a laser marking machine, a three-station turntable, a jacking mechanism and a control system. The motor drives the three-station turntable, which rotates one station counterclockwise; according to different chips, the lifting mechanism lifts the tooling board to different heights; the laser marking machine marks the chips in the tooling board according to the chip type; the marking is completed After that, the motor drives the three-station turntable, and the turntable rotates one station counterclockwise again.

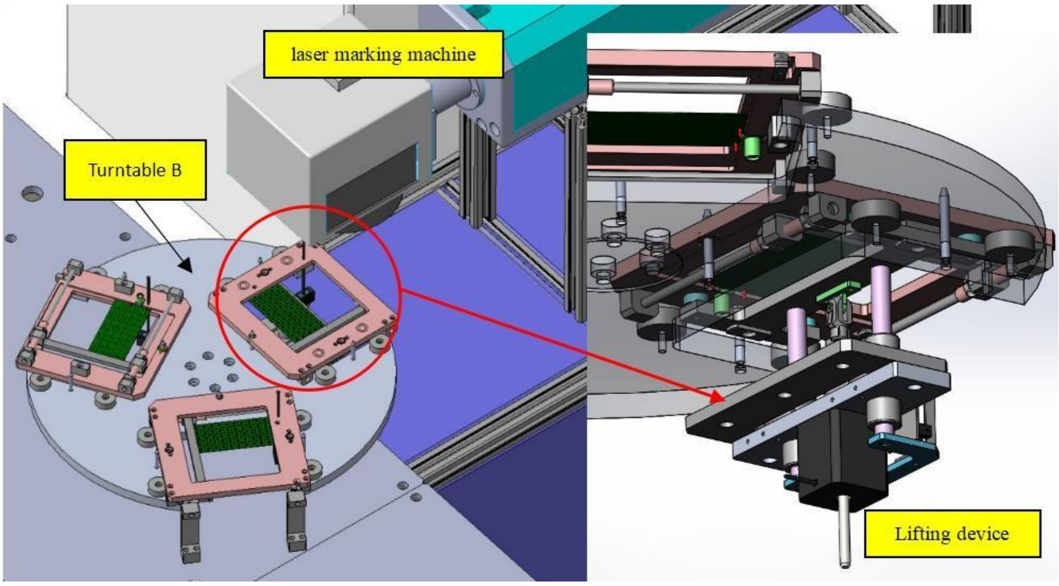


Figure 5. Laser marking station design

3.5. Visual Inspection Station Design

At the visual inspection, The visual inspection equipment detects the front and back sides of the chip through the upper and lower cameras at the same time, and uploads the inspection results to the MES system. After the inspection, the turntable rotates a station again. The appearance of this type of PCB board is modeled in advance, and the defect-free area is kept consistent through external light source lighting and pretreatment. When an abnormal point is detected in the golden finger area, it is judged as NG.

4. Force Analysis of Key Components

When programming the chip, the plate of the turntable A is deformed by the pressure of the probe. Whether the force exceeds the yield strength of the turntable, after finite element analysis, as shown in Figure 6 and Figure 7, the force of the turntable is much less than the yieldstrength, The maximum force can produce an elastic deformation of 0.05mm, which can meet the requirements of working conditions.

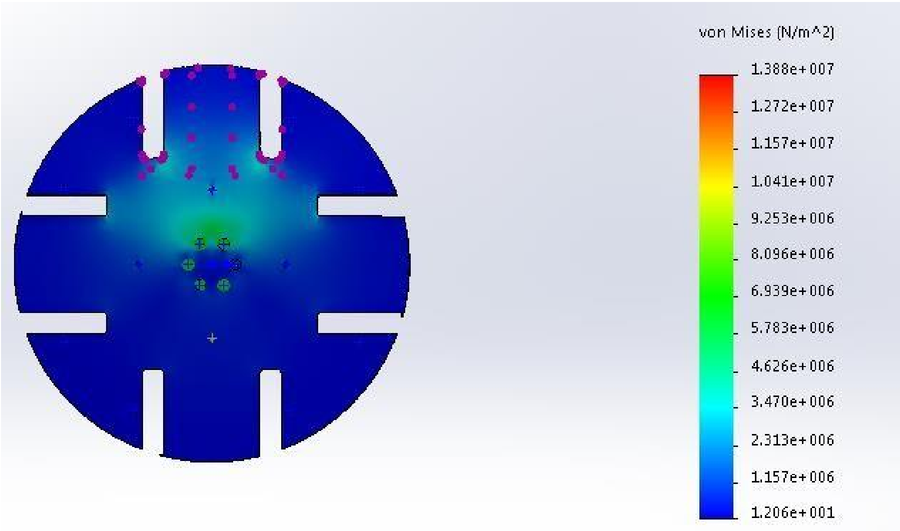


Figure 6. Stress distribution diagram of turntable A plate

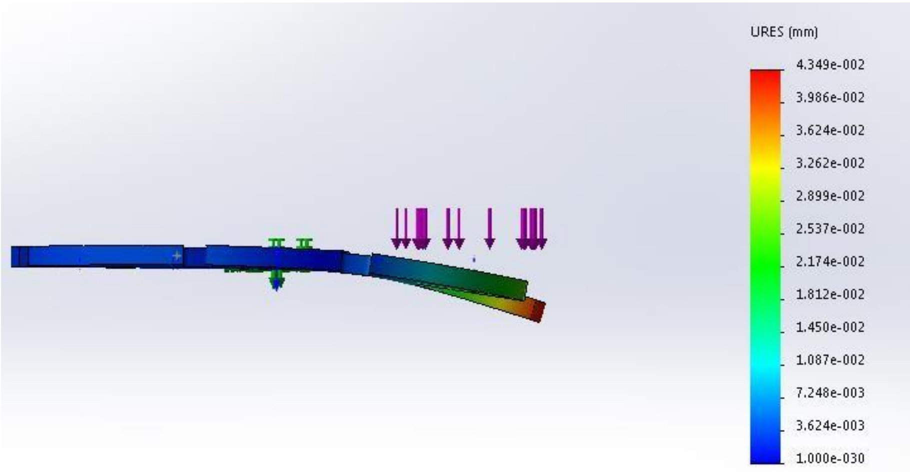


Figure 7. Strain distribution diagram of turntable A plate

5. Conclusion

Through the analysis of chip process requirements, an automated chip production line was designed, including chip program automatic burning, chip automatic laser marking, chip appearance visual inspection, etc. The equipment runs stably, reduces labor intensity, improves working environment, and avoids production accidents. While improving production efficiency, reducing operating costs, and ensuring product quality.

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