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Design of Laser Quenching Equipment for Stainless Steel Dining Knife

Feng Gao[1], Qipeng Cao[1,*], Xuhao Wu[2], Miaolong Jiang[1]

[1]Wenzhou Polytechnic, Wenzhou 325200, China
[2]Zhejiang Jiuheng Photoelectric Technology Co.Ltd, Wenzhou 325200, China
*Corresponding Author

Abstract: Based on the research of laser quenching technology of thin blade edge, the laser quenching equipment of stainless steel dinner knife is developed. According to the structure of stainless steel knife and quenching process layout, the feeding mechanism, positioning mechanism and feeding mechanism are designed to meet the functional requirements of laser quenching automatic operation, which has high practical value to solve the problem of automatic loading and unloading of tool and accelerate the production speed of tool.

Keywords: Laser Quenching, Stainless Steel Knife, Automatic Feeding.

1. Introduction

In order to meet the requirements of wear resistance and hardness of stainless steel knife, the tool material is martensite stainless steel [1]. At present, the traditional heat treatment of martensite stainless steel dining knife adopts the mesh belt furnace which has problems such as poor tool performance, insufficient energy saving process and environmental pollution. Laser quenching is a heat treatment technique with the laser as a heat source, controlling the part of the laser scanning heat treatment to bringing the scanned area to 104~106 With the heating and cooling speed of ℃ / s, the solid phase transition is completed within 1 second to obtain the desired quenching effect [2]. Laser quenching has obvious advantages over conventional quenching [3-5]. Literature [6] discloses a quenching enhancement process of thin blade blade, indicating that the laser quenching of food-grade knife blade has entered the stage of industrial practice. However, the equipment for laser hardening of food-grade stainless steel cutting tools is yet to be developed and is in the laboratory stage. Based on this, this paper develops the automatic equipment of tool blade laser quenching, realizes the automatic operation of tool loading and unloading and laser quenching, and promotes the improvement of food-level tool manufacturing level.

2. Overall Scheme Design

The laser quenching equipment of stainless steel dining knife includes feeding mechanism, quenching mechanism and feeding mechanism, as shown in Figure 1. The working process is as follows: place the tool to be processed on the inlet of area A, the tool moves forward by the slope and stops the claw. After starting, press the tool and drive the tool to the area C transfer line through the cylinder drive area B feeding mechanism. Area D positioning module cylinder action, complete product positioning clamping. When the product flows to area E, the laser quenching of the blade is performed. After processing, the product flows out to the area F material tank and collects it manually.

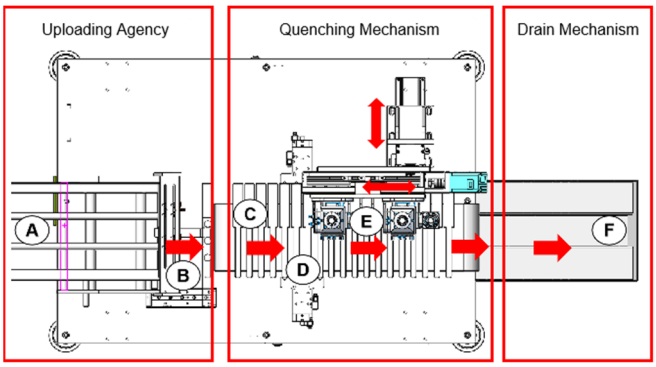

Figure 1. Process diagram of laser quenching equipment for stainless steel dining knife

3. Uploading Agency

3.1. Sloping Guide Rail Mechanism

This design adopts slope feeding, the mechanism is shown in Figure 2. The tool is neatly placed on the guide rail, using the effect of gravity to make the tool slide naturally. The guide rail is designed to be cylindrical, which reduces the contact area between the tool and the guide rail through the transition from surface contact to line contact, so as to reduce the friction force. Compared with the guide rail conveyor belt, the tool placement operation is simpler, and has the advantages of low cost, not easy to damage.

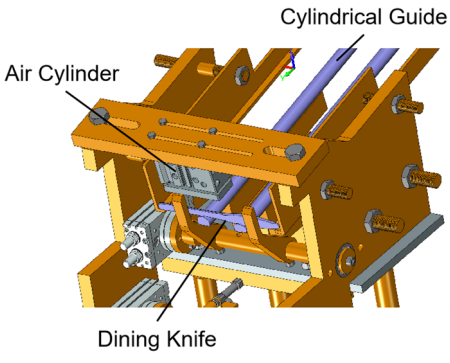

Figure 2. Sloping guide rail mechanism

Analyze the force situation during the tool slide according to Figure 2. In order to make the tool slide smoothly, the tangential dividing force of the tool in the guide rail direction must be greater than the friction force.

$$mg\sin\theta > f \quad (1)$$

In the formula, the tool mass is m, and the value is 0.15kg; The scale factor is , and the value is 0.98N/kg; The inclination angle of the guide rail is θ; The friction force is f, and the calculation formula is f=μ·m·g·cos θ, where μ is the friction coefficient, with a value of 0.1.

Therefore, the minimum guide rail tilt angle is 5.71°, there is no need to use a larger Angle guide rail, which makes the adjustment of the feeding mechanism more convenient.

3.2. Positioning and Discharging Mechanism

The tool slides along the ramp cylindrical guide and stops. Cylinder drive claw to achieve retaining and discharging: first of all, the control switch starts the upper press cylinder pressing tool. Then, the horizontal clamping device turns 90° counterclockwise, and the straight-moving cylinder clamps the tool. Later, the retaining cylinder rotates clockwise for 45°. At this point, the cylinder of the tool is returned to the original position and the tool is released to the conveyor belt. Return the claw to the original position to block the tool again, the press cylinder releases the tool, the tool slides to the pending position with gravity and presses again to complete a cycle. Figure 3 shows the state when the claw is released.

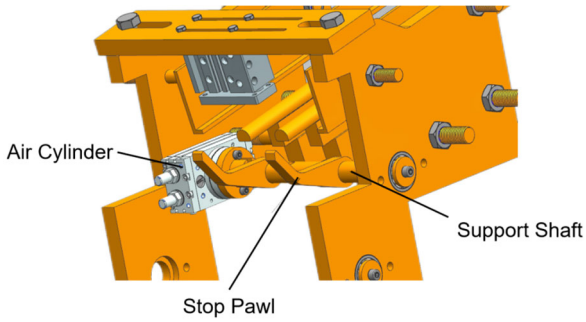

Figure 3. The state of rotating the stop pawl

According to the basic parameters in Table 1, the cylinder is selected by calculation.

Table 1. Design Parameters for Selection of Claw Cylinder

Fender Quality /kg	Tool mass / kg	radius of gyration /m	Required work-piece with 1s rotation angle / °
0.186	0.15	0.125	90°

The calculation formula of torque is as follows:

$$T = k * J * P \quad (2)$$

In the formula, the torque coefficient is k, and the value is 5; The moment of inertia is J, and the calculation formula of J is 1/2mr2, in which m is the total mass of the baffle and the tool, and r is the radius of rotation; The angular acceleration is P, and the calculation formula of P is w/t.

The obtained torque is calculated. Check the HRQ 20 in the selection pressure, and the conclusion is that the check is available.

3.3. Clip-up and Extraction Mechanism

The main function of the clip mechanism is to clip the tool from the circular guide rail and transport it to the conveyor belt. The mechanism consists of a rotary cylinder and a pen-shaped cylinder, as shown in Figure 4. The working process is as follows: the rotary cylinder rotates the entire clip extraction mechanism to the specified position. At this time, the tool is in the operating range of the pick-up mechanism, and the tool clamp is realized through the push expansion shaft of the cartridge cylinder. Then, the rotary cylinder rotates again to deliver the tool above the conveyor belt. At this point, the expansion shaft is released and the tool falls on the conveyor belt. Subsequently, the rotating cylinder turns downward for 10°, and the meal knife is transported by the conveyor belt to the next position.

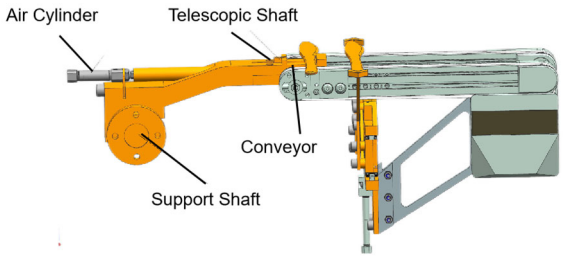

Figure 4. Clip-up mechanism

According to the basic parameters in Table 2, the cylinder is selected by calculation.

Table 2. Design Parameters for Cylinder Selection Calculation of the Clip-up Mechanism

Rotary Part mass /kg	radius of gyration /m	Required workpiece with 1s rotation angle / °
0.6346	0.195	90°

The obtained torque is calculated. Check the HRQ 20 in the selection pressure, and the conclusion is that the check is available.

The output force of the pen-shaped cylinder is calculated to be 4.1N, and the force required for tool transportation is 1.47N, which can be checked.

4. Quenching Mechanism

Two quenching of the blade was performed with a double laser head as shown in Figure 5.

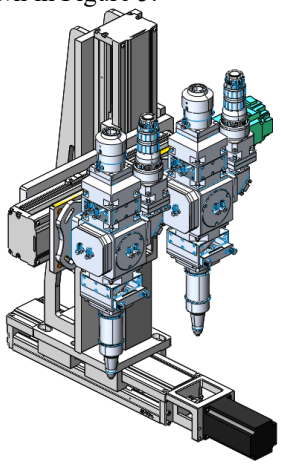

Figure 5. Synchronous quenching of dual laser head

Laser laser quench the blade and requires the fast and accurate fixed position. Due to the irregular shape of the meal knife, a specific positioning mechanism needs to be designed. This design adopts the mode of centering and realizes the smooth transportation on the conveyor belt through the axis. The working process is: after the tool is placed on the assembly line, by the conveyor belt to the designated position; the positioning mechanism starts to move, the cylinder drive connecting rod moves upward, clamp the tool, then the cylinder shrinks downward, the arm is released, the assembly line carries the tool to the drop bin. The tool positioning structure is shown in Figure 6.

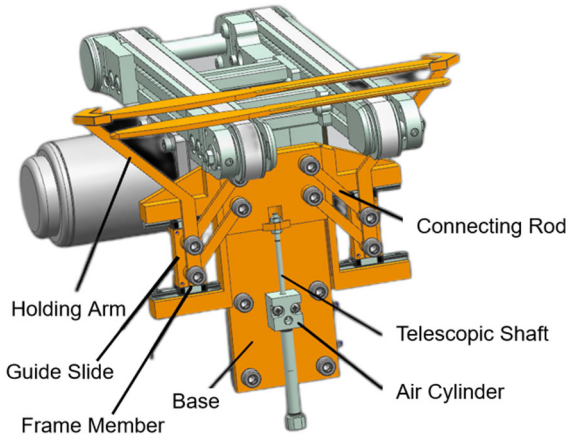

Figure 6. Tool positioning mechanism

At the same time, the contact part of the design arm and the tool is dovetail type, so that the work-piece is not easy to fall off. The swallowtail-type holding arm is shown in Figure 7.

Figure 7. Swallowtail-type holding arm

5. Drain Mechanism

A simple, practical and undamaged slope feeding mode is adopted, as shown in Figure 8.

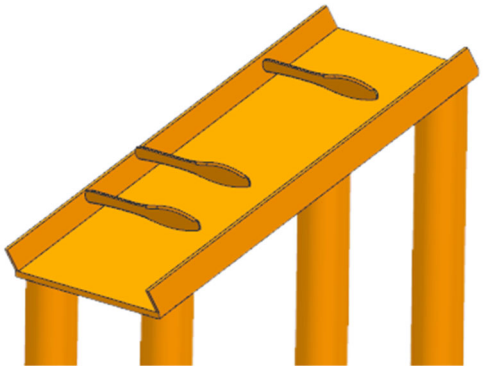

Figure 8. Slope feeding mechanism

6. Conclusion

In view of a series of problems in the current heat treatment of stainless steel knife, the laser quenching equipment is designed to replace the traditional mesh belt furnace. The equipment is composed of a feeding mechanism, a quenching mechanism and a blanking mechanism. Four cylinders are used to realize the feeding of the dinner knife, the conveyor belt and the positioning mechanism are used to realize the precise control of the quenching process, and the gravity is used to complete the blanking storage of the knife.

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