Mechanical Design of Semi - automatic Stainless Steel Pot Polishing Machine Based on SolidWorks

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Abstract

In this paper, the use of SolidWorks three-dimensional mapping software, a detailed design of a semi-automatic stainless steel pot polishing machine. This polishing machine will be grinding machine and the host on the same box above, simplifying the machine structure. The use of the cylinder can achieve both the front and rear movement of the grinding wheel, but also to ensure constant pressure polishing, improve the level of polishing technology to ensure the polishing processing accuracy and processing quality. And the use of screw can also be achieved in a certain range of different diameter stainless steel pot polishing, improve the processing efficiency and reduce processing costs, so that further practical polishing technology .This semi-automatic stainless steel pot polishing machine with a stable, good processing quality, high efficiency, low cost and other advantages.

Keywords

Polishing machine, Stainless steel pot, Semi-automatic, Efficiency.

1. Introduction

1.1 An Overview of the Polishing Machine

The polishing machine is a common equipment for mechanically grinding, polishing and waxing. In the modern machinery manufacturing, the polishing machine has become an important follow-up machine. Since some mechanical parts must be polished in order to meet their processing and installation requirements. And some mechanical products must also Polish some of their parts in the later stage of mechanical processing, so that they can not only make the appearance of the products more beautiful, but also facilitate the sale of the market.

1.2 Development Status of Polishing Machine

In the past more than 20 years, the traditional manufacturing industries in China usually use the way of grinding or manual grinding. This technology is low in technology and low in automation level, which is no longer suitable for today's production needs. Highly efficient production, intelligent and convenient operation and unmanned management system have become the main trend of today's manufacturing industry, which should also be the main development direction of China's polishing machine.

1.3 Working Principle of the Polishing Machine

When polishing machine, polishing wheel begins to rotate at high speed, between the polishing wheel and parts rotate with each other to create friction, allowing the parts to produce high temperature, so that a part of shaping, parts of the surface are more prone to plastic deformation, this causes the metal surface protruding part is filled in the concave part, so that the surface of metal parts can be polishing.

This design uses longitudinal and lateral pressure cylinders to control the adjustment of feed. With the lead screw, the polishing machine can polish the stainless steel pot with a diameter of 144 ~ 340mm,

and the pneumatic fixture can rapidly change the workpiece, so that the working efficiency has been greatly improved.

2. Conceptual Design

The main structure of semi-automatic stainless steel pot polishing machinery design includes: motor, V belt drive, spindle, coupling, guideway, cylinder, bottom plate, screw rod, polishing wheel, box and other components.

After investigating and consulting the relevant information, the overall assembly drawing of the polishing machine is now determined as shown in the following figure. The software used in this design is SolidWorks 2014.

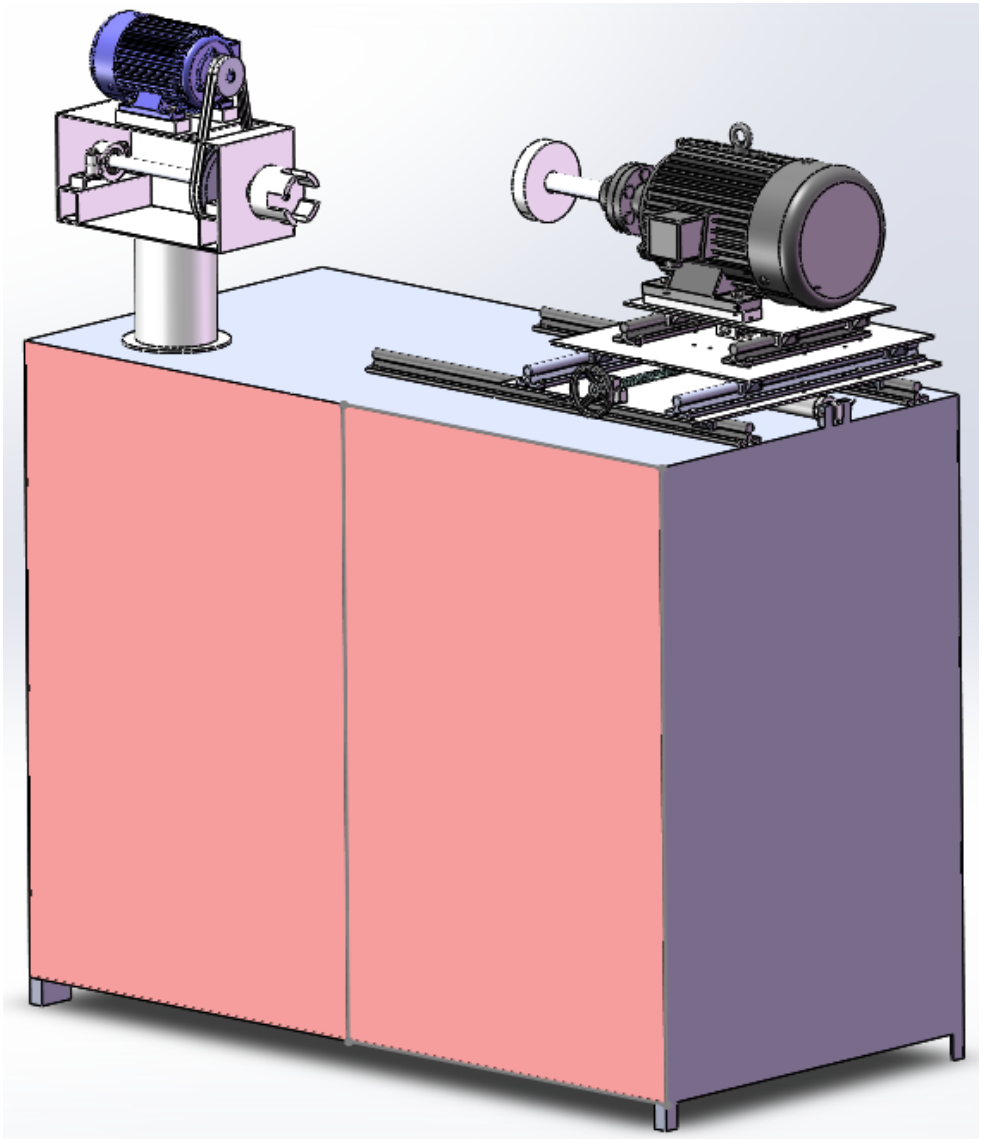

Fig. 1 Semi-automatic stainless-steel pan polishing machine

3. Design and Calculation of the Main Parts of the Polishing Machine

The design of parts follows the following steps:

According to the requirements of the use of the parts, the type and the structure size of the parts are reasonably selected. Therefore, we must make a comprehensive comparison of various parts, such as different types, advantages and disadvantages, characteristics and scope of application, then choose the most suitable parts.

According to the working requirements of the polishing machine, the size of various loads on the parts is calculated in detail.

According to the working conditions and other conditions of the parts, choose the most suitable material, determine the basic size of the parts, then design the structure of the parts reasonably, and draw the working drawings of the parts at last.

3.1 Selection of Motor

The main problems to be taken into consideration when choosing an electric motor

(1) The type of motor is mainly chosen according to the load characteristic of the machine.

(2) The main consideration is the load torque, the speed range of motor and the frequency of motor startup. Then the temperature limit, overload capacity and starting torque of motor are taken into account.

(3) The rated speed of the motor is selected according to the maximum speed required by the production.

In addition, the choice of motor, also must consider whether accord with the requirement of energy saving, taking into account the universal motor operation reliability and motor spare parts are good, and the level of product prices and the subsequent expenses, are all factors when we select the motor must be considered.

According to the known conditions, the initial rated power of the main motor is 7.5kW, and the rated speed is 1440r/min. The rated power of the auxiliary motor is 0.55kw, and the rated speed is 1390r/min. After researching and consulting related mechanical course design manuals, Y series (IP44) three-phase asynchronous motor (JB/T9616 - 1999) is selected. The main motor is Y132M-4 and the auxiliary motor is Y801-4.

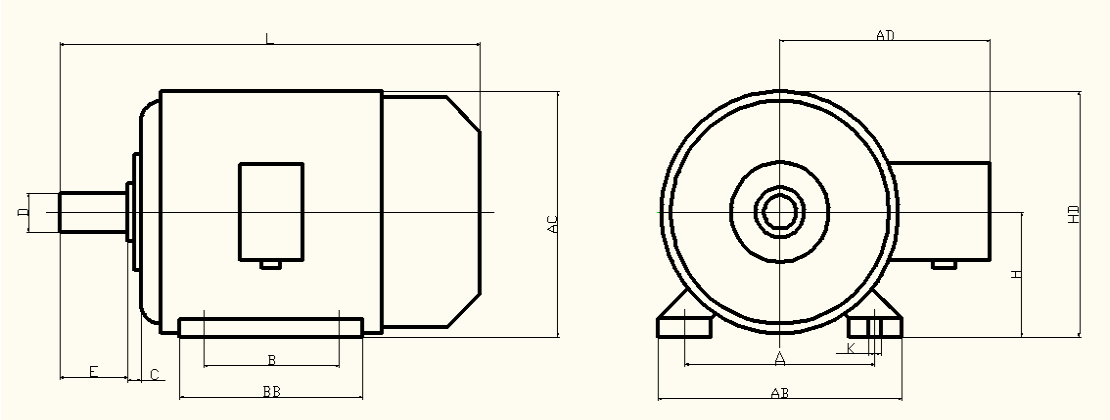

Fig. 2 Motor

3.2 Design of V Band

The purpose of this belt drive is to convert the rotational speed of the auxiliary motor 1390 r/min to the workpiece speed 600 r/min.

3.2.1 Determine the Power of Calculation

The calculated power is determined in accordance with the working conditions of the transmitted power P and the V band.

$$\text{Pca} = K_A P \tag{1}$$

According to the analysis of known conditions, the work of this design is small load change, empty and light start mode, and the number of working hours per day is less than 10 hours. Lookup machine design (Ninth Edition) table 8-8. The selection work condition coefficient is: K_A =1.0.

$$\text{Pca} = K_A \text{P} = 1.0 \times 0.55\text{kw} = 0.55\text{kw} \tag{2}$$

3.2.2 Selection of Band Type of V Band

According to the calculation power and the number of the motor, the ordinary V band Z type is selected by figure 8-11 (Mechanical Design).

3.2.3 Determine the Base Diameter of the Pulley and Check the Speed of the Belt

Refer to the type of belt selected above, according to table 8-7 and table 8-9 mechanical design", take the base diameter of the drive wheel.

$d_{d1} = 71\text{mm}$

As the rotation speed of the shaft is 600r/min, the base formula

$$\frac{n_1}{n_2} = \frac{d_{d2}}{d_{d1}} \tag{3}$$

$$d_{d2} = \frac{d_{d1} n_1}{n_2} = 71 \times \frac{1390}{600}\text{mm} = 164\text{mm}$$

The reference diameter of the moving wheel is taken from the mechanical design of table 8-9 $d_{d2} = 160\text{mm}$.

Press formula $v_1 = \frac{\pi d_{d_1} n_1}{60 \times 1000}$ speed formula for checking the band

$$v_1 = \frac{\pi d_{d_1} n_1}{60 \times 1000} = \frac{\pi \times 71 \times 1390}{60 \times 1000}\text{m/s} \approx 5.2\text{m/s} > 5\text{m/s} \tag{4}$$

So the speed of the selected belt is suitable.

3.2.4 Determine the Base Length and Center Distance of the V Band

According to $0.7(d_{d1} + d_{d2}) < a_0 < 2(d_{d1} + d_{d2})$

$0.7(71+160) < a_0 < 2(71+160)$

The center distance can be preliminarily determined $a_0 = 200\text{mm}$ Basis

$$L'_d = 2a_0 + \frac{\pi}{2}(d_{d2} + d_{d1}) + \frac{(d_{d2}.d_{d1})^2}{4a_0} \tag{5}$$

$$= [2 \times 200 + \frac{\pi}{2}(71+160) + \frac{(160-71)^2}{4 \times 200}]\text{mm} \approx 773\text{mm}$$

Reference length of table 8-2 (Mechanical Design) L_d=780mm

Calculating the actual center distance a

$$a = a_0 + (L_d - L'_d)/2 = [200 + \frac{780-773}{2}]\text{mm} = 203.5\text{mm} \tag{6}$$

3.2.5 Checking the Upper Wrap Angle of the Active Wheel

$$\alpha_1 \approx 180° - \frac{dd2 - dd1}{a} \times 57.5° = 180° - \frac{160-71}{203.5} \times 57.5° \approx 155° > 120°$$

So the angle of the package on the active wheel is suitable.

3.2.6 Determine the Number Of Roots of the Band Z

According to the formula

$$Z = \frac{Pca}{(P_0 + \Delta P)K\alpha K_L} \tag{7}$$

From n_1=1390 r/min , d_{d1}=71mm , Table 8-4 and table 8-5 "Mechanical Design"

P_0=0.29kw ΔP=0.03kw

Table 8-6 and table 8-2 (Mechanical Design) K_α=0.93, K_L=1.00

$$Z=\frac{0.55}{(0.29+0.03)\times 0.93\times 1.00}\approx 1.85$$

So the number of roots of the fetch band is Z=2.

3.2.7 Determination of the Initial Pulling Force of the Belt

The initial pulling force of a single V band can be determined by the following formula:

$$F_0=500\frac{Pca}{vz}(\frac{2.5}{K\alpha}-1)+qv^2 \tag{8}$$

Lookup table 8-3 "Mechanical Design" q=0.060kg/m

So, $F_0=[500\times\frac{0.55}{2\times 5.2}(\frac{2.5}{0.93}-1)+0.060\times 10^2]N=50.64N$

3.2.8 Calculation of the Axial Force on the Axis

According to the formula

$$F_P=2zF_0\sin\frac{\alpha_1}{2}=[2\times 2\times 50.64\times\sin\frac{155^\circ}{2}]N=197.76N \tag{9}$$

3.3 Design of V Pulley

We know the conditions of the reference diameter and belt speed of the pulley, which can be used to determine the material for making the wheel, the structural shape of the pulley, the corresponding dimensions of wheel grooves, spoke and hub and so on.

The commonly used pulley materials are HT150 or HT200. The typical structure of V pulley mainly consists of the following four forms: 1) solid type; 2) web type; 3) hole plate type; 4) wheel spoke type.

3.3.1 The Design of the V Pulley on the Auxiliary Motor

The design parameter of the V pulley of the auxiliary motor has been designed by the front side: the nominal diameter d=71mm, the number of the root Z of the belt is 2, the extension axis diameter of the motor is 19mm, so d = 20mm. The design of the belt wheel is a solid structure.

The value of a wide B of a belt wheel

$B=(Z-1)e+2f=(2-1)\times 12+2\times 7=26mm$

Outer diameter: $d_a=d_d+2h_a=71+2\times 2\approx 75mm$

Selection of wheel slot angle φ=34°, Limit deviation $\pm 1^\circ$.

The other sizes are:

$L=(1.5\sim 2)\mathrm{d}=1.8\times 20\approx 36mm$

$\mathrm{d}_1=(1.8\sim 2)\mathrm{d}=1.8\times 20\approx 36mm$

The types of keys can be selected from the above data. GB/T1096 6×6×32

3.3.2 Design of V Pulley on Shaft

The design parameters of the V wheel on the axis are known from the front design: the nominal diameter dd2=160mm; the root number of the band Z is 2; the diameter of the coordinate with the axis is 25mm so d = 26mm. The design of the structure is a web type.

The value of a wide B of a belt wheel

$B=(Z-1)e+2f=(2-1)\times 12+2\times 7=26mm$

Outer diameter: $d_a=d_d+2h_a=160+2\times 2\approx 164mm$

Selection of wheel slot angle $\varphi = 34°$, Limit deviation $\pm 1°$.

The other sizes are:

$$L = (1.5 \sim 2)\mathrm{d} = 1.8 \times 26 \approx 47mm$$

$$C' = (\frac{1}{7} \sim \frac{1}{4})B = 26 \times \frac{1}{5} = 5.2mm$$

$$\mathrm{d}_1 = (1.8 \sim 2)\mathrm{d} = 1.8 \times 26 \approx 47mm$$

3.4 Design of the Mainframe Axis

In order to determine the axial size of the axis, if the parts on the axis need to be positioned with the shaft shoulder, the diameter of the adjacent axis is generally 5-10mm. When the rolling bearing is positioned with the shaft shoulder, the diameter of the axle shoulder is determined by the number checked in the standard of the rolling bearing of the design manual. The difference between the diameter of the adjacent shaft should be 1-3mm in order to remove the parts of the shaft to be more convenient or processed. The rolling bearing on the shaft and the diameter of the shaft section at the transmission parts should be taken as the corresponding standard value in the design manual.

The axial orientation of the parts on the spindle selects the shaft shoulder and sleeve, and the circumferential positioning mode selects the key.

3.4.1 Design and Calculation of Shaft

The material used in this design shaft is 45 steel and is tempered. The stiffness of the shaft is the main consideration of the working capacity of the shaft, so the minimum diameter of the shaft must be calculated according to the size of the torsion strength of the shaft.

The formula for calculating the minimum diameter of a shaft is:

$$\mathrm{d}_{\min} = A_O \cdot \sqrt[3]{\frac{P}{N}} \tag{10}$$

Look-up table $A_0 = 126$;

There are known P=0.55kW, $\eta_{带} = 0.95$, N=600r/min

So , $\mathrm{d} \geq 126 \times \sqrt[3]{\frac{0.55 \times 0.95}{600}} \approx 12\mathrm{mm}$

Two keyways are set, and the diameter of the shaft is increased by 15%.

So $d \geq 11 \times (1+15\%) = 13.6mm$

Considering that the shaft is subjected to torque at the same time, the bending moment is smaller, and the d=18mm is taken at the end.

Primary bearing: because the shaft is mainly subjected to radial force during the operation, the axial force is relatively small, so the deep groove ball bearing is chosen. The check table selects the deep groove ball bearing 6205, its size is.

Structural design of shaft: right end of the first section is connected with chuck L = 40mm, d = 18mm; the second section is a period of adjustment from L = 50mm, d = 23mm; the third section is the shaft of rolling bearings and V pulley installation, the sleeve on the V pulley axial positioning, so the shaft length L = 80mm, d = 25mm; the fourth section design of shoulder location of L = 8mm, d = 30mm; the fifth section length is adjusted by the host box width, diameter d=25mm. The sixth section is designed for one axis shoulder structure: L = 8mm, d = 30mm; the last installment bearing, L = 15mm, d = 25mm.

So the structure of the shaft is preliminarily identified as shown in Fig. 3.

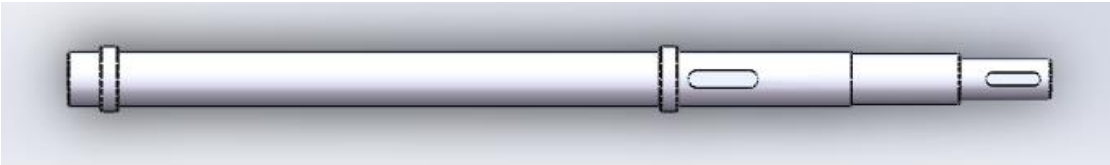

Fig. 3 A three-dimensional schematic diagram of the spindle

3.5 Selection of bearings

When choosing the bearing type, we should consider the following aspects: 1) the load of the bearing; 2) the speed of the bearing; 3) the aligning performance of the bearing; 4) the installation and disassembly of the bearing.

The design is selected for deep groove ball bearings, code code 6205. The bearing is mainly subjected to radial force in operation, but the axial force is relatively small. In the work, the axis deflection of the inner and outer rings is less than equal to 8 'to 16'.

3.6 Selection of Couplings

3.6.1 A Summary of Couplings

Coupling is widely used in various parts of mechanical transmission. Its main function is to transfer motion and torque, and sometimes it can be used as a safety device. When the machine runs, the two part of the coupling can not be separated. Only after the machine is stopped, the coupling of the coupling is disassembled, and the two axes can be separated.

3.6.2 The Selection Steps of the Coupling

The selection of the type of the coupling: according to the size of the two axis load, the speed of the two axes and the installation precision of the two parts which are connected to each other. The most suitable type of coupling is selected by consulting the different characteristics of the various kinds of couplings on the manual of mechanical design. The following factors should be taken into consideration when selecting a coupler:

(1) The size of the torque between the two axes and the function of buffer damping needs to be transmitted by the coupling.

(2) The speed of the working speed of the coupling.

The size of the relative displacement between the two axes of the coupling and the direction of the relative displacement.

(4) The reliability of the coupling and the working environment of the coupling.

Couplings in the manufacturing, installation, maintenance and cost of consideration.

Coupling torque calculation: as the machine is starting, the machine may be overloaded during the operation. So the maximum torque on the shaft needs to be used as the calculated torque T_{ca} of the axis. The calculated torque can be calculated by the formula (3-19).

$$Tca=KAT \tag{11}$$

In the formula, T is a nominal torque, the unit is N m, and K_A is the working condition coefficient.

Refer to the "mechanical design manual" shaft and the connecting piece separate table 15.1-2, because of changes in the work of the polishing machine when the torque is relatively small, and the original motivation for the motor, so we choose to work K_A is 1.3.

Determine the model of the coupling: according to the calculation torque T, the type of coupling type selection, and according to $T \leq [T]$.

The limiting condition also takes account of the installation position of the coupling at the shaft end of the motor. The final selection of the coupling is: the flange coupling GY5 in the rigid coupling, the J1 type in the axle hole, and the A in the keyway type.

Check the maximum speed of the coupling: the speed of the working state of the coupling is less than the maximum allowable speed of n_{max} for the selected coupler, that is:

$$n \leq n_{max}$$

The relevant information shows that the allowable speed of the flange coupling GY5 in the rigid coupling is [n] 8000 n/min, while the actual speed of the coupling is n = 1450n/min. Conform to the $n \leq n_{max}$ condition.

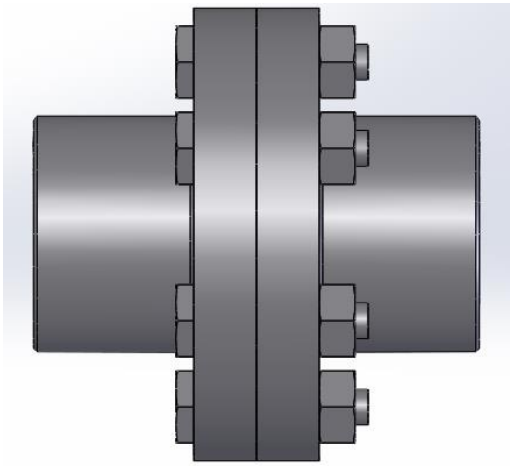

Fig. 4 The contour map of the flange joint GY5

3.7 Selection of Polishing Wheel

The design is to polish the outer circle of stainless steel pot with polishing wheel, because the polishing wheel is mobile, and the pot body is fixed, so the polishing wheel should not be too large. In the process of polishing, the longitudinal grinding method is used. The grinding wheel rotates the transverse longitudinal feed and the workpiece rotates in the reverse direction. After checking the relevant books, the design of the solid polishing agent for the use of green polishing paste, the selection of grinding wheel: 1-150 x 30 x 30-SA60L5B-35m/s.

3.8 Design of Guide Rail

The guide way is to realize the horizontal and vertical movement of the motor. On all kinds of machines, the moving parts need to move relative to the supporting parts, and the two contact parts are called guides.

After a variety of factors, the selection of TBS20, the axis diameter is 20mm, the length of the longitudinal guide is 340mm and 640mm, the length of the transverse guide is 940mm. The distance between the adjacent bolt holes on one side of the guide is 150mm, and the distance between the corresponding bolt holes on both sides is 40mm, and the three-dimensional diagram of the TBS20 guide is shown in Fig. 5.

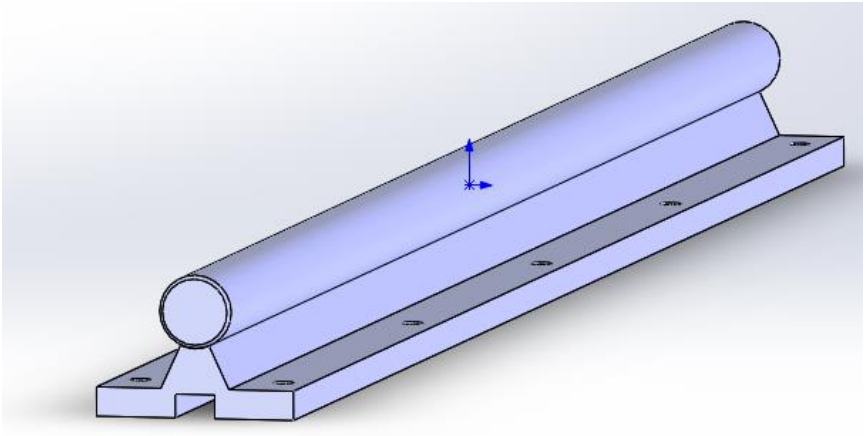

Fig. 5 Three dimensional sketch map of TBS20 guide rail

3.9 Selection of Cylinder

The standard cylinder should be chosen as far as possible. During the selection process, we should consider the following factors: the type of installation, the size of output force, the stroke of cylinder and the speed of cylinder.

The cylinder we choose is the 10Y-2 series cylinder of Guangdong Zhaoqing Fang Pneumatic Co., Ltd., and 10Y-2 series cylinders are divided into standard type, switch type, valve type and valve type switch type. The specific type of selection is the switch type 10Y-2R.

The main advantages of 10Y-2 series cylinder are: the parts are made of aluminum alloy, the quality is light, and the volume is small. The inner hole of cylinder tube is anodized, with good wear resistance and long service life. And the operation and maintenance is very convenient. The reference diagram of the 10Y-2 series cylinder is shown in Fig. 6.

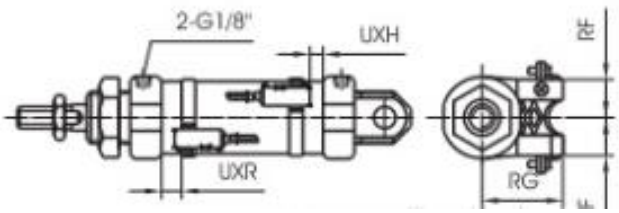

Fig. 6 Reference diagram of the shape of 10Y-2R cylinder

According to the size of the machine tool, the final designation of the longitudinal cylinder is 10Y-2R-32-125. Bore diameter 32mm, inner diameter of 10mm rod, the rear hole diameter 10mm, stroke is 125mm, the total length of 263mm. The transversal cylinder code is 10Y-2R-40-300. Bore diameter 40mm, inner diameter of 12mm rod, the rear hole diameter 12mm, stroke is 300mm, the total length of 438mm.

The pressure size is estimated by the following formula.

$$F_2 = \frac{\pi}{4}(D - \mathrm{d})^2 p\eta \tag{12}$$

The friction coefficient of the guide is 0.05, the cylinder 1 pushes the component to be about 100kg, and the cylinder 2 drives the component to be about 150kg. Finally, we get the required pressure P = 0.15MPa.

3.10 The Design of the Floor

The function of the floor is to install the motor and the guide rail to play the role of support. The main design floor is divided into the upper floor, the middle floor and the bottom floor, and their respective sizes are determined according to the actual requirements.

Upper floor: the length is 400mm, the width is 300mm, the thickness is 5mm. The upper floor is welded with two tables mounted on the motor, and the threaded holes are arranged according to the standard of the motor. Under the upper floor, four guide seats are welded to the fixed seat of the cylinder, and the distance between the guide seats is 275mm. The schematic diagrams are shown in Fig. 7 and Fig. 8.

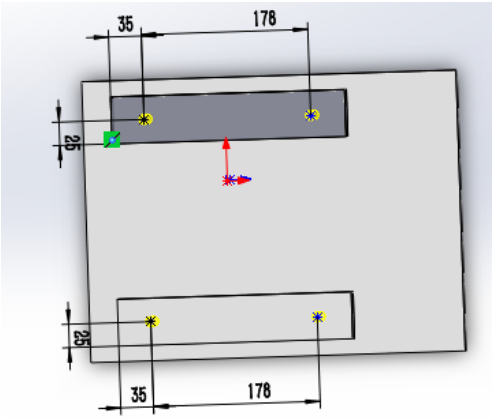

Fig. 7 Upper floor size diagram

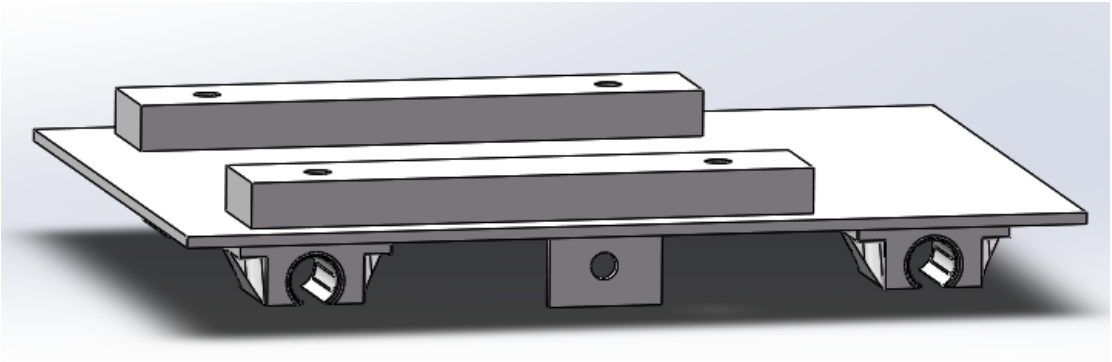

Fig. 8 Upper floor figure

Middle floor: the length is 500mm, the width is 500mm, the thickness is 5mm. The middle floor is made up of the screw hole according to the guide seat, and the fixed seat of the cylinder is welded. Under the middle floor, the screw nut needs to be installed, and four threaded holes are made. Four guide seats are welded under the middle floor, and the distance between the guide seats is 375mm. A schematic diagram is shown as shown in Fig. 9.

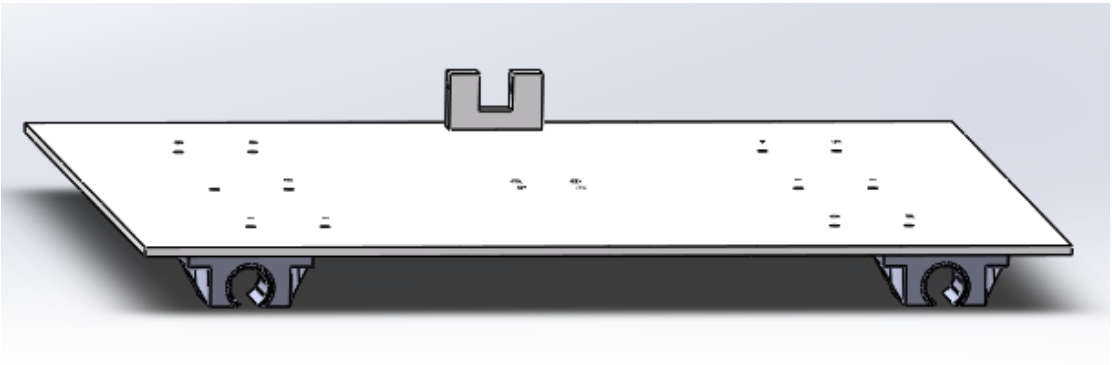

Fig. 9 Middle floor figure

Bottom plate: length 500mm, width 650mm, thickness 5mm. The upper part of the bottom plate is threaded holes based on the guide rail and the screw base. The four bottom rail seats and the cylinder fixed seat are welded on the bottom of the bottom plate, and the distance between the guide seats is 450mm. A schematic diagram is shown as shown in Fig. 10.

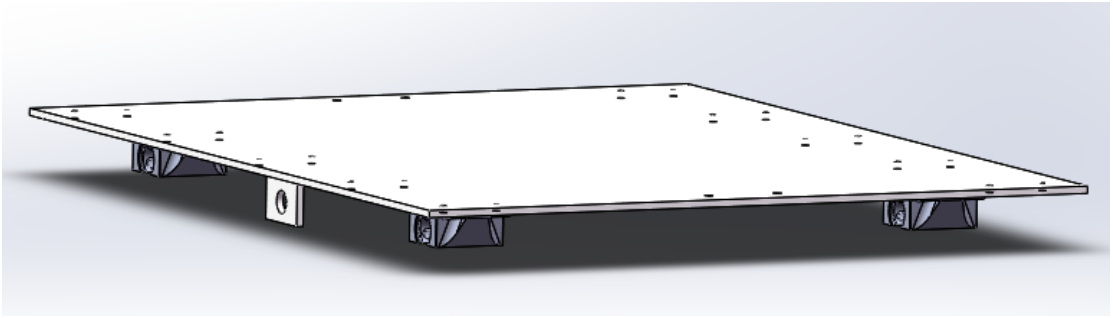

Fig. 10 Bottom plate figure

3.11 The Design of the Box

The bottom box is the most important supporting part of the main machine of the polishing machine. It supports all the components on the main engine. Besides, the box can also be used as a toolbox, which is convenient for storing some maintenance tools.

When designing the size of the box, it is necessary to meet the size of other parts, determine the size of the box, and design the height of the box according to ergonomics 1.2m. The wall thickness of the box is 3mm, and the wall thickness of the box on the box is 5mm.

Generally speaking, we increase the strength and stiffness of the way of increasing wall thickness, but a better way is to set up a floor. Because a rib when, can be very good to increase the strength and stiffness of the box. For welding parts, it is easier to get better welding quality if the wall of the box is thin. If the floor layout is not reasonable, so the actual effect will affect the floor, not only to increase the strength and stiffness of the role, and will be a waste of time and increase the quantity and difficulty of manufacturing the box. So we need a reasonable arrangement of ribs, rib in the right place to let play the biggest role.

The length and width of the box design high is 1600mm*700mm*1200mm, the box body with ribs improve the strength and rigidity of the box shape is shown in Fig. 11.

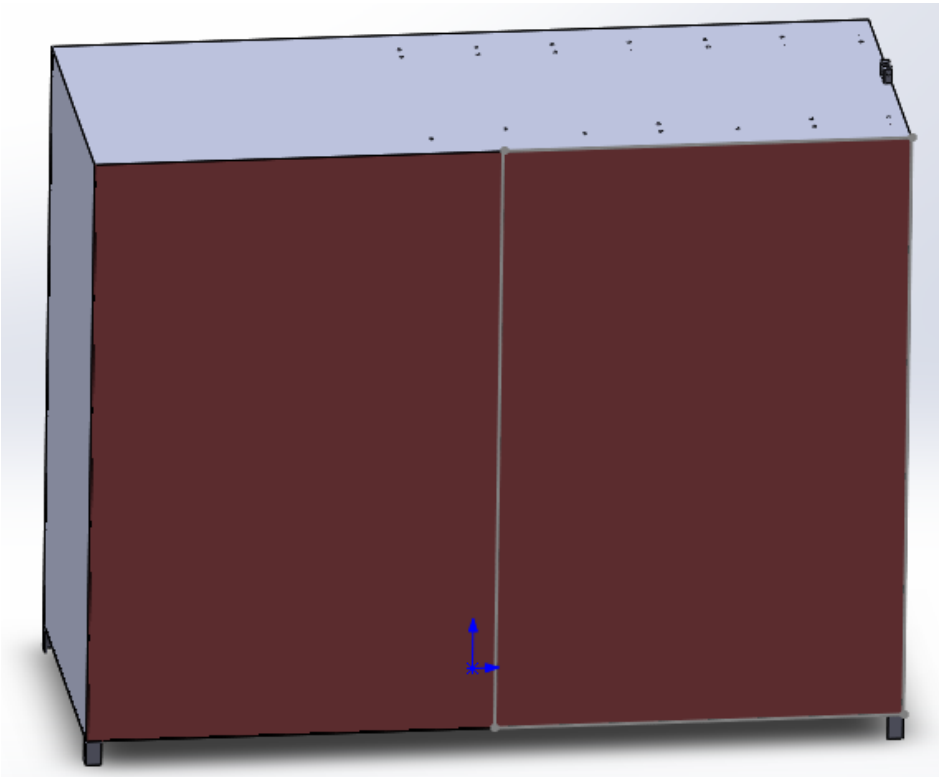

Fig. 11 Shape diagram of box

4. Conclusion

In this paper, on the basis of analyzing the polishing machine on the market, this semi-automatic stainless steel pan polishing machine is designed. This polishing machine can use screw adjustment of stainless steel pot processing of different diameter of pot, and the use of motor and pneumatic drive, not only high efficiency, simple structure and safe and reliable, has stable working condition, good machining quality, high machining efficiency.

The main work of this design is as follows:

1. Familiar with the working principle of the polishing machine and some main polishing methods, and make out the design scheme.

2. The connection method between the auxiliary motor and the worktable and the connection and transmission method between the main motor and the worktable are designed, and a reasonable scheme is designed, and the other mechanical institutions are designed in detail.

3. According to the design content and the main design parameters to carry out the calculation, the reasonable design or selection of the corresponding parts.

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