# Design of Partial Structure of Bridge Crane

Haichao Cui, Yang Liu, Shuai Hu, Sheng Liu

College of Mechanical and Electronic Engineering,Shandong University of Science and Technology, Qingdao, 266590, China.

## Abstract

According to the basic working principle of the crane hoist mechanism, the driving scheme of the sub-hoisting mechanism is determined, and then the transmission device of the sub-hoisting mechanism is designed. Then, the sub-hoisting mechanism of the sub-hoisting mechanism is designed. Design and determine the hook group, reel, motor, reducer and other components. In this paper, the structure of the crane crane is more reasonable, the operation is more convenient, the quality and safety are further improved.

## Keywords

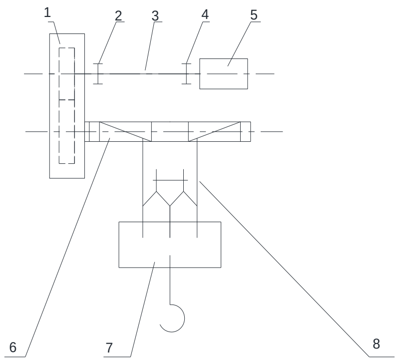
Crane; bridge crane; hoisting mechanism; deputy hoisting mechanism.

## 1. Introduction

Overhead traveling crane is hoisting equipment, widely used in factories, ships and other industries to transport steel and other production materials. At this stage, the extensive use of cranes further improves the work efficiency and plays an irreplaceable role in handling in a fixed range. Bridge cranes, which are mainly responsible for loading and unloading in factories, ships and other industries, are indispensable. With the continuous expansion of production scale, the application of crane is becoming more and more extensive, and crane has become an indispensable part in the process of mechanization and automation.

The main structures of overhead traveling cranes are six parts: lifting trolley, bridge frame, cart operation mechanism, wheel, track and driver's cab.The lifting trolley consists of three parts: horizontal running mechanism, lifting mechanism and small frame. The horizontal running mechanism makes the lifting trolley moving horizontally on the bridge. The lifting mechanism drives the lifting of the goods, and the small carriage is the working platform of the horizontal running mechanism and the lifting mechanism .The lifting mechanism is composed of the main lifting mechanism and the auxiliary lifting mechanism; the lifting cargo is heavier and the main lifting mechanism is used. When the lifting cargo is lighter, the lifting mechanism of the lifting weight used in this paper is lifted; the running mechanism of the big car drives the wheels under the bridge to carry the bridge along the track.The bridge of the overhead traveling crane is composed of main girder and end beam, and the main girder has two modes: single beam and double beam.The lifting mechanism of bridge crane is composed of wire rope, drum, motor, reducer, gear coupling, brake wheel brake and hook group.

There are two ways to install the reel. The first way of installation is that one end of the drum is connected with the low speed shaft of the reducer through a special coupling, and the other end is supported on a tapered roller bearing.The second installation methods are installed directly on the low speed shaft of the rigid roller reducer, and the reducer is installed on the cutter shaft, which can avoid the load and deformation of the small frame, and the rolling bearing adopts self sliding bearing.Because of the second installation methods, the output shaft of the reel and the reducer is directly installed together, and this method allows the axial movement, and the structure is simple and convenient for maintenance. So, choose second ways.




1- gear deceleration period; 2- half toothed coupling with brake wheel; 3- high speed floating shaft; 4- ordinary half toothed coupling; 5- motor; 6- drum.

7- hook group; 8- wire rope

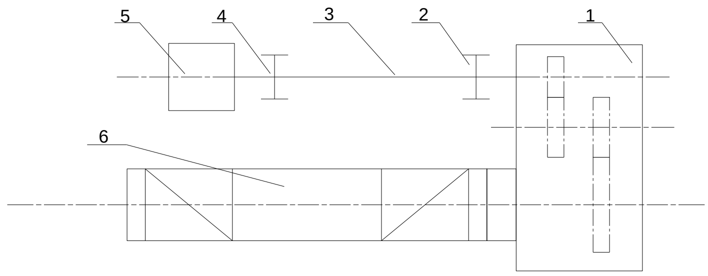
Figure 1.Brief diagram of lifting mechanism of bridge crane

## 2. The Concrete Design of the Lifting Mechanism of the Bridge Crane

### 2.1 Determine the Transmission Device

Because the lifting height, speed and quality of the crane are different, different crane uses different transmission methods, and the transmission mode of the two lifting mechanism of the bridge type crane generally adopts the gear transmission. And the gear transmission mainly has two kinds of transmission methods: closed gear drive and open gear transmission.

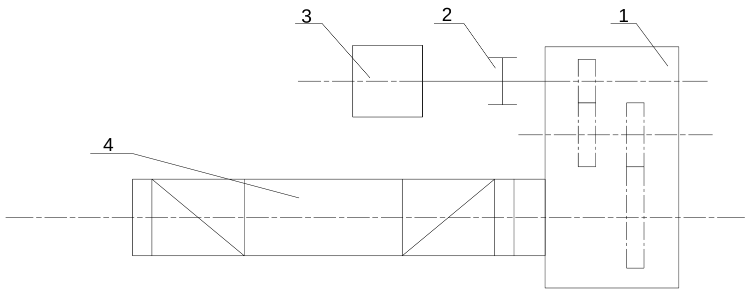
Referring to the crane design manual, it is found that the driving mechanism of a bridge crane (small or medium bridge crane) with a faster lifting speed uses a closed transmission gear (a standard cylindrical gear reducer), and the driving mechanism of a slow lifting bridge type crane (large or super large crane) is used for opening. Type gear drive.On the basis of the above, the closed gear transmission is selected.For example, the radial deviation of the allowable angle and a simple intermediate axis is called the high speed floating axis, and the high speed floating shaft allows a certain installation error, so the floating shaft should not be too short (> = 500mm); and because the high speed floating shaft has a certain length, it is more convenient to remove or repair the parts.The reducer is connected with a high-speed floating shaft through a half toothed coupling with a brake, and the motor is connected with a high-speed floating shaft through a common half toothed coupling.s shown in Fig.3, the elastic pin coupling is used between the motor and the coupling, which requires higher installation requirements and is not easy to adjust and maintain.In figure 2, a high-speed floating shaft is used to connect the two couplings, and the high-speed floating shaft is finally selected by figure 2-1a. Some installation errors are allowed, and installation and maintenance are more convenient, so choose the transmission device of figure 2.




1- cylindrical gear reducer; 2- half toothed coupling with brake; 3- high speed floating shaft;

4- ordinary half toothed coupling; 5- motor;

Figure 2. A drive equipped with a high speed floating shaft




1- cylindrical gear reducer; 2- elastic pin coupling; 3- motor; 4- drum.

Figure 3. Ordinary transmission

### 2.2 Design of a Reel

If the crane requires a compact and beautiful appearance and a high demand for work, it can be arranged and installed on the coaxial line of the power shaft and the reel group, and the planetary gear reducer is installed inside the reel, so that the arrangement makes the shape compact and lighter.According to the difference of wire rope winding in the upper number of the roller, it can be divided into single layer winding reel and double layer winding reel; according to the difference of winding wire rope on the roller, it can be divided into single coil and double coils. The double pulley block has two threads at both ends of the drum.When using single layer winding, use the threaded reel with it. When using double winding, use the light reel to match it, keep the height allowance of 1 to 1.5 times the diameter of the wire rope on both sides of the drum to prevent the rope from falling off the drum. When double layer winding is used, the wire rope is worn out, so the double layer winding is suitable for crane with slow speed or low working type and high lifting height.Gray cast iron is used as a roller for making material, usually not less than HT-200 (minimum tensile strength 200MPa). If the crane has higher requirements for the drum, it is made of gray iron or high strength cast iron. The welding drum is made of Q235 after bending and welded together, and the quality is light.

The material used in this paper is HT-200, single layer winding and double drum (as shown below).

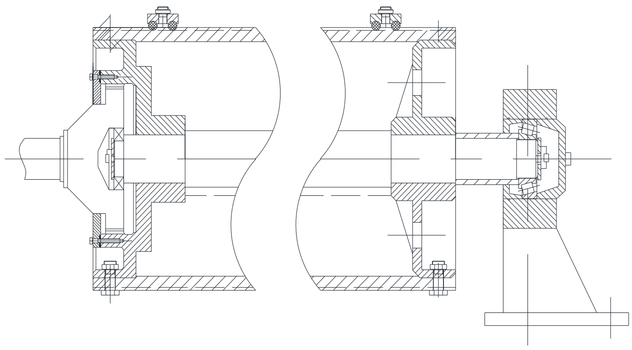


Figure 4. Single Winding, Double Coiling

### 2.3 Design and Calculation of a Reel

（1）The value of the reel:

$$\begin{aligned} D &\geq e \times d \\ &\geq 25 \times 14.5 \\ &\geq 362.5mm \end{aligned} \tag{1}$$

$D$ ——Diameter of a reel, D=400mm;

$e$ ——Work type coefficient, $e = 25$;

$d$ ——Radius of selected wire rope, $d = 14.5$.

Nominal diameter of a ree: $D_0 = D + d = 400 + 14.5 = 414.5mm$

(2)Reel groove calculation:

Groove radius: $R = (0.54 \sim 0.6)\ d = 7.83 \sim 8.7mm$

Groove depth (standard slot): $C_1 = (0.25 \sim 0.4)\ d = 3.6 \sim 5.8mm$

Slots pitch : $t_1 = d + (2 \sim 4)\ d = 16.5 \sim 18.5mm$

Reel groove size $R = 8mm$; $t_1 = 16mm$; $C_1 = 4.5mm$.

Determine the length of the drum and check it:

Double couplet

$$\begin{aligned} L &= 2(L_0 + 4t) + L_3 \\ &= 2(H_{max} \times i_h / \pi \times D_0 + n + 4)\ t + L_3 \\ &= 2(16 \times 10^3 \times 2 / 3.14 \times 414.5 + 2 + 4) \times 16 + 185 \\ &= 1163.8mm \end{aligned}$$

$L$ ——The length of a double couplet;

$H_{max}$ ——Maximum lifting height, $H_{max} = 16m$;

$n$ ——Number of additional security rings, $n = 2$;

$t$ ——Slots pitch, $t = 16mm$;

$L_0$ ——Winding length, $L_0 = (\frac{16 \times 10^3 \times 2}{3.14 \times 414.5} + 2) \times 16 = 425mm$;

$L_3$ ——The length of the middle part of the double reel does not cut, $L_3 = 185mm$;

$D_0$ ——Nominal diameter of a reel, $D_0 = 414.5mm$.

Selection L=1500mm, Grey cast iron is used in reel material.Look up the design of the crane course [table 2-12],uts $\sigma_1 = 195MPa$ ,Compression $\sigma_{by} = 3\sigma_1 = 385MPa$ .Its wall thickness can be formulated by formula: $\delta = 0.02D + (6 \sim 10) = 14.29 \sim 18.29mm$, $\delta = 16mm$.

(4) Pressure stress of the wall of a drum:

$$\begin{aligned} \sigma &= \frac{S_{max}}{\delta \times t} \\ &= \frac{2.06 \times 10^4}{16 \times 16} \\ &= 80.5MPa \end{aligned} \quad (2)$$

The maximum static tension of a wire rope $S_{max} = 2.06 \times 10^4 N$;

$\delta$ ——Drum wall thickness $\delta = 16mm$;

$t$ ——Reel grooves $t = 16mm$.

Due to permissible pressure $[\sigma] = \frac{585}{5} = 117MPa$ , So $\sigma = 80.5MPa < [\sigma]$, So the strength is enough.

(5)Checking calculation of tension stress of drum:

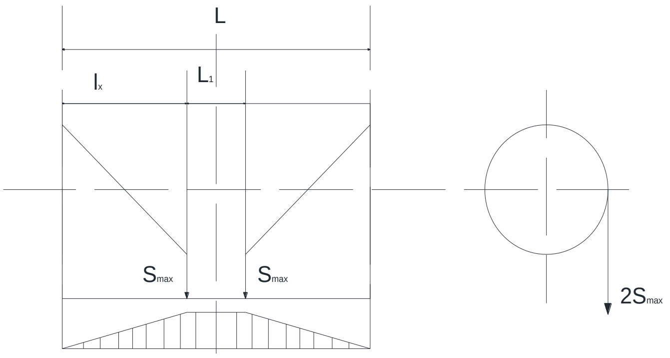



Figure 5.Drum bending moment diagram

When the drum is $L > 3D$:

$$\sigma_L = \frac{M_W}{W}$$

When the drum works normally, the maximum bending moment occurs in the center of the drum:

$$\begin{aligned} M_W &= S_{\max} \times L_1 \\ &= S_{\max} \times \left(\frac{L - L_3}{2}\right) \\ &= 2.06 \times 10^4 \times \left(\frac{1500 - 185}{2}\right) \\ &= 13544500 N \cdot mm \end{aligned} \quad (3)$$

$L$ ——Reel length,L=1500mm;

$L_3$ ——The part length of the uncut slotting of the reel , $L_3 = 185mm$

$S_{\max}$ ——The maximum static tension of a wire rope $S_{\max} = 2.06 \times 10^4 N$ .

(6) Section coefficient of reel:

$$\begin{aligned} W &= 0.1 \times \frac{D^4 - D_1^4}{D} \\ &= 0.1 \times \frac{400^4 - 368^4}{400} \\ &= 181510 mm^3 \end{aligned} \quad (4)$$

$D$ ——Drum outer diameter, $D = 400mm$;

$D_1$ ——Inner diameter of drum, $D_1 = D - 2\delta = 368mm$.

$\therefore \sigma_L = \frac{M_W}{W} = \frac{13544500}{1815100} = 7.46MPa$ .

(7) Synthetic stress:

$$\begin{aligned} \sigma_L' &= \sigma_1 + \frac{[\sigma]_L}{[\sigma]_y} \times \sigma \\ &= 7.46 + \frac{39}{117} \times 80.5 \\ &= 34.29MPa \end{aligned} \quad (5)$$

$[\sigma]_L$ ——Allowable tensile stress, $[\sigma]_L = \frac{\sigma_1}{5} = \frac{195}{5} = 39MPa$;

$[\sigma]$—— Allowable stress $[\sigma] = 117MPa$;

$\sigma_1$ ——ultimate tensile strength, $\sigma_1 = 195MPa$ .

$\therefore \sigma_L' < [\sigma]_L$ , Roll strength check through.

Drum diameter $D = 400mm$ , Reel length $L = 1500mm$ . Reel grooves $R = 8mm$ ,Slots pitch $t = 16mm$ ,hoisting height $H = 16m$ , Multiple rate $i_n = 2$ ; A reel with a reel slot on the left, Marked as:

drum $A400 \times 1500 - 8 \times 16 - 16 \times 2ZBJ80.007.2 - 87$

(8) Drum speed:

$$n = \frac{v \times i_h}{\pi \times D_0} = \frac{14 \times 2}{3.14 \times 414.5} = 21.5\, r/\min \tag{6}$$

$v$ ——Lifting speed, $v = 14\, m/\min$ ;

$D_0$ ——Nominal diameter of a reel, $D_0 = 414.5mm$.

## 3. Conclusion

This design is mainly based on the existing formula and standard to design the lifting mechanism of overhead traveling crane. According to the working principle of the lifting mechanism of the overhead traveling crane, the transmission plan of the vice lifting mechanism should be determined.Then the transmission mechanism of the vice lifting mechanism is designed, and then the hook group, drum, motor, reducer and other components are gradually designed and determined.According to the design requirements, first select the suitable hook group; then according to the lifting weight and the field working environment design calculation, determine the reel; according to the radius of the reel and the lifting weight design calculation, determine the wire rope; the main role of the design of the wire rope is lifting, so the first to ensure the choice of pulley group to save force, and then The pulley block is selected according to the diameter of the wire rope and the working type of the crane.The motor mainly selects the right type according to the lifting weight and the weight of the hook group, and the reducer, brake and coupling are selected according to the specific parameters and with the design manual. As an important part of the connecting motor and reducer, the high-speed floating shaft is connected by the 2.5 tooth coupling to connect the motor and the reducer.

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