Study on performance of integrated pipeline vibration isolator

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Abstract. For power machine pipeline, a pipeline isolator with integrated pipeline surrounding rubber and base vibration isolating rubber is designed. Adjusting the rubber parameters of the pipeline mainly changes the impedance of the isolator and adjusting the base rubber mainly changes the force transfer rate. Thus the optimal vibration isolation effect can be achieved by increasing the rubber hardness of the pipe surrounding rubber and reducing the rubber hardness of the base rubber. The analysis also shows that the base rubber structure has a decisive influence on the low-frequency vibration isolation performance of the integrated pipeline isolator compared to the pipeline rubber.

1. Introduction

Noise of the power machine includes the mechanical noise generated by the moving parts and the noise generated by the internal fluid motion excitation[1]. Generally, the vibration of the power machine body can be weakened or eliminated by installing isolator arranged centrally, and the power pipeline in power system has a large distribution range and a long distance[2]. It is not suitable to reduce vibration through the centralized vibration isolation device. By installing flexible joints and clamps, the vibration transmitted by the power machinery through the pipeline structure and the vibration of the fluid excitation pipeline in the pipeline are weakened, as the clamp is a single-layer rubber-pair, the isolation of vibration is limited, especially in low frequency condition[3-5].

In order to improve the vibration isolation effect of the power pipeline, an integrated pipeline isolator is proposed, which includes a vibration-insulating rubber tightly surrounding pipeline and a diagonal vibration-isolating rubber coupled with the base. Its vibration isolation performance is analyzed by a finite-point method.

2. Modal analysis of isolator

The structure of the integrated vibration isolator is shown in Figure 1. The vibration isolator has a inner diameter of 250 mm and an axial length of 100 mm. In the finite element model, the unit type is solid185, the unit size is 10mm, total nodes is 9488 with 6730 units. The boundary condition is set as that the degree of freedom in the three directions is constrained at the mounting hole to keep it simple. The material parameters of the isolator are shown in Table 1. The first 10 modal results are calculated as shown in Table 2.
Figure 1. Integrated pipeline vibration isolator.

Table 1. Material settings in the finite element model.

| Density (Kg/m³) | Damping | Elastic modulus (GPa) | Poisson's ratio |
|-----------------|---------|-----------------------|-----------------|
| Steel           | 7800    | 200                   | 0.3             |
| Rubber          | 920     | 4                     | 0.49            |

Table 2. The first 10 modal natural frequencies of the structure

| Order | Natural frequency (Hz) |
|-------|------------------------|
| 1     | 11.798                 |
| 2     | 27.12                  |
| 3     | 34.3                   |
| 4     | 38.217                 |
| 5     | 50.175                 |
| 6     | 65.026                 |
| 7     | 366.78                 |
| 8     | 368.91                 |
| 9     | 385.35                 |
| 10    | 385.72                 |

3. Vibration isolation response calculation results and discussion

The origin impedance and the force transmission rate are used as evaluation parameters of the performance of the isolator. The effects of rubber damping, rubber hardness and vibration isolator structure on the performance of the isolator were analyzed.

3.1. Effect of rubber hardness on the performance of the isolator
In general, the hardness of rubber is proportional to the elastic modulus. Therefore, the rubber hardness (Hs) is used as a variable parameter to analyze the rubber hardness of 2MPa (Hs=42), 3MPa (Hs=51), and 4MPa (Hs=58). The vibration isolation effect below, the result is shown in Figure 2 and Figure 3. It can be seen that the lower the rubber hardness, the greater the force transmission rate of the isolator, especially at low frequencies, but in opposite, the greater the rubber hardness, the greater the impedance of the origin. The pipeline rubber is close to the excitation source and is the main component that affects the impedance of the origin. The base rubber is the main component that affects the force transmission rate. Therefore, the rubber hardness of the rubber coated in the pipeline can be appropriately increased, and the rubber hardness of the base rubber can be reduced to maximize the vibration isolation effect of the vibration isolator.
3.2. Effect of pipeline surrounding rubber configuration on performance of the isolator

The pipeline rubber is close to the excitation source and is the main component that affects the impedance of the origin. The base rubber is the main component that affects the force transmission rate. In order to more accurately analyze the vibration isolation effect of the isolator, the results of the two main damping components can be changed for comparative analysis. Figure 4 and figure 5 show two structural types of pipeline surrounding rubber, which are sawtooth and continuous rings separately.

Figures 6 and figure 7 show the change of force transmission rate and origin resistance after the change of the pipe surrounding rubber. It can be seen that as the sawtooth shape is changed to a ring shape, the rubber volume is increased, the impedance of the vibration isolator is significantly improved, and the force transmission rate is slightly increased in the high frequency region.
Figure 6. Effect of pipe surrounding rubber configuration on force transmissibility

Figure 7. Effect of pipe surrounding rubber configuration on origin impedance

3.3. Effect of base rubber configuration on performance of the isolator

Figure 8 shows two configurations of base rubber. One type of vibration isolator has a base rubber with horizontal limit structure and the other has not.

Figure 8. Base rubber with horizontal limit

Figure 9. Base rubber without horizontal limit

The change of force transmission rate and origin impedance is shown in Fig. 10 and Fig. 11. It can be seen that the volume base rubber of the vibration isolator without horizontal limit is large, and the transmission rate of low frequency and high frequency force is somewhat improved.

Figure 10. Effect of base rubber configuration on force transmissibility

Figure 11. Effect of base rubber configuration on origin impedance
4. Conclusions
An integrated vibration isolator is designed for power machine pipeline, which includes the pipe surrounding rubber and the obliquely arranged base rubber. The pipeline surrounding rubber is close to the excitation source and is the main component that affects the origin impedance. The base rubber is connected to the foundation and is the main component that affects the force transmission rate. The rubber hardness of the pipe surrounding rubber can be appropriately increased, and the rubber hardness of the base rubber can be reduced to achieve the most suitable vibration isolation effect. The analysis also shows that the base rubber structure has a decisive influence on the low-frequency vibration isolation performance of the pipeline isolator compared to the pipe surrounding rubber, which is very important in power machine pipeline.

References
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