Design of a Ceramic Brick Cutting Robot

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Abstract. Ceramic tiles are now widely used in indoor and outdoor decoration projects. Aiming at the shortcomings of the existing ceramic tile cutting machine, a ceramic tile cutting robot is designed. PLC is used as the control core of the robot to make the size adjustment of ceramic tile cutting convenient and flexible, the cutting error is small, the tile section is smooth and tidy, and the breakage rate is low, which improves the efficiency of ceramic tile cutting and reduces the labour intensity of workers.

1. Introduction
Ceramic tiles are mainly used for office, residential, shopping malls and other interior decoration. Now the size of the whole tile on the market is 800 mm×800 mm. It is often necessary to cut the whole tile into different sizes according to the actual situation. In order to achieve the effect of convenient cleaning, protecting the corner and beautifying the decoration, the strip tile is often used as the indoor kick line, and the tile that makes the kick line is made by cutting the whole tile into strips and grinding the corners.

There are two main types of ceramic tile cutting machines in the market. The first one uses saw blade rotation for cutting. This type of cutting machine includes a rack, a sliding platform (installed on the rack), a saw blade drive device (installed on the top of the rack), and its working process is as follow: manually positioning the tile feeding, opening the saw blade drive device to make the saw blade rotate, manually pushing the sliding platform to cut, after one cut, manually pulling the platform to return to discharge, and then feeding positioning, repeat the previous action. The disadvantages of this cutting method are: the cutting process requires a high level of operation for workers, and improper operation can easily cause ceramic tile breakage; the degree of machine automation is low, the labor intensity of workers is high, and the working efficiency is low.

The second one is the cutting machine that slips the cutter head made of hard material along the surface of the tile for cutting (glass knife form). According to the operation mode, this type of cutting machine is divided into manual and mechanical, and its working process is as follow: artificial feeding and pressing the tile to pull the knife head pressed on the tile, draw a scratch on the tile, and then use manual or mechanical vibration tile, so that the tile along the scratch split. The disadvantage of this cutting method is that the section of ceramic tile is uneven, it needs further grinding and leveling treatment, at the same time, the breakage rate of ceramic tile is high, and the material such as marble cannot be cut.

According to the market demand and customer requirements, a ceramic tile cutting robot is developed, which has the functions of automatic loading and unloading, automatic positioning and automatic cutting. All the working process of the whole machine is automatically completed by PLC control, the width of ceramic tile cutting can be set arbitrarily, and the ceramic tile cutting efficiency is high and the cutting effect is good.
2. Three-dimensional model and working process of robot

The mechanical structure of the whole robot machine is mainly composed of automatic loading and unloading mechanism, automatic positioning mechanism, compression mechanism, cutting mechanism and so on, and the positioning, grasping, clamping and loosening actions realized by the above mechanism are realized gas path and pneumatic components, which ensures that each mechanism can run reliably and quickly. The 3D model is shown in Figure 1, where the automatic up-unloading mechanism is shown in Figure 2, and the tile compaction mechanism is shown in Figure 3.

![Fig 1. Three-dimensional model of ceramic tile cutting robot](image1)

![Fig 2. Robot Automatic Up-unloading Mechanism (Top View)](image2)
3. Design of mechanical structure of robot
The robot works as follows: The tile 28 is placed on the automatic feeding platform (see the platform formed by supporting frame 1 and cutting platform 2 in Figure 2), and the positioning block is first driven down by positioning cylinder 12 (see 16 in Figure 3) to prepare for the accurate positioning of the tile; Control the contraction of the clamping cylinder 7 to increase the distance between the two clamping heads 6 (i.e. the opening of the clamping mouth, prepare the clamping tile); Then make the front cylinder 9 and the rear cylinder 8 extend simultaneously, so that the sliding translation frame 4 moves forward the maximum distance, and then control the clamping cylinder elongation, the two clamps can clamp the tile. After the tile is clamped, the rear cylinder is controlled to shrink, and the sliding translation frame is driven back until the rear top of the tile is leaning against the positioning block, so that the feeding action of the tile is realized. After the tile cutting is finished, the clamping cylinder shrinks, the chuck opening is opened, the tile is loosened, and the positioning cylinder 12 shrinks, making the positioning block move up. After the positioning block is moved up, the clamping cylinder protrudes out, the clamping head clamps the finished ceramic tile, the front cylinder shrinks, causes the sliding translation frame to retreat, the clamping cylinder shrinks, the two ends open, then realizes the unloading action. All the above cylinders are controlled by PLC control system, so repeat the above action to realize the automatic unloading and cutting of ceramic tile.

3.1. Automatic loading and unloading mechanism (Figure 2)
Automatic loading and unloading mechanism is an important part of robot mechanical structure. Taking the movement direction of the ceramic tile as the longitudinal direction of the upper unloading device, the ceramic tile feeding place is the front part of the device, and the device includes a cutting platform mounted on the lower part of the cutting mechanism and a supporting frame located above the cutting platform. The structural features are as follows: the supporting frame is connected with a positioning block driven up and down by a positioning cylinder 12, the supporting frame is also slidably connected with a translation frame, the two sides of the translation frame are hinged with a clamping rod 5, the front end of the two clamping rods is equipped with a corresponding clamping head, the rear end of one clamping rod is connected with the rear cylinder and the front cylinder, the rear cylinder back seat is connected with the supporting frame 1, the rear cylinder piston rod is connected to the front cylinder, and the front cylinder piston rod is powered.

The front end of the rear cylinder is fixed with a forward extended guide rod 20, the back seat of the front cylinder is provided with a casing sliding connected to the guide rod, and the front end of the rear cylinder is also threaded with a limit rod which can limit the distance of the front cylinder's backward movement.
The support frame is provided with a bearing seat 11, the bearing seat is embedded with 4 linear bearings 26, and the translation frame is fixed with a guide rail 10 that is sliding connected in 4 linear bearings.

The supporting frame is provided with two supporting plates 13 extending in opposite directions, the supporting plate is bolted with an adjusting support 14, the adjusting support is provided with a long strip hole 15 for bolt passage, the front part of the adjusting support is provided with a guide seat 24, the positioning cylinder 12 is provided with two vertical mounting supports respectively, and the positioning block is slidably connected in the guide seat and its upper end is connected with the piston rod extending under the positioning cylinder.

3.2. Automatic positioning mechanism
The positioning mechanism includes two supporting plates protruding from the front lateral sides of the two front extension arm. The support plate is connected with an adjustment support, the adjustment support is provided with a scale, the front part of the adjustment support is connected with a positioning cylinder and a guide seat, and the guide seat is slidably connected with the positioning block. The setting of the positioning block and the piston connecting guide seat under the cylinder makes the upper and lower sliding of the positioning block more accurate, that is, the positioning is more accurate, and the advantage of setting the two positioning blocks is that it can make the leaning tile locate accurately. In addition, the positioning mechanism is also designed to use step motor drag, pneumatic component positioning, further improve the positioning accuracy; and can adjust the positioning distance through the man-machine interface, so that the tile according to the set width line cutting, solve the existing mechanical cutting machine tile cutting width fixed adjustment inconvenience.

3.3. Compaction mechanism (Figure 3)
The compression mechanism includes an adjustment support connected with two support plates, the upper part of the adjustment support is connected with a cylinder and a guide seat, and the guide seat is connected with a positioning block. When cutting the tile, the cylinder action causes the positioning block to move down and press the tile. There are two positioning blocks, which can make the tile cut more firmly, avoid the size error caused by loosening, and further improve the precision of cutting.

4. Design of Electrical System of Robot
A programmable controller (PLC) is used to control the action of each mechanism, and a man-machine interface is used to adjust the variable parameter data of the system, and the equipment can work automatically. Electric control system of the whole machine adopts PLC as the core, receives the peripheral state signal transmitted by proximity switch, photoelectric switch and other sensors, implements the combined control of machine, electricity and gas, and realizes the operation of each mechanism according to the prescribed beat. The design idea is as follows: the controller uses Mitsubishi FX1S-14MT, stepper motor model 57BYG250H, and the definition of PLC part of input and output points is shown in Table 1.

| Input   | Meaning        | Output   | Meaning                      |
|---------|----------------|----------|------------------------------|
| X0      | start-up       | Y0       | control pulse                |
| X1      | suspend        | Y1       | Knife head down, cutting     |
|         |                |          | forward                      |
| X2      | Close switch 1 | Y2       | directional control          |
| X3      | Close switch 2 | Y3       | Knife head rising, cutting   |
|         |                |          | back                         |
| X4      | Location of    | Y4       | Unloading cylinder           |
|         | origin         |          |                              |
5. Conclusions

This designed robot has been applied to the actual production of ceramic tile processing enterprises, the production efficiency can reach 600 pieces/8h, when ceramic tile cutting, the size adjustment is convenient and flexible, the cutting error is small, the tile section is smooth and tidy, and the breakage rate is very low. Design innovations can be summarized as follows:

1) By PLC control, the designed mechanical mechanism can realize automatic feeding, automatic positioning, automatic cutting, automatic unloading and other actions, cutting efficiency is high, and the labour intensity of workers is low.

2) Using step motor drive, pneumatic element positioning, can make the machine cut tile according to the set width, solve the shortcomings of the existing mechanical cutting machine tile cutting width fixed adjustment inconvenience.

3) The upper unloading system adopts double action cylinder linkage control, and the efficiency is high.

4) The whole machine integrates mechanical, electrical and gas path design, and has a high degree of automation in the working process.

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