

Research on a new wire feeder with automatic braking feature

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Aiming at the shortcomings of the existing wire feeders, in this paper we design a new wire feeder which adopts pneumatic brake and new design of shafting to achieve the function of prompt braking which could significantly improve the security and reduce the labor intensity of workers. We also simulated the important components of the wire feeder, the simulation results show that the new wire feeder completely comply with the design requirements.

Keywords: wire feeder; prompt braking; simulation

1. Introduction

Polygonal reinforcing cage seam welder which has been widely used in many large projects is a high efficiency, high quality, high-technology construction equipment. It has already obtained good economic benefit and greatly saves labor and material for the users. In the polygonal reinforcing cage seam welder design and development process, according to the design requirements, it is necessary to design a new wire feeder to transport rebars to the polygonal reinforcing cage seam welder to weld reinforcing cage.

Existing wire feeders have some technical flaws which lead to low safety coefficient, poor stability and reliability. For example, in order to transport the rebars of $\phi 5\text{mm}$ and over 2 tons, the common method is that installing a bearing into the material salver. External traction pulls the rebars and drives the material salver [1,2].

In the practical application, because of the cease or suddenly disappear of the external traction, the material salver could not stop automatically and rotates with rebars which is easy to damage the equipment or hurt the workers [3]. For those wire feeders without brake apparatus, because of their own inertia, the material

salver which is used to place the rebars still rotates after the reinforcing cage seam welder stopped to work, workers have to brake the material salver by their feet which easily happens safety accident [4]. Other wire feeders brake the material salver by adopt cylinder to push the brake pads to rub the principal axis. However, the braking time of this method is too long and the brake effectiveness is pretty poor. Because of the terrible working conditions, impurities such as dust easily enter into the important components such as bearing, which could shorten the service life of the equipment [5].

Existing wire feeders adopt two bearings to load the material salver, the conical roller bearings place at the top of the axis of rotation which are used to bear the inferior radial force the thrust ball bearing placed at the bottom of the principal axis is used to bear the weight of the whole roll of the rebars. The minimum space between the axle sleeve and the principal axis is 2 mm and the bottom of the axle sleeve and the principal axis do not have a supporting structure to bear the inferior radial force. During the using process we found that the material salver has certain transient impact and rotation when the whole roll of rebars is placed on it.

The friction is generated between the principal axis and the axle sleeve because it is scarcely possible to ensure the coaxiality between the two parts when the polygonal reinforcing cage seam welder is working. The bearing life greatly reduces and the rotation of the bearing is not flexible which causes the material salver rotates roughly [6].

So how to solve the technical flaws existing in the existing wire feeders is a crucial technical problem. Aiming at the shortcomings of the existing wire feeders, in this paper we design a new wire feeder which adopts pneumatic brake and new design of the shafting to achieve the function of prompt braking.

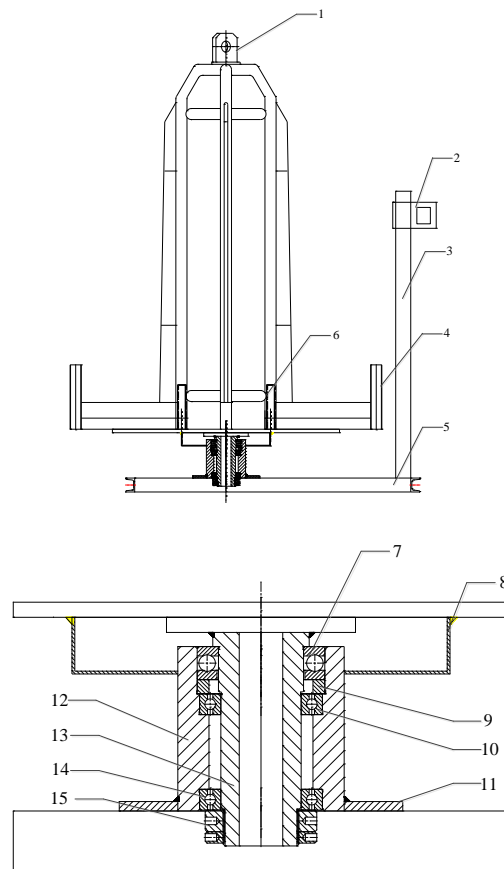
2. Composition of the Equipment

As shown in fig.1, the wire feeder consists of lifting hook, wire feeding throat, pillar, material salver, thrust ball bearing, dust cap, sleeve, first angular contact bearing, bearing pedestal, bearing pedestal base, second angular contact bearing, principal axis, position limiting device, foundation bed and brake apparatus.

The top and bottom of the material salver connect with the lifting hook and the principal axis respectively. The thrust ball bearing, the first angular contact bearing and the second angular contact bearing are sleeve-jointed in sequence on the principal axis. The sleeve is mounted between the thrust ball bearing and the first

angular contact bearing. The second angular contact bearing is mounted at the bottom of the bearing pedestal and the top of the position limiting device.

In order to ensure that the material salver could run smoothly, in this paper we adopt one thrust ball bearing and two angular contact bearings. The first angular contact bearing and the second angular contact bearing are used to bear the capsizing moment when the material salver rotates to achieve the purpose of flexible rotation. The thrust ball bearing placed at the top of the principal axis is used to bear the weight of the whole roll of the rebars.



1. Lifting hook, 2. Wire feeding throat 3. Pillar 4. Material salver 5. Foundation bed 6. Welding lath 7. Thrust ball bearing 8. Dust cap 9. Sleeve 10. First angular contact bearing 11. Bearing pedestal base 12. Bearing pedestal 13. Principal axis 14. Second angular contact bearing 15. Limit device
Fig.1 the composition of the equipment

It is obvious that this kind of design scheme could avoid the design flaw that there is no supporting structure at the bottom of the principal axis and ensure that the wire feeder rotates smoothly and performs reliably.

The lifting hook is used to sling the material salver and it is convenient to move or break down the wire feeder.

Because of the poor working conditions of the wire feeder, it is necessary to design a dust cap to prevent the impurities such as dust from entering the bearings and other important components.

In order to avoid the phenomenon that the material salver overturns when the rebars are placed on it, we adopt quadrate foundation bed which made of box iron. The foundation bed is designed to prevent the dumping phenomenon and provide enough installation space and location for the brake apparatus.

The bearing pedestal base welded on the center of foundation bed could ensure that the bearing pedestal and the foundation bed are welded firmly.

The brake apparatus could break the wire feeder timely when the external traction is withdrawn or the rebar is suddenly broken during the process of conveying the rebars to the reinforcing cage seam welder which is easy to damage the equipment or hurt the workers.

The brake apparatus of the wire feeder is mainly composed of air cylinder or electromagnetic clutch. Comparing with electromagnetic clutch, air cylinder has many advantages when it is used for wire feeder, for example

- 1) The principle and construction of air cylinder are simple and it is easy to be installed and maintained, so the user's requirements are not high.
- 2) Air cylinder is well-adapted with the functions of strong water-proof and dust-proof. It could normally work in relatively tough environments, such as high and low temperatures.
- 3) The output force of air cylinder is enough to brake the wire feeder.

3. The Working Principle of Equipment

The reinforcing cage seam welder pulls the rebars and drives the material salver and bearings rotating around the principal axis. At the end of the wire feed, press the stop switch and then PLC controller sends an output control signal to the solenoid valve through the EtherCAT connector. The solenoid valve drives the air cylinder stretching out into the material salver to stop it. The flow chart, the LAD and the hydraulics and pneumatics systems principle drawing of the wire feeder are respectively shown in fig.(2), fig.(3) and fig.(4)

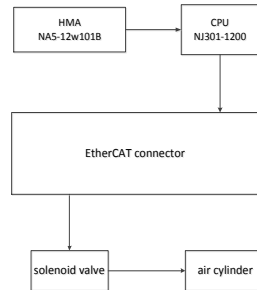


Fig. 2. The flow chart of the wire feeder

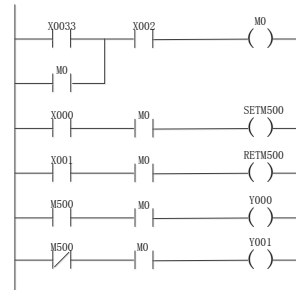


Fig. 3. The LAD of the wire feeder

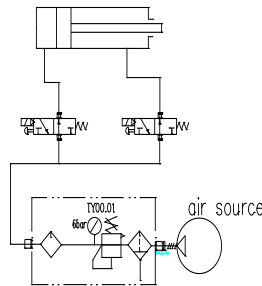


Fig.4. the hydraulics and pneumatics systems principle drawing of the wire feeder

4. Important Components

Bearing is an important supporting part in all kinds of devices, it is used to support the axis and the components on the axis to keep the rotation accuracy of the axis and reduce the abrasion between the axis and the supporting. Rolling bearings which have small friction resistance, high mechanical efficiency are widely used in the design and maintenance of the mechanical equipment, they are convenient for lubrication and maintenance and have been standardized. The angular contact ball bearing can bear radial load and axial load at the same time, so it is frequently used in the construction machinery which bears the axial force.

The inner ring of the angular contact ball bearing rotates relative to the outer ring when the angular contact ball bearing is working and the rolling elements rotate along with the inner ring. The contact points between the inner ring and the rolling elements continually change periodically. It is necessary to make calculations of the angular contact ball bearing according to the working conditions.

In this paper we choose the angular contact ball bearing 7017AC. According to the GB/T301-1995, we could get its specific data $d = 85\text{mm}$, $D=130\text{mm}$, $B=22\text{mm}$, $z=17$.

The specific value of the radial load F_r and the axial load F_a is

$$\frac{F_a}{F_r} = \frac{2700}{230} = 11.74 \quad (1)$$

$$\frac{F_a}{F_r} > e \quad (2)$$

For the angular contact ball bearing 7017AC, $X=0.44$, $Y=1.327$, $f_p=1.5$ [7]. So the equivalent dynamic load

$$P = f_p (XF_r + YF_a) = 1.5 \times (0.44 \times 230 + 1.327 \times 2700) = 5526.15\text{N} \quad (3)$$

The basic dynamic load rating

$$C = P \sqrt[6]{\frac{60nL_h'}{10^6}} = 30500\text{N} \quad (4)$$

The rated speed of the angular contact ball bearing $n=10\text{r/min}$. So the service life [8]

$$L_h = \frac{10^6}{60n} \left(\frac{C}{P} \right)^6 = 52860.78\text{h} \quad (5)$$

By above equations we prove that angular contact ball bearing conform to the specifications and design requirements.

The design of the axial contact ball bearing makes it has high capability of bearing thrust load. The axial contact ball bearing consists of ferrules and the rolling elements.

The thrust ball bearing bears axial force and supports the weight of the whole material salver.

In this paper we choose the thrust ball bearing 51218, according to the GB/T301-1995, we could get its specific data, $d=90\text{mm}$, $D=135\text{mm}$, $T=35\text{mm}$, $d_1=93\text{mm}$, $D_1=135\text{mm}$, $D_w=17.5\text{mm}$, $z=17$.

If $D_w \leq 25.4$, $\alpha=90^\circ$, then the dynamic load rating [9]

$$C_a = b_m \times f_c \times \frac{Z^2}{3} \times D_w^{1.8} \quad (6)$$

Query the rolling bearing samples we could get that $b_m=1.3$, $f_c=102.9$. So

$$\begin{aligned} C_a &= b_m \times f_c \times \frac{Z^2}{3} \times D_w^{1.8} \\ &= 1.3 \times 102.9 \times \frac{17^2}{3} \times 17.5^{1.8} = 152 \text{KN} \end{aligned} \quad (7)$$

The rated load of the wire feeder is 3 tons. So the dynamic equivalent axial load [10]

$$P_a = F_a = 3000 \times 9.8 = 29.4 \text{KN} \quad (8)$$

$P_a < C_a$. So the rated life of the thrust ball bearing

$$L_{10} = \left(\frac{C_a}{P_a} \right)^3 = \left(\frac{152}{29.4} \right)^3 = 1.53 \times 10^{11} r \quad (9)$$

The rated speed of the thrust ball bearing $n=10\text{r/min}$. So the service life

$$L_h = \frac{10^6}{60n} \left(\frac{C}{P} \right)^{\epsilon} = 25500h \quad (10)$$

By above equations we prove that the thrust ball bearing conforms to the specifications and design requirements

It is necessary to analyze and simulate the important components of the wire feeder to check their yield strength and stiffness to ensure that the wire feeder could normally work.

The principal axis is constructed of 45°. The top of the principal axis supports the weight of the material salver and rebars. Through the analysis of stress result as shown in fig. (5), we could get that the maximum value of the stress is 2.52×10^7 N/m² which is smaller than the yield stress of material which is 3.55×10^8 N/m² and satisfy the strength requirements.

Through the analysis of stress result as shown in fig. (6) we could get that the maximum value of the strain is 3.92×10^{-7} N/m² which is smaller than the yield stress of material which is 3.55×10^8 N/m² and satisfy the strength requirements.

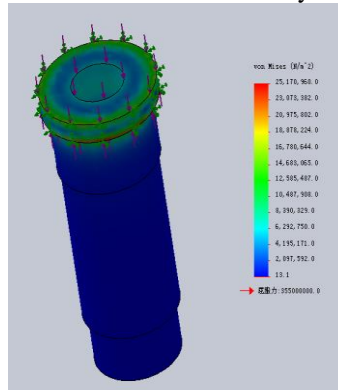


Fig.5 the analysis of stress result for the principal axis

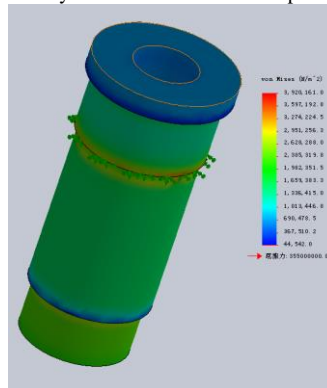


Fig.6 the analysis of strain result for the principal axis

The bearing pedestal is constructed of Q235 and bears over 3 tons. The top of the bearing pedestal supports the thrust ball bearing, the material salver and rebars. Through the analysis of stress result as shown in fig. (7) We could get that the maximum value of the stress is $2.55 \times 10^7 \text{ N/m}^2$ which is smaller than the yield stress of material which is $2.35 \times 10^8 \text{ N/m}^2$ and satisfy the strength requirements.

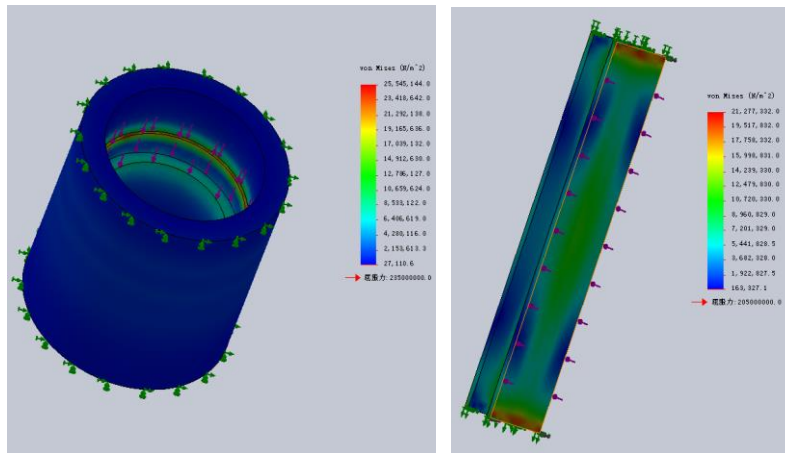


Fig.7 the analysis of stress result for the bearing pedestal; Fig.8 the analysis of stress result for the material salver

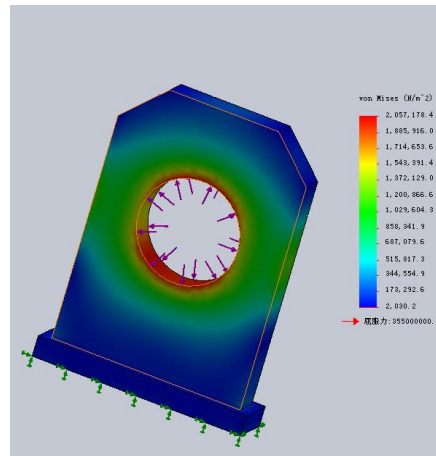


Fig.9 the analysis of stress result for the lifting hook

The material salver constructed of Q235 supports the rebars which is over 3tons. Through the analysis of stress result as shown in fig. (8) We could get that the maximum value of the stress is 2.13×10^7 N/m² which is smaller than the yield stress of material which is 2.05×10^8 N/m² and satisfy the strength requirements.

The lifting hook which is constructed of Q235 is used to sling the material salver which is about 100 kg. Through the analysis of stress result as shown in fig. (9) We could get that the maximum value of the stress is 2.06×10^7 N/m² which is smaller than the yield stress of material which is 3.55×10^8 N/m² and satisfy the strength requirements.

5. Conclusion

In this paper we design a new wire feeder which adopts pneumatic brake and new design of shafting which is used to ensure that the material salver could run smoothly and achieve prompt braking which could significantly improve the security and reduce the labor intensity of workers. We also simulate the important components of the wire feeder and the results show that the design and the material comply with the design requirements.

Acknowledgment

The authors declare that there is no conflict of interests regarding the publication of this paper.

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