



## Load-bearing of axle-box assemblies

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### Abstract

This paper discusses the types of loads experienced by bearings in the boxes of railway cars. The authors give examples of using a ball bearing as an axial stop to reduce the load on the frame of railway cars. The paper reviews existing solutions, considers the components of a single row of radial bearings and a roller bearing without separators, and highlights their advantages and disadvantages. The purpose of this study is to consider improving angular contact ball bearings with toothed rings to increase its reliability. The operating principle and the scope of the application of these bearings were investigated.

*Keywords:* Bearing, axle box, axial stop, axial load, radial load, railway wagons;

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### 1. Introduction

The bearing assembly is an element that determines the performance of the rolling stock. The most loaded bearings in railway trains are box bearings. These bearings have relatively low durability and low reliability. The bearing life is affected by the weight of the truck, track conditions (track stiffness) and speed of movement.

The axle box is a node of the running gear of a car and a railway locomotive. The axle box perceives and transmits the force of gravity and the dynamic load that occurs while moving. The axle box (Figure 1) is a reservoir for placing bearings and lubricants. It protects the axle necks from contamination and damage. The axle box restricts the movement of wheel pairs in the longitudinal and transverse direction relative to the frame.



Figure 1 - Axle box

PTC's are classified according to the type of bearings used on axle box with roller bearings and axle boxes with plain bearings. In boxes with rolling bearings, cylindrical and spherical are most often used. The most popular bearings in modern locomotives and wagons in Russia and Europe are cylindrical roller bearings (Figure 2).

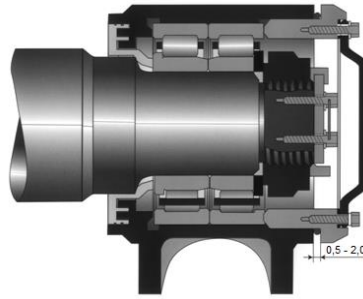


Figure 2 - Axle box bearings

## 2. Forces

The condition of the axle box bearing affects traffic safety. Current trends suggest an increase in the speed of trains and as well as an increase in the load on the axle. This means that the requirements for support systems enhance. More than a half of axle box breakdowns are related to bearing failure. There are shells, peeling, corrosion, cracks, chipping, and etc. on the bearing rings. Bearings in the axle boxes are subjected to high dynamic loads. The main reason for the appearance of defects on the ends of rolling bodies and ring sides is the work under combined load which includes radial load and frame force [2].

The action of the frame force (Figure 3) leads to rapid wear of the rings and rollers because rollers are slowed down on the end surfaces when they contact the sides of the rings [1]. When the roller ends slide relative to the sides of the rings, the rollers are slowed down and the parallel eyes of the roller rings are disrupted. The resulting metal particles fall into the lubricant and onto the raceways leading to abrasive wear. In addition, grease leaks occur during operation which cause heating of the rubbing surfaces.

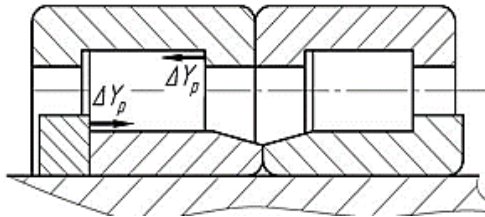


Figure 3 - Transmission scheme of frame force for cylindrical bearings

There are several ways to transfer the frame forces such as rolling bodies and axial stops, in particular special bearings. The experience of using deep groove or thrust ball bearings as axial stops in axle boxes exists both in domestic and foreign practice [4, 5].

The disadvantage of using ball bearings as an axial stop is that they perceive a part of the radial load (Figure 4)

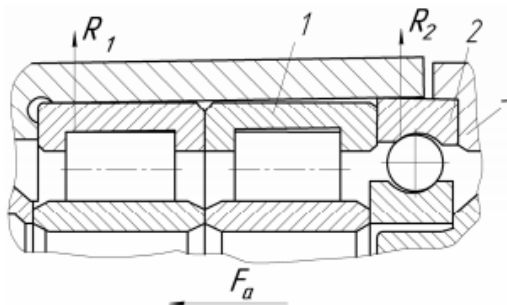


Figure 4 - Distribution of radial load in axle box

The mounting covers the third and the outer ring of the ball bearing covers two together with the ring of the cylindrical bearing one. The ball bearing misalignment affects the radial load of the first cylindrical bearing. It is hard to fix this scheme. There is also a diagram of installing a ball bearing as an axial stop between cylindrical bearings (Figure 5).

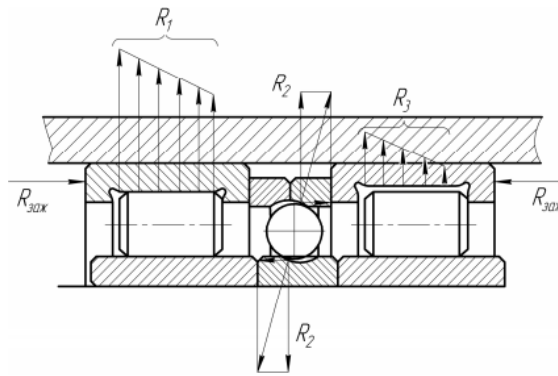


Figure 5 - Radial load distribution in axle box with ball bearing and shortened cylindrical roller bearings

The outer ring in this case is split. But when we shorten the length of the rollers, it is followed by a significant reduction in the load capacity which is contrary to contemporary trends [3].

On the basis of the aforesaid, we can see the complexity of working conditions of bearings in the boxes of railway cars, as well as the need to improve the bearings in terms of their perception of complex loads and increase their durability.

### 3. Angular contact ball bearings

The abovementioned disadvantages in bearings can be overcome by a ball angular contact rolling bearing with conical involute toothed rings (Figure 6). At the ends of the inner ring, conical involute toothed crowns are made. Conical involute gears are located on the rolling elements; the balls engage with the conical involute ring gear. The tangent drawn to the rolling body coincides with the initial formation of conical involute gears and conical involute gear rims at the point of contact with the treadmill of the inner ring [1, 3].

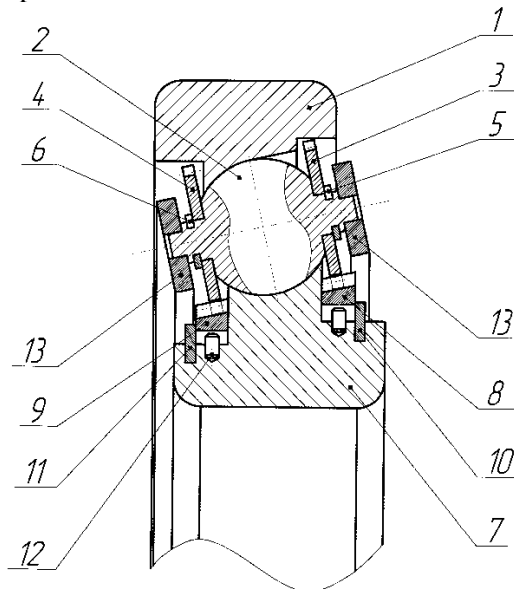


Figure 6 - Angular contact ball bearing with rotating inner ring

Figure 6 shows a ball angular contact bearing. This bearing has an inner rotating ring (7) and an outer ring № 1. Rolling bodies (2) are made in the form of balls. Rolling bodies on the end part have conical involute gears (3 and 4). Involute gears the wheels are engaged with the gear rings (8 and 9). To hold the rings (8 and 9), the locking release rings the tenth or 10 and 11 and the pin 12 is used. The positioning of the rolling bodies relative to each other is provided by the separator 13 [6,7].

In practice, when we use rolling bearings, one ring is fixed and the second makes rotational movements. During the operation of a ball angular contact bearing, the outer ring 1 is stationary, while the inner ring 7 performs a rotational movement. The rotating ring where conical involute gears 8 and 9 are located transmits the torque to balls 2 through pairs of conical involute gears 3 and 4. As a result, balls 2 are rolled without sliding along the raceways of the bearing rings [1].

#### 4. Conclusion

This type of bearing will enable to increase the frequency range and enhance reliability while simplifying the design (relative to the rolling bearing radial roller separator. Angular contact ball bearings with toothed rings can be used in shipbuilding (for example, power drives of underwater vessels) and helicopter construction. Wide application of this type of bearing can be found in railway transport, in particular in the node of the undercarriage of the car. This unit receives and transmits the wheels of gravity from the car load, as well as dynamic loads which occur when the train moves.

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