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A method of fretting wear reduction in an automatic wheel set gauge change system

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ABSTRACT

The SUW 2000 railway vehicle wheel set with an automatic gauge change system is especially exposed to fatigue wear due to the specific working conditions. Taking into consideration the role which a wheel set has in both vehicle handling on a track and providing safety of railway traffic, the wheel set damage is impermissible. It also applies to the sleeve–axle rotational connection. This article presents research into both finding new and low-cost materials for a slide sleeve in the wheel hub node and looking for cheaper technologies for improving the surface layer of the wheel set under-hub which would eliminate fretting wear. The research was conducted on a simplified physical model of a real connection between a wheel and an axle. The results of the conducted wear tests show that fretting wear can be effectively limited by applying a metallic layer in the form of molybdenum coating. Grease with the addition of molybdenum disulphide can also protect the co-operating surfaces against fretting wear. It also allows for sustaining proper working conditions of frictional pair elements. This solution, however, is onerous due to the limited maintainability of the connection node. The studies carried out show that there is a full possibility of using this solution in real exploitation.

1. Introduction

Economic development depends to a great extent on an efficient transportation system which should enable reliable, safe and effective shipment of goods in both national and international traffic. It is especially difficult to satisfy these conditions for the international railway transport due to different track gauges on the Eurasian continent. The majority of European countries, like Poland, have rails with a 1435 mm gauge, but the railways of the former Union of Independent Countries and other countries (e.g. Lithuania, Latvia, and Estonia) have railways with the gauge of 1520 mm. In Asia, a train goes on a wide track (1520 mm), but in China and Korea it goes back on a regular track (1435 mm). Wider tracks are still in Spain and Portugal, i.e. 1668 mm. These differences constitute considerable operational handicaps since the cargo has to be reloaded or the running gear of a railway vehicle has to be changed where the rail gauges become different. Such operations are expensive and time-consuming. They require advanced infrastructure together with very expensive storage-reloading back-up facilities on the borders between countries. Moreover, these operations increase significantly the time of transportation up to 46% of the total transport time [1–3].

The research into a smooth change from one rail gauge into another without the need for stopping the train has been conducted for a long time [4–7]. The oldest solution of a wheel set with a changeable wheel gauge was registered in

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1898 in Germany in a patent No. 105907 known as: *A device for a rail gauge change in railway vehicles.* No solution had reached more than a prototype form until the year 1945 [8]. For a long time the automatic wheel set gauge system could not be used due to its complicated construction, poor reliability, and high operational costs. At the moment, there are three systems of a rail gauge automatic changing:

– the Spanish system – TALGO,
– the German system – RAFIL,
– the Polish system SUW 2000.

Taking into consideration the fact that the work on the development of the RAFIL German system has been stopped recently and the Spanish system TALGO is used only in passenger traffic, it can be stated that the Polish system SUW 2000 for the automatic wheel set gauge changing is the most advanced system in freight traffic. The first application of the SUW 2000 prototype system in cargo rail vehicles took place in 1995. The analysis of different variants of construction, materials, technologies of an axle, a wheel and a slide sleeve, and lubricating enabled the introduction of an automatic wheel set gauge changing system into a supervised trade operation conducted in the years 2000 – 2004 between Poland and Lithuania. Each of the rail carriage travelled more than 100,000 kms and underwent more than 100 changes of the rail gauge on the rail gauge change stand.

An analysis of professional literature shows that a lot of works on wheel sets referred mainly to the conditions of the assembly of a classical wheel set in which the joints are of a forced-in type. Professional literature review reveals that a wheel set undergoes a great number of tests. It is proved in numerous papers and articles. The majority of those papers and articles refer to increasing the element joints durability as well as increasing the fatigue strength of wheel sets. However, the authors of the papers did not examine the influence of technological processes on the initiation and development of fretting wear. The authors concentrated only on the increasing of fatigue strength. Moreover, quite a number of academic papers dealing with the causes of fretting wear forming in wheel sets refer to the examination of forced-in joints. Due to the specific character of an automatic wheel set gauge changing system, in which a connection of the wheel with the axle is of a rotational type, the problem of the fretting wear development mechanism in such joints has not been studied in detail.

Complex physical and chemical phenomena occurring in the place where the connected surfaces meet and the influence of a great number of factors make the mechanism of the fretting wear development difficult to describe and to define explicitly. The common part of various scientific papers and publications is a statement that fretting is a deterioration process of the surface layer which takes place during very small mutual dislocations of the bodies in contact caused by vibrations at the amplitude in the order of 25 μm [9–15]. The process is accompanied by such phenomena as adhesion, micro-cutting, corrosion, plastic strain, and surface fatigue. Fretting wear can be seen, for example, as: the traces of corrosion on the surfaces of elements, the increase in surface roughness, or micro-cracks in the surface layer.

A research review of fretting wear yields a conclusion that wear development is strictly connected with both a real contact of the matched element surfaces and with the presence of the so-called third body in the contact zone. The form of this wear development depends though, first of all, on the oscillation conditions and the slip amplitude [9,12,13]. The majority of authors most frequently indicate forced-in joints as the examples of the elements or connections in which fretting wear occurs [16–19].

Research descriptions provided by, e.g. Waterhouse, Fenner, Collins, or the descriptions of the test stands in [9,20,21] refer to the contact between matched surfaces, that occurs only on a small fragment of either the shaft circumference or the flat element.

2. Research object description

The SUW 2000 consists of wheel sets with the automatic gauge changing system and a rail gauge change stand which enables the change of the wheel gauge in a rail vehicle. The wheel set of the SUW 2000 system shown in Fig. 1 has a far more complicated construction than a standard wheel set. It consists of the following parts:

– the axle sub-assembly (1),
– the wheel (2),
– the locking mechanisms (3),
– the axle bearings with casings (4),
– the external cover (5),
– the internal cover (6),
– the stopper rings (7),
– the self-locking nuts (8).

Wheel sets can adapt to three different combinations of rail gauges (1435/1520 mm, 1435/1668 mm, and 1435/1520/1668 mm). Wheel gauge change takes place when a train moves along the rail gauge change stand TSP (Fig. 2a) where the wheels are automatically adjusted to the required track gauge (Fig. 2b).