Structural Design of Steel Bar Bending Machine

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Abstract: In order to solve the current situation of the sharp increase of steel consumption in China, a steel bending machine with adjustable support is designed. This design selects a reasonable power source, and designs an efficient deceleration device and executive system. The design of reducer includes belt, gear, shaft and key; The executive system includes rotatable support block, lead screw, lead screw base, bending core, working disc and other parts; and the working performance of the important parts inside the bending machine is analyzed. This design can control the bending speed at 20 meters per minute and the bending diameter at Φ18mm~Φ28mm.

1. Introduction
At present, with the substantial growth of the real estate industry, followed by the rapid development of the construction industry, the current situation of the construction industry is that more and more reinforcement is used. After field investigation, most of the steel bars are now used by steel bar bending equipment. In China, the development of bending machine, although there is a little gap between foreign technology, but through the strong support and rapid development of industry in China, China has also produced more advanced bending machines in recent years. For the bending system with special process, China can also process it efficiently and quickly through a series of automation equipment.

2. Working principle and scheme of steel bending machine

2.1. Working principle
The purpose of this paper is to design the structure and optimize the system of the existing steel bar bending machine[1]. In addition, the main key parts of the steel bar bending machine are designed. The technology of the original steel bar bending machine is improved, which has the characteristics of large diameter range of steel bar bending arc, large bending radius and high efficiency[2]. The motor is used to provide the power system, and the corresponding reducer is configured to complete the related functions of adjustable speed. It is suitable for completing a variety of different shapes of steel structures.

In fact, the bending machine is a work plane that rotates the steel bar in a plane. As shown in Fig. 1 schematic diagram of steel bar bending machine, the rotatable support block is adjusted by the lead screw, so as to reduce the distance between the replaceable central pin and the steel bar. When the working disc rotates, the bending pin on the disc will also rotate to press the steel bar to achieve the purpose of the final steel bar.
2.2. Technical parameter
Diameter range of round steel bending arc of reinforcement $\Phi 18mm \sim \Phi 28mm$; Bending arc radius $\geq 50mm$; Bending speed is $20m/min$; The bending force is $2500N$; Matching power YE3-100l-6 motor, rated power is $1.5kW$, speed is $920r/min$; The rotating speed of disc is $21r/min$.

3. Key parts design

3.1. Transmission design

3.1.1 Belt drive design
Considering the need of smooth transmission, vibration absorption, overload and slipping, V-belt transmission is selected. Through design and calculation, three A-type V-belts are selected, and the transmission ratio is four.

3.1.2 Reducer design
(1) Transmission gear
The gear parameters obtained by calculation and check are shown in table 1 and table 2:

| Parameter                  | Symbol | Pinion | Rack wheel |
|----------------------------|--------|--------|------------|
| Number of teeth            | $z$    | 19     | 75         |
| Pitch circle diameter      | $d$    | 57     | 225        |
| Tooth width                | $b$    | 65     | 57         |
| Center distance            | $a$    | 141    | 141        |

Table 2 Parameter table of counter shaft pinion and low speed shaft pinion

| Parameter                  | Symbol | Pinion | Rack wheel |
|----------------------------|--------|--------|------------|
| Number of teeth            | $z$    | 30     | 83         |
| Pitch circle diameter      | $d$    | 180    | 498        |
| Tooth width                | $b$    | 186    | 180        |
| Center distance            | $a$    | 339    | 339        |

(2) Parameters of each axis
According to the calculation of the minimum shaft diameter, the parameters of each shaft are obtained, and the calculation and simulation results meet the design requirements.
Table 3 High speed shaft parameters

| Dimension parameter | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ |
|---------------------|---|---|---|---|---|---|---|---|
| Diameter            | 25 | 30 | 33 | 50 | 60 | 45 | 33 | 30 |
| Length              | 48 | 50 | 16 | 180| 10 | 63 | 9  | 30 |

Table 4 Intermediate shaft parameters

| Dimension parameter | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
|---------------------|---|---|---|---|---|---|---|
| Diameter            | 30 | 33 | 60 | 80 | 60 | 33 | 30 |
| Length              | 20 | 10 | 184| 20 | 57 | 13 | 20 |

Table 5 Low speed shaft parameters

| Dimension parameter | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ |
|---------------------|---|---|---|---|---|---|---|---|
| Diameter            | 60 | 66 | 70 | 90 | 70 | 66 | 60 | 40 |
| Length              | 30 | 6  | 180| 20 | 70 | 8  | 22 | 60 |

3.2. Executive system design

3.2.1 Design of rotatable support block

The rotatable support block is mainly composed of turntable handle, turntable, lead screw, lead screw nut, lead screw base, connecting seat, pin, support block, rotating shaft etc. The main purpose of this device is to adjust the rotation position of the support block according to different bending core diameter, so that different steel bars can bend different bending arcs. If the device is operated manually, it only needs to be reasonably designed to ensure that it can rotate under the lead screw in and out.

As can be seen from the following figure, designing a slot can change the in and out linear movement of the lead screw into the rotation of the support block.

![Graphic model of rotating support block](image1)

![Analysis diagram of support block](image2)

According to the above analysis, the stress of the support block is concentrated on the edge. It can be seen from the figure that most of the stress on the part is within the scope of safety permission, so the design of the part meets the requirements.

According to the size of the reserved space of the worktable, the length of the screw rod is designed as l=235mm. Through the actual rotation demonstration of the three-dimensional diagram, its range is d=100mm. When the radius of the required arc is r≥150mm, the formula can be used:\[^3\]:

\[
S = d + r = (0 \sim 100) + (150 \sim d_{\max})
\]

According to the size of the maximum bending core of the national standard steel bar bending and the size of the actual design working disc, the maximum bending core diameter is 256.
3.2.2 Design and analysis of disk

The bending disc is mainly used to place the steel bar, and the bending core of different specifications can be placed in its center. Its material is steel grade 45, then quenched and antirust treated to make its rigidity and hardness meet the requirements [4].

The main structure is that a large hole diameter is set in the center of the disc to make it fit with the bent core. Around the big hole is the installation position of two circles of partial bending gear rod.

According to the requirements of the specification, the bending radius \( R \geq 150 \text{mm} \) can be completed, and the bending core range of HRB400 and HRB500 steel bars is \( 72 \text{mm} \sim 256 \text{mm} \) in the range of \( 18 \text{mm} \sim 28 \text{mm} \). Not exceeding the design requirements of 300mm arc diameter. Therefore, the design diameter and bending of the product can meet the design requirements.

According to the above analysis, the stress of the disc is concentrated on the central edge, and it can be seen from the figure that most of the stress on the part is within the scope of safety permission, so the design of the part meets the requirements.

3.2.3 Design and analysis of bent core

The function of bending core is mainly to bind the bending steel bar to make the steel bar reach the bending diameter required by the standard [5]. Setting bent core, on the other hand, also achieves the purpose of saving materials. Using common bent core, its diameter is \( \Phi = 24 \text{mm} \). For bent cores larger than 24mm in diameter, a hole with a diameter of \( \Phi = 24 \text{mm} \) is drilled in the center. In this way, a common bending core with a diameter of 24mm is saved for each bending core. The general structure is shown below:
According to the above analysis, the stress of the bent core is concentrated on the central edge, and it can be seen from the figure that most of the stress on the part is within the scope of safety permission, so the design of the part meets the requirements.

3.2.4 Design and analysis of bent core seat

According to the functional requirements of the bent core seat, the seat is connected to the disc position by the key, and the flat key is added at two symmetrical positions, so that the torque is not only concentrated on one key, which improves the practicability[6].

The design parameters are as follows:
1. Diameter setting \( d = 90\text{mm} \).
2. Its length is superimposed according to the length of other parts to form \( L=97\text{mm} \).

There is a core bending hole with diameter of 53mm and depth of 35mm.

Check the mechanical design manual to select 25mm×14mm, shaft depth 9mm, hub depth 5.4mm. Through the above design, the key should connect a cushion block 30mm and a turntable 40mm, so the length of the key is set as the thickness superposition of two parts, and the length of the key is 70mm.

In order to meet the requirements of torque transmission at the output shaft, two flat keys are arranged 180 degrees, as shown in Figure. The key is of non-standard design. In order to fit the thickness of the shaft, the key is reduced by 2mm and the designed shaft depth is 5mm.
According to the above analysis, the stress of the bent core seat is concentrated on the central edge, and it can be seen from the figure that most of the stress on the part is within the scope of safety permission, so the design of the part meets the requirements.

4. Conclusion
Through the research and investigation on the development of steel bar bending machine at home and abroad, combined with the characteristics of threaded round steel, to ensure that on the basis of fully meeting the requirements of modern steel bar bending machine, this steel bar bending machine is designed for the purpose of reducing cost and miniaturization. This design mainly realizes the bending of a variety of steel bars and bending diameters.

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