ABSTRACT
In this paper, using the FEA software Ansys, with rubber material as the analysis of experimental data input, The FEA for the rubber locator products of railway vehicle bogie, Paper studied the influence about the rubber layer on the three directions of stiffness of the product.

Keywords: Rubber locator; FEA; Railway vehicle

Introduction
With the speeding up of the railway operation speed, passengers put forward higher request to the safety and comfort of a passenger train, so there use more rubber vibration isolation components on the vehicle. it requires a lot of manpower, material resources, financial resources when operating, also cost a lot of time. This method of using FEA software to analyze the performance of rubber products is more and more attention by people.

The axle box rubber locator of bogie is rubber and metal get together that use vulcanization process, the common bearing structure. when vehicle running, Axle box positioner under the direction of force. Therefore, in order to achieve the requirements of the running train, the locator should have certain stiffness. [1]

According to the actual working condition, the ideal stiffness ratio for:
Vertical direction: longitudinal direction: transverse direction = 1:16:10
Scientific research team developed the new product stiffness test results as follows:

<table>
<thead>
<tr>
<th>Vertical (KN/mm)</th>
<th>Radial (KN/mm)</th>
<th>Axial (KN/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.42</td>
<td>4.5</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Can’t meet the requirement of the working condition, the need to adjust the structure. We adjust the stiffness ratio relationship of Rubber locator by using ANSYS through the finite element analysis software.

The establishment of the finite element model
Locator of the establishment of the finite element model in ANSYS software,
because it is through the finite element analysis to optimize the element stiffness, do simplify the processing of the site has no effect on the stiffness in the structure, improve the operation efficiency. Finite element model is shown in figure 1.

![Finite element model](image)

Figure 1. Locator finite element model.

**Material constant input**

The geometric characteristic of the rubber material is nonlinear. There has great impact of rubber's mechanical properties about the change of temperature, the environment, strain, loading rate and the strain rate, production technology and additives on the mechanical property of rubber has important influence. [2]

Natural rubber is elastic material, in the calculation using strain potential energy (U) to express the stress - strain relationship. Strain potential energy expression is as follows:

\[
U = \sum_{i=1}^{N} C_{ij} \left( i_1 - 3 \right)^{(i)} \left( i_2 - 3 \right)^{(i)} + \sum_{i=1}^{N} \frac{1}{D_i} (J_{el} - 1)^{2i}
\]

In the formula:
- **U**—potential energy of strain
- **J_{el}**—The ratio of elastic and volume
- **i_1, i_2**—Strain invariants
- **D_i**—Define material's compressibility
- **C_{ij}**—The coefficient of Rinval

We use ANSYS Odgen (N = 3) model are analyzed. To simulate the metal part with Solid45 entity unit, simulation of the rubber part with Hyper58 hyperplastic unit. Considering the elastic rubber material, so the structure is divided into 30742 units. According to the actual working condition, respectively applying vertical load, radial load and axial load in the different load. [3]

To solve in the solver, three-way stiffness results shown in the table below:
Table 2. Three direction stiffness results.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Computing structure</th>
<th>deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical (KN/mm)</td>
<td>0.41</td>
<td>4.6%</td>
</tr>
<tr>
<td>Radial (KN/mm)</td>
<td>3.9</td>
<td>9.3%</td>
</tr>
<tr>
<td>Axial (KN/mm)</td>
<td>2.3</td>
<td>8%</td>
</tr>
</tbody>
</table>

Maximum deviation of calculation results and the comparison of experimental results is 9.3%. By using ANSYS software for structural stiffness ratio adjustment. According to the experience of product development, various adjustment methods impact on the stiffness of products as follows:

With the increase of slot Angle, 3D stiffness are reduced, but the degree is different. The most significant is the lateral stiffness, The second is vertical stiffness, The longitudinal stiffness reduction is minimal. Hole Angle's influence on the 3D stiffness is shown in figure 2.

![Figure 2. Hole Angle's influence on the 3D stiffness.](image)

With the increase of rubber layer Angle, lateral stiffness and longitudinal stiffness of the products’ are greatly increased. When the vertical stiffness in slope Angle is small, there is less growth. When the tilt Angle is bigger, and as the Angle increases. The tilt Angle of 3d stiffness of diaphragm effect as shown:

![Figure 3. Partition’s Angle for the influence of the stiffness.](image)

With the increase of rubber layer number of slots, stiffness value of the product is monotone decreasing. As slots of layer increased, the lateral stiffness decreased fastest, the second is the vertical stiffness and longitudinal stiffness fell the slowest. Different hole layer on the influence of the stiffness as shown in figure 4:
With the increase of rubber hardness, stiffness value of the product is monotone increasing. And, with the increase of the hardness of the rubber, the lateral stiffness and longitudinal stiffness of the product increase amplitude is roughly same, were greater than the vertical stiffness of rise. The influence of different rubber hardness to stiffness as shown in figure 5:

![Figure 5. The influence of different rubber hardness to stiffness.](image)

According to the above analysis, calculation and analysis functions of ANSYS, after adjustment. the adjusted product stiffness calculation results shown in the following table in the end.

<table>
<thead>
<tr>
<th>Vertical (KN/mm)</th>
<th>Radial (KN/mm)</th>
<th>Axial (KN/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.32</td>
<td>4.28</td>
<td>2.75</td>
</tr>
</tbody>
</table>

The stiffness ratio of the product is:
Vertical direction: longitudinal direction: transverse direction = 1: 13.4: 8.6
Can satisfy the requirement of stiffness ratio.
Equivalent stress nephogram of rubber parts as shown in the figure below:
Summary
The use of ANSYS software, can make us convenient adjustment rubber locator stiffness ratio. After experimental verification, the calculation results are consistent with the experimental results.

References