Vibration Isolation Design of Mine Centrifugal Pump

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Abstract

Vibration is an important index to evaluate the operation reliability of the pump unit. In the operation process of water pump, low-intensity mechanical vibration is inevitable, the cause of pump vibration is various, But the vibration exceeds the standard will threaten the equipment operation and personal property safety. Therefore, it is very important to control the vibration of the pump well. Based on the principle of vibration isolation, the proper isolation mode is selected, and the design of vibration isolator is carried out. Finally, a reasonable vibration isolation scheme is selected for the selected pump motor.

Keywords

Centrifugal pump, Vibration isolation principle, Vibration control.

1. Introduction

Mine drainage equipment should not only exclude the mine water flowing into the mine at any time, but also be able to drown the mine under the sudden water gushing. The drainage equipment always works with the construction and production of the mine until the life span of the mine is cut. Therefore, the drainage equipment is indispensable in the construction and production of the coal mine. It plays a very important role in ensuring the normal production of the mine.

Centrifugal pumps are used in the mine drainage equipment, but it will produce vibration when the pump is running. There are many reasons for the vibration of the pump: First, the rotating shaft of the pump is directly connected with the drive motor shaft, which makes the dynamic performance of the pump and the dynamic performance of the motor interfere with each other. Next, high speed rotating parts, dynamic and static balance can't meet the requirements. In addition, the components acting with the fluid are greatly influenced by the flow conditions and the fluid motion itself is very complex. Vibration is an important index to evaluate the operation reliability of the pump unit. Vibration exceeding standard will cause pump unit to run abnormaly, vibration of motor even serious damage to machine and pipeline, the damage of bearing and form noise. Therefore, it is very important to control the vibration of the pump well.

2. Organization of the Text

Vibration isolation means that the vibration source and equipment or other objects are connected by elastic or damping devices, so that most of the energy generated by the vibration source is absorbed by the vibration isolation device, through which to reduce the interference of the vibration source to the equipment.

Because of the design of the vibration isolation system is composed of motor and pump, so it is necessary to choose the Independent isolator, material with reinforced concrete. Considering the heavy equipment, base thickness is 200mm, As shown in Figure 1. The main parameters of the pump are shown in Table 1.

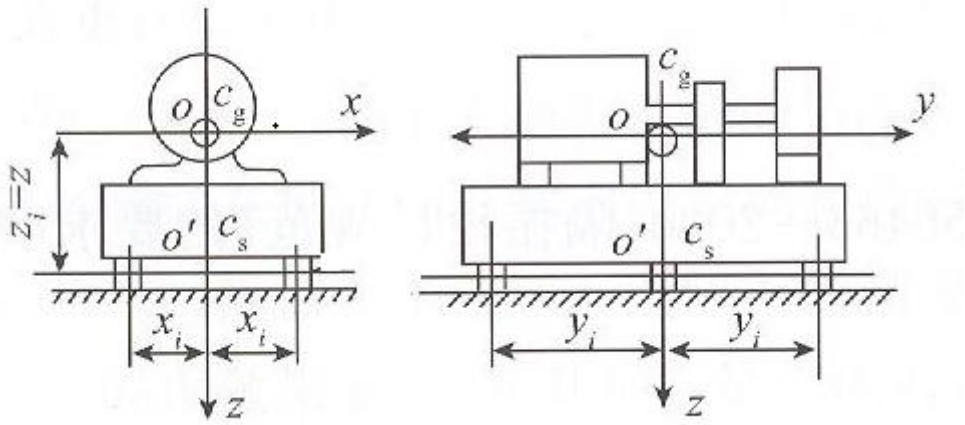

Fig.1 Independent isolator

Table.1 Parameters of three phase asynchronous flameproof motor of YB2 4053-2

project name	Numerical value
Power (kw)	630
Rated current (A)	72.1
Rated speed r/min	2980
Maximum torque multiplier	2
Plugging torque multiplier	0.7
locked rotor current multiplier	7
Efficiency (%)	95.6
Noise (dB)	110
Power factor	0.88
weight (kg)	4990

2.1 The interference force of the rotating machinery.

The vibration of a rotating machine is caused by the unbalance of the mass of the rotating parts, such as the impeller, the rotating shaft, and so on. The centrifugal force of the rotating part is as follows:

$$p_{01} = m_0 r_0 \omega^2 \quad (1)$$

Where, m_0 is the quality of the rotating parts, $m_0 = 0.4Q_0$. r_0 is an equivalent eccentricity to the center of rotation, ω is the angular velocity of the machine when it is rotating.

$$p_{02} = \frac{2.4 m_1 f^2}{20 + f^2} \quad (2)$$

m_1 is quality of motor rotor, m_1=0.25~0.4Q_0, Q_0 is quality of motor rotor, f is rotating frequency for motor.

For the whole vibration isolation system, the total interference force is:

$$p_0 = p_{01} + p_{02} \quad (3)$$

Substituting the data into the formula can obtain p_0=24452.11N.

2.2 The quality of the vibration isolation system.

The quality of vibration system include quality of vibration equipment, quality and additional quality of isolation platform. The quality of vibration isolation system is one of the important parameters of

vibration isolation design, which has a great influence on the amplitude. The quality of the vibration isolation system is as follows:

$$m \geq \frac{p_0}{\omega[v]} \tag{4}$$

where, [v] is the allowed vibration velocity of the vibration isolator [v]=10~20mm/s.

Assuming [v]=15mm/s, according to the formula (3), m=5188.9kg. The obtained quality is small, in order to ensure the isolation effect, increase of 200mm reinforced concrete pedestal, and its thickness is 280mm, as shown in figure 2. The vibration isolation mass of 3165kg, so the total quality system for vibration isolation is: the quality of motor pump + quality + pedestal quality =10560kg.

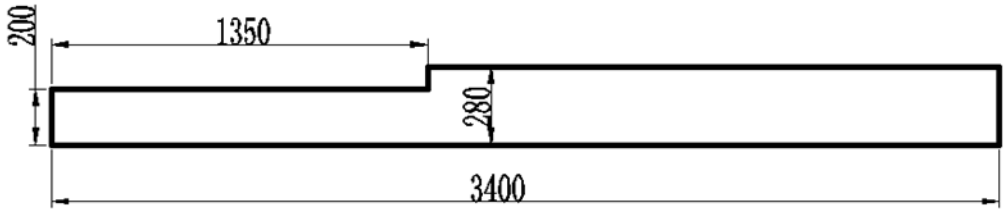

Fig.2 Pedestal shape

2.3 Design of steel spring isolator.

The vibration isolator is usually divided into steel spring isolator, rubber isolator, metal wire isolator, air spring and so on. By comparing the advantages and disadvantages of several vibration isolators, combining the actual situation of coal mine and considering the energy saving, this design selects the steel spring shock absorber.

This design adopts 8 isolators, each isolator has 4 steel springs, so requires a total of 32 springs, material is 60Si2Mn. Permissible shear stress [R]= 470MPa, shear modulus G=80000MPa.

According to the calculation method of the reference, By calculating the load and stiffness of the spring, the diameter and diameter of the steel wire, the number of circles, the vertical rigidity, the compression deformation and the pitch, the free height and the working height, we get the specific size of the spring. In this way the concrete structure of the isolator can be obtained. The concrete structure of the isolator is shown in Figure 3.

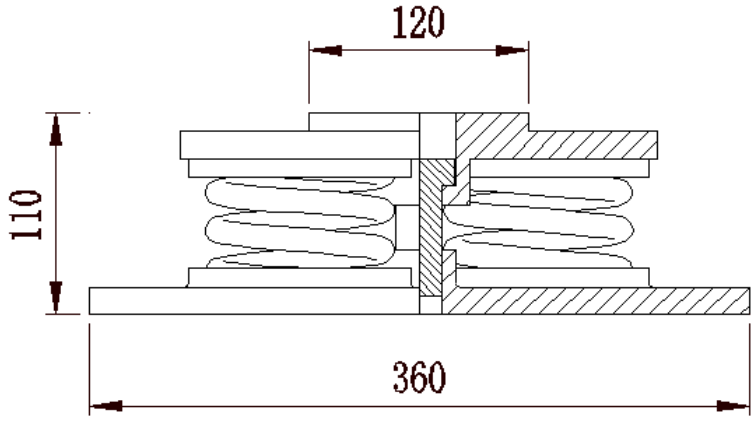

Fig.3 concrete structure of the isolator

2.4 Determination of center of mass of vibration isolation system and arrangement of vibration isolator.

The pedestal is irregular in shape, so the centroid position of the seat is first sought, and then the centroid position of the vibration isolation system is obtained. The pedestal is simplified as two cubes, the heart is the center of mass, as shown in Figure 4, according to the formula (5) obtained pedestal centroid.

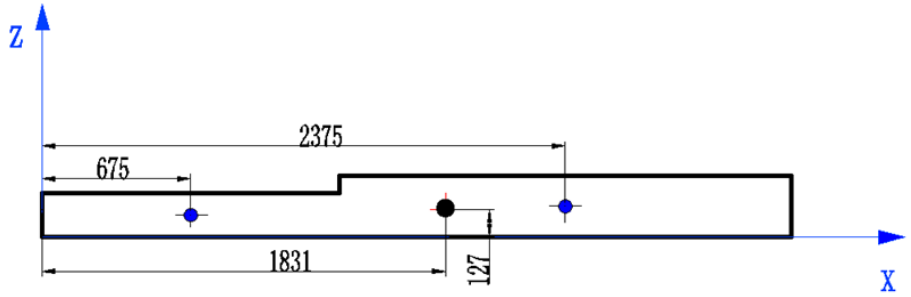

Fig.4 the centroid position of pedestal

$$x_c = \frac{\sum m_i x_i}{\sum m_i}$$
$$y_c = \frac{\sum m_i y_i}{\sum m_i} \quad (5)$$
$$z_c = \frac{\sum m_i z_i}{\sum m_i}$$

Through calculation

x_c=1831.2

y_c=0

z_c=127.2

In order to easily get the center of mass, the pump and motor are now simplified as a homogeneous cylinder with the center of mass in the cylinder, as shown in Figure 5.

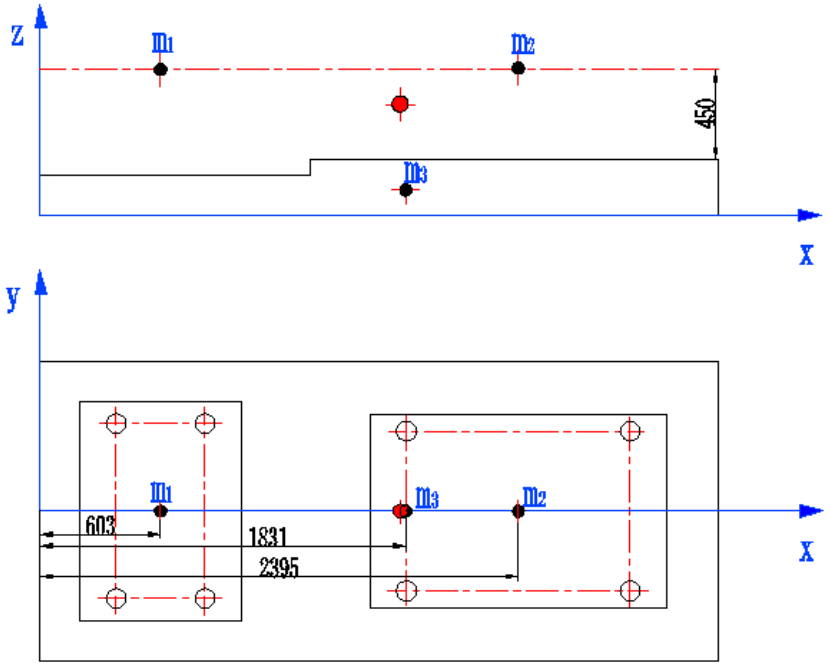

Figure.5 mass center of vibration isolation system

In the coordinate system shown in Figure 5, according to the formula (5), The coordinates of the center of mass can be obtained

x_c=1802.6

y_c=0

z_c=555.5

The arrangement of the vibration isolator has the following requirements: (1) in the installation plane, it should be symmetrical to the inertial spindle.(2) there is an elastic symmetry relative to the axis of inertia.

In the XY plane, the centroid position as the origin of coordinates, reestablish the axis of the coordinate, that is the axis of inertia. Vibration isolator arrangement about X axisymmetric, that is $\sum y_i = 0$,The vibration isolator is arranged as shown in Figure 6.

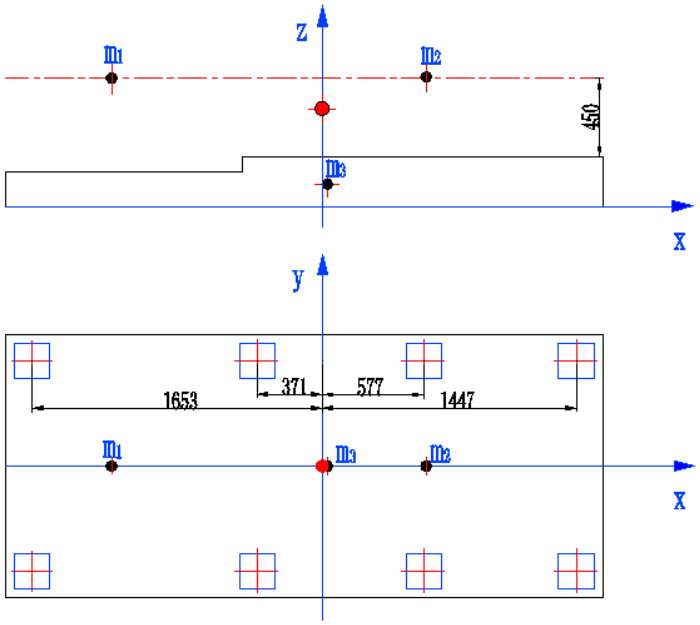

Fig .6 Arrangement of vibration isolator

3. Conclusion

Based on the vibration control method, the design of vibration control is carried out by contrast selection, and the design scheme of active vibration isolation is finally determined. According to the principle of isolation, complete the design of reinforced concrete isolation platform, determines the quality and size of the pedestal. According to the material mechanics, the centroid of vibration isolation system is obtained. According to the arrangement principle of the isolator, vibration isolator is disposed rationally, Finally, giving a reasonable and effective vibration the control scheme which minimize the equipment vibration impact on the surrounding environment and personal safety.

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