

Design and Implementation of Test Paper Binding Machine Based On Single Chip Microcomputer

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Abstract: The bookbinding is an important segment in the school examination work. The efficiency and quality of the binding work is related to the level of the teaching service. The professional test paper binding machine can be bound and sealed according to the requirements of each school. It can realize the automatic, convenient and efficient binding of examination papers, besides that, it has the functions of automatically completing punching and finishing binding efficiently, in addition, it also has the characteristics of simple operation, no damage, and convenient maintenance. This topic is based on extensive research, believing that the current market demand for paper binding machine. This demand requires professional and efficient paper binding equipment, so innovating on the basis of the current binding equipment to design a professional test paper binding equipment to meet the needs of the society is necessary. The design of the special test paper binding machine is of great significance to improving the quality of the test paper binding, improving the efficiency of the school teaching and saving the intensity of the teachers' work.

Keyword: bookbinding machine, automatic perforating, innovative design, Stepper motor

INTRODUCTION

At present, the general used tool is awl, needles and thread when binding papers. However at the time the paper is thick, sometimes awl with bending is also very difficult to punch a hole.

The test paper binding is not easy. After investigating, the test paper bookbinding machine on the market has the following shortcomings: first, the degree of automation is not high and the operation is troublesome; the two is the low of the working reliability, which is often stuck in the hole, and the noise is also very large. After network retrieval, there is no bookbinding machine designed specifically for binding test papers on the market [Huang, *et. al.*, 2006].

The examination paper bookbinding machine designed in this subject mainly complete the following work: one is the automatic and efficient completion of test paper punching without manual operation, which can be easily automated and efficient completion of drilling test; the other is the operator can then play different distances of holes according to needs from selecting the corresponding mode and achieving arbitrary control of hole spacing.

OVERALL DESIGN SCHEME

The test paper is placed on the binding table, and the motor is automatically reset by sensors of each component after opening the binding machine. The test bookbinding machine is composed of two parts motion, horizontal and vertical. Horizontal movement

determines the distance between the holes in the test paper, the vertical movement controls the motor drilling, and the whole motion is controlled by the 89C52 microcontroller [Chen, *et. al.*, 2010]. All parts of the binding machine are shown in Figure 1.

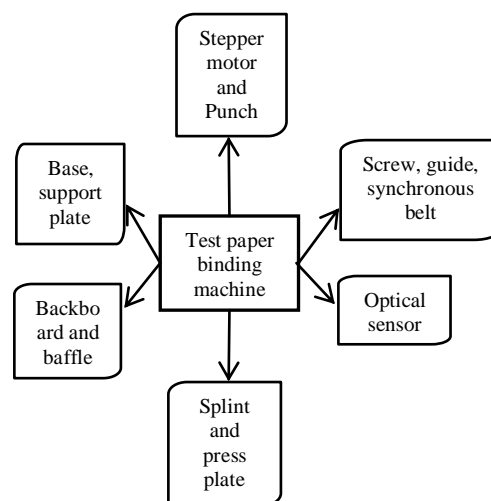


Figure 1. The overall composition of the binding machine

DESIGN OF MAIN PARTS

Design of a binding table

The binding table is not only mainly used to place the test paper, but also to bear the weight of the

support, guide and other parts. The binding table of the special paper binding machine uses three plywood materials, which is beautiful, generous, and can withstand certain weight. The three plywood plates with thick 18mm can fully meet their use strength.

The size of examination paper for general school is 8, that is 375mm*260mm, and the length of clamping plate of the clamping device is at least 100mm longer than that of the examination paper, so that the examination paper can be compacted. In addition, both ends of the table should at least have 80mm margin to install the support plate bracket and the side

plate (There must be a large gap between the support plate and the side plate, otherwise the side plate can not move up and down); Because $260\text{mm}+80\text{mm}\times 2+100\text{mm}=520\text{mm}$, so the table width is 540mm (extra 20mm installation allowance). At the lower right corner of the workbench, the 78mm*45mm keyboard is left with the allowance. Therefore, the final size of the worktable is determined to be 540mm*540mm*18mm. The design of the binding table is shown in Figure 2.

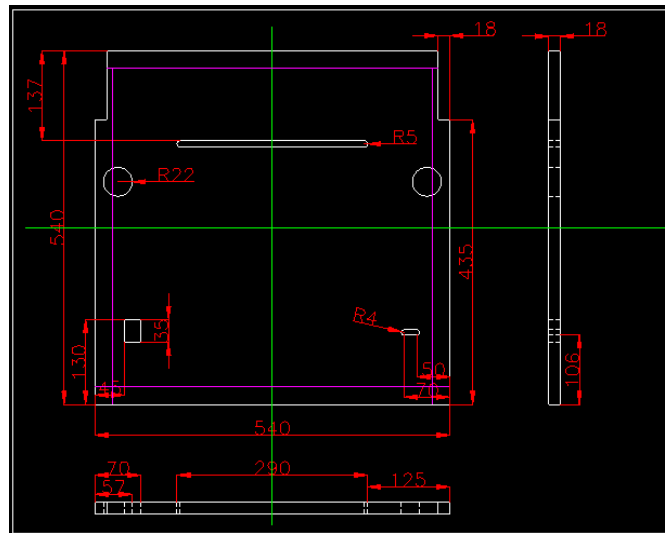


Figure 2. Binding table structure size

Design of support plate

The most important function of the support plate is to bear the weight of the horizontal guide. The estimated weight of the horizontal guide is less than 7.5kg. As mentioned in the previous design of the main frame, the overall mechanism is made of three plywood plates. So the 15mm thick three plywood fully meets the strength requirements.

If the side plate is too high, and it is higher than 520mm, when the horizontal guideway motor of the binder rotates works, the center of gravity is unstable and the noise is large, which is easy to cause the jitter, vibration and even rollover of the binding machine. If

the side plate is too low to be lower than 360mm, the stability of the binding machine work is guaranteed, but the thickness of the binding test paper is greatly limited. The above two points determine the determination of the height of the supporting plate. When the height of the side plate is 468mm, the stability of the working of the binding machine is better [Xu, 2011]. Considering the convenience and smooth operation of the installation, the width of the support plate is best when 100mm is taken. Therefore, the size of the support plate is finally determined to be 100mm*468mm*18mm. The design of the supporting plate is shown in Figure 3.

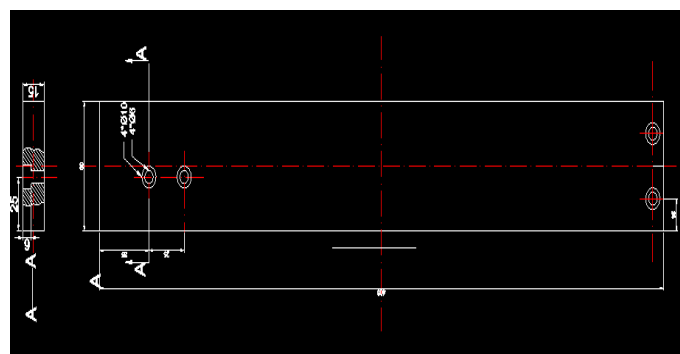


Figure 3. Support plate structure size

Vertical motion

Determination of the parameters of the guide screw

The drilling motor is installed on the slideway block, and requires certain requirements for the precision of the drop depth. According to the market survey, the vertical movement mostly adopts the screw guide, whose movement is more stable and speed of movement is moderate. The slide block installation position of the horizontal guide is 360mm from the worktable and at the bottom of the vertical guide, at least the 130mm should be reserved. If the reserved length is too short, the bit drill down to the bottom is still not through papers, even not in contact

with the test paper. If the reserved length is too long, this will lead to two consequences: one is inconvenient to install, the other is the weight increasing and the horizontal guide load increasing. So the guideway is $360\text{mm} - 130\text{mm} = 230\text{mm}$. 60mm is suitable for length design, overlength increases weight, and too short length leads to the poor installation of a drilling motor. When the width of the design is 55mm, the load bearing capacity is better and the guide rail looks more beautiful on the whole. So the size of the vertical guide is $230\text{mm} \times 60\text{mm} \times 55\text{mm}$. The design of a vertical screw guide is shown in Figure 4.

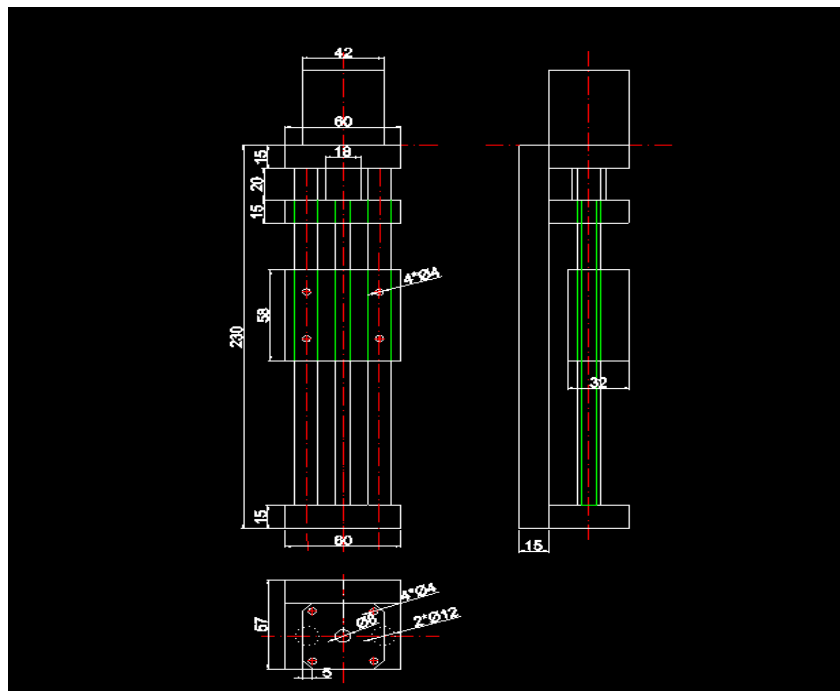


Figure 4. Vertical screw structure size

Motor selection

Considering the vertical movement load is small and the vertical size has been determined, the use of a more moderate price of the 42 motor can get the guarantee of work [Huang, *et. al.*, 2008].

Calculation of motor speed parameters

The speed of the vertical guide motor is determined by the speed of moving up and down of the slideway slider, that is the speed of perforation. If the speed is too fast, the drilling motor is too late to punch, and the drill will stretch into the test paper which is possible to break the drill. If the speed is too slow, there will lead to two consequences: the one is the vibration of the motor and the other is too slow, which will not meet the requirement of its efficient drilling. After many tests, when the slideway descending speed is 698mm/min and the rising speed is 2450mm/min, the

special paper binding machine can achieve its quick use requirement.

Horizontal movement

Horizontal guide design

There are many types of guideway drives in the market, such as sliding guides, rolling guideways (ball guides, ball screws, guideways), hydrostatic guideways and so on. This design adopts a sliding guide synchronous belt device. The purpose of adopting a synchronous belt is moderate price, and the transmission precision is also satisfied. So it is designed as a guide and a synchronous belt device.

The length of the guide is as long as the length of workbench, which is 540mm and its width is determined by the width of two sides supporting plate. Because the horizontal guide rail and the slider are installed equal to the width of the wing plate which is 60mm, while the thickness of the slider is 26mm and

the installation depth is 16mm, so the width of the guide rail is determined to be 50mm.

Because the size of the slider is 90mm*90mm*26mm and the installation of the slider requires a interference fit, so there is a gap between

the upper and lower which is 5mm, that is the guide height being determined to be 100mm.

The size of the horizontal guide is finally determined to be 540mm*50mm*100mm. The horizontal guide design is shown in Figure 5.

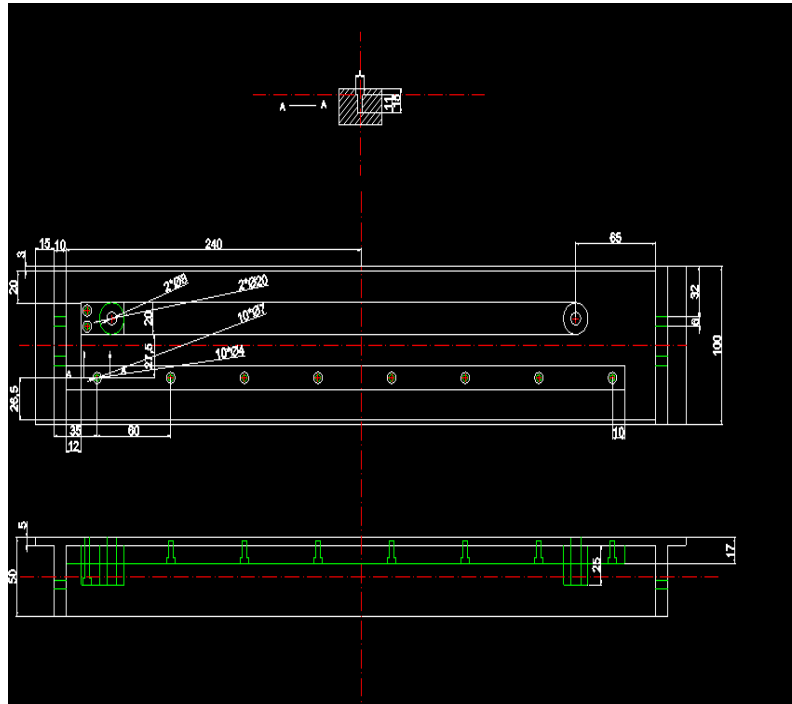


Figure 5. Horizontal guide structure size

Motor selection

The step motor can meet the requirement of positioning precision. Every electric pulse lead to the step motor rotates a certain angle, and drive the machine to move a small distance. Its characteristics:

- (1) a pulse, turn a step angle.
- (2) control the pulse frequency, can control the motor speed, and then change the horizontal motion speed.
- (3) change the pulse sequence, change the rotation direction, and realize the left and right movement.

The working characteristics of the stepping motor coincides with the requirements of the digital control system. Therefore, the stepper motor as a power device can be choose .

Calculation of motor speed parameters

The speed of the horizontal rail motor is determined by the speed of horizontal movement. However, in order to get the best horizontal moving speed, it must be obtained through experiments.

After several experiments, when the horizontal moving speed is 0.0785m/s, the working state of the special test paper binding machine is best, and the vibration and jitter will not occur.

Selection of drilling motor

The drilling machine is the core component of the special test paper binding machine, which directly affects the quality of the perforation. Therefore, the selection of the drilling motor is particularly important. The perforation requires higher speed , general motor precision and its weight accounts for the vast majority of the vertical load. Therefore, the 220v-80w DC motor is selected. The motor can be connected to the 220V AC circuit through the rectifier bridge. The joint action of the photoelectric sensor and relay is used to control the switch off of the motor [Xu, *et. al.*, 1993].

CONCLUSION

The binding table is used for the placement and clamping of the test paper. The support plate is used for the support of horizontal and vertical motion devices. Horizontal motion is realized by photoelectric sensor, guideway, stepping motor and synchronous belt. Vertical motion is realized by photoelectric sensor, stepper motor, screw rod and punching motor. The whole motion control is realized by the MCU control step motor driver. The main steps of the test paper binding machine are shown in Figure 6.

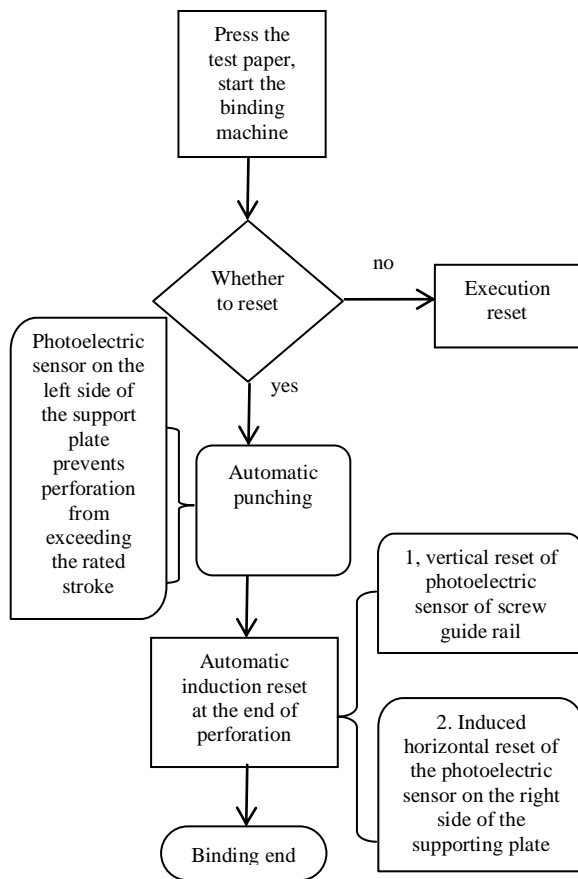


Figure 6. Binding flow-process diagram

The design of this special test paper binding machine is based on the application of mechanical design, electronic control system, Auto CAD and so on. Through the market research, this subject realizes that the application of the test paper binding machine is very wide in life, and the market demand for the special test paper binding machine is huge.

Because the dedicated test bookbinding machine has some advantages in itself, so it will have a wider range of use than the ordinary binding machine, as well as the prospects for development. At the same

time, the requirements of the motor selection, the configuration of the drive and the selection of materials of general purpose examination bookbinding machine can generally be satisfied, making up for the market blank. The final version of the binder is shown in figure 7.

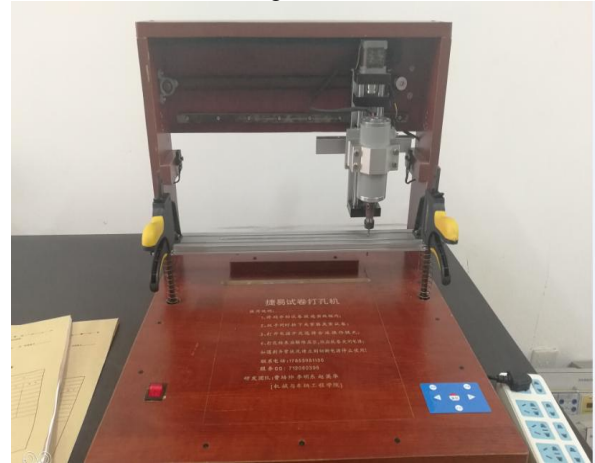


Figure 7. Final edition of test paper binding machine

REFERENCE

- Chen Haiyan, 2010, "The principle and application of 51 single chip microcomputer", Beihang University press, pp. 175-190.
- Huang Jingyuan, Gao Zhi, Chen Zhulin, 2006, "Mechanical design", Machinery Industry Press, pp. 255-243.
- Huang Yong, Liao Yu, Gao Lin, 2008, "Design of motion control system of stepper motor based on single chip microcomputer", Electronic measurement technology, vol.31, no. 5, pp. 150-154
- Xu Gaoyan, Xu Ruiying, 1993, "Drill rig design", China University of Geosciences press, pp. 56-72.
- Xu Jinjuan, 2011, "Research and development of mechanical design auxiliary tools based on AutoCAD", Academic papers.