The study of the fixed form of spherical bearing spherical stainless steel with weak constraint

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Abstract: In this paper, the force characteristics of spherical stainless steel plates are analyzed. The advantages and disadvantages of welded spherical stainless steel plates are qualitatively analyzed based on the mechanical characteristics and the working conditions of the supports. A new constraining and fixing method of spherical stainless steel plate is proposed, its structural advantages are analyzed, its theoretical feasibility is analyzed, and the accuracy of the theory is verified through experiments.

1. Integral structure of spherical bearing and force analysis

Generally speaking, the vertical bearing force is transferred from the upper bearing plate to the plane wear plate, the spherical liner, the spherical wear plate, the lower bearing plate, and finally pass to the pier. The plane wear plate and stainless steel plate welded with upper bearing plate constitute glide plane, to complete the displacement of the bearing and the offset while making the rotation; the spherical wear plate and spherical liner welded with spherical stainless steel plate constitute glide plane, to complete the requirement of the turning points of the bearing. When the rotation center of the spherical bearing is coincided with the rotation center of the superstructure, the sliding between the spherical liner cricket crown and the the spherical wear plate can cause the bearing to rotate.

However, when the center of rotation between the spherical bearing and the superstructure do not coincide with each other, the rotation of the bearing is constrained by the beam, at this time, the second groups of sliding surfaces must be set between the upper support plate and the plane wear plate. According to the relative position of the center of rotation between the upper structure and the bearing, the spherical rotation direction can be the same or opposite to the direction of plane slip. If two rotation centers coincide with each other, there will be no sliding on the plane. The rotational moment of the spherical bearing is related to the frictional resistance of the sphere and the plane. The static equilibrium relationship is shown in Figure 1.
The equilibrium condition for the center force of a spherical surface is:

\[ V \bullet e - (R - h) \bullet \int \tau_e \bullet dF - R \bullet \int \tau_k \bullet dF = \mu \] (1-1)

And \[ \int \tau \bullet dF = \mu \bullet V \] assume that \( \tau_e \approx \tau_k \), \( \mu_e \approx \mu_k \), then

\[ e = \mu \bullet (2R - h) \] (1-2)

In the equation, \( \tau_e \), \( \tau_k \) is the frictional force of the plane and the sphere, respectively, \( \mu_e \), \( \mu_k \) are friction coefficient of plane and spherical surface; \( V \) is bearing reaction; \( R \) is spherical radius; \( h \) is the height spherical crown.

2. Analysis of welding performance of spherical stainless steel plate

The most common way to fix spherical stainless steel plates is to weld them on iron part, which belongs to strong constraint. There will be no problem in the use of spherical stainless steel for conventional spherical support when stainless steel has high molding precision and attached well with iron part. Welding is a good structure method, which can fix the gap between the spherical stainless steel plate, the closed spherical stainless steel plate and the middle seat plate, and prevent the middle seat cricket surface from rusting. But when stainless steel has high molding precision and attached bad with iron part, the spherical stainless steel will be extruded and formed folds during the rotation of the bearing, which will eventually damage the weld.

Repeated friction of the friction pair during an earthquake generated a great deal of heat for isolated spherical bearings requiring higher friction coefficient, at this time, the spherical stainless steel will expand at high temperature and it is very likely to damage the weld joint.

In view of the particular situation that welding fixed form of spherical stainless steel, the serious defect of the weld bead may damage, a new fixed form of spherical stainless steel is put forward, and takes the weak constraint way by buckle and integral gap mosaic through none weld at the edge.

Different from the way of welding, the steel parts on the back of stainless steel need anticorrosive coating. This article takes mosaic as an example to analyze.

3. Specific force analysis of weakly constrained spherical stainless steel plate

3.1 Static force analysis

The static force is always in the radial direction, \( F_s \) and \( F_t \) are shown in Fig 2. The new design does not change the thickness of the spherical stainless steel plate, and the area of spherical stainless steel plate is larger than that of spherical slide plate. So the radial bearing capacity of the spherical stainless steel plate is constant, static pressure capacity is constant.
3.2 Dynamic force analysis

In addition to the radial force, the outer surface of the spherical stainless steel plate (mirror plane, Ra<0.1) is subjected to the tangential friction of the spherical plate, and the inner surface is subjected to the static friction of the spherical surface of the medium plate and the welding fastening force while Cup turned around.

The roughness of the Cup sphere surface reaches 6.3. The roughness of stainless steel plate surface reaches 1.6, and there is no lube. According the "manual of mechanical design", the static friction coefficient can reaches μ_s=1.5. Surface roughness of stainless steel mirror reaches Ra≤0.1, and the Surface roughness can reach Ra≤0.2 after the stainless steel mirror is shaped spherical. The friction coefficient between stainless steel and the wear plate can reach μ≤0.015 for conventional spherical bearing, 0.03≤μ≤0.06 for isolated spherical bearing. So the radial movement of spherical stainless steel plates is negligible when the Cup rotates, and the force is balanced in the radial direction:

\[ F_S = F_t \]

According to friction, \( f = F \mu \), And \( \mu_s \leq 0.008 < \mu_t = 0.15 \), So

\[ f_s = \int \mu_s \bullet dF_s < f_t = \int \mu_t \bullet dF_t \]

The above formula shows that the maximum friction \( F_s \) provided by the middle seat plate to the spherical stainless steel plate is larger than that of the spherical slide plate on the spherical stainless steel plate (Diagram of frictional force analysis as shown in Fig 3).

4. Experimental verification of stainless steel with weak restraint

An experiment was carried out with using spherical stainless steel inlaid isolated spherical bearing. Spherical stainless steel was designed to planar structure directly, which can simulate the poor situation that spherical stainless steel and iron parts attached bad. The edges of the stainless steel and
the iron parts are set enough gap to adapt to the deformation of stainless steel under the condition of isolation, at the same time, it is convenient to simulate and observe the pure friction and relative sliding of stainless steel and ferrous parts. Designed vertical pressure and horizontal shear are loaded to the bearing to simulate actual working condition, and to see whether the spherical stainless steel is sliding relative to the iron part, which can verify the feasibility of circumferential gap mosaics.

Fig 4. Test process

The Fig 4 shows the test process. According to the mark of the stainless steel and iron matrix after testing, there are only pressure mark and no abrasion mark. The results shows that there is no relatively friction, which indicated that no slip between the stainless steel and the iron matrix, and it is proved that the weak constraint method is feasible.

5. Conclusion
The weak restraint method of spherical stainless steel with spherical bearing is feasible. It can effectively avoid the wrinkling of spherical stainless steel when it is subjected to compression and rotation. At the same time, it can avoid the indeterminate influence of the crack and shedding of the weld to the bearing performance and the influence of the bearing corrosion resistance. So that the performance of the bearing is more stable and reliable.

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