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Influence of sanding parameters on adhesion recovery in contaminated wheel–rail contact

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ABSTRACT

Adhesion in wheel/rail contact influences performance and safety of railway traffic. Low adhesion brings problems during braking and traction. Sanding is the most common way how to increase adhesion when the poor contact conditions due to a contamination occur. On the other hand, excessive sanding leads to higher wear of wheel and rail. To optimize the sanding process, description of the influence of sanding parameters on the adhesion in the contaminated contact is highly required.

In this work a new twin-disc machine in scale 1:3 was developed and addressed to the study of wheel/rail adhesion under different contact conditions. An influence of sanding parameters such as sand quantity, wheel slip and rolling speed was investigated using a real sanding system in the contact contaminated with water, leaves and wheel flange grease.

It has been shown that under wet, leaf or grease contamination, quantity of the sand applied during fixed time period has significant effect on adhesion recovery only for low wheel slip and low rolling speed. In the contaminated contact the effect of sanding on adhesion recovery increases with wheel slip and rolling speed.

1. Introduction

In comparison with other modes of transport particularly road and air, rail transport is among the most energy efficient and environment and social-friendly. To further improve the efficiency and performance a wheel–rail interface is the subject of interdisciplinary research efforts. The interaction between wheel and rail depends on vehicle–track dynamics, contact mechanics and tribology. These phenomena are related to cost, safety, maintenance, reliability, environment and energy consumption.

Tribology of the wheel and rail contact substantially determines performance and safety of railway traffic. The amount of energy transferred through the contact depends on adhesion level. When traction effort exceeds an adhesion limit a wheel slipping occurs, while a sliding arises when the adhesion is low during a braking. In the first case the low adhesion is responsible for delays in railway traffic and increased wear of wheel and rail when wheel is slipping. The low adhesion during braking causes extension in the braking distance which may result in crossing of platforms and which may bring safety risks in emergency cases.

Low adhesion is mainly caused by poor contact conditions due to the contact contamination. The most significant natural contaminants are humidity [1,2] and water [3–9]. Serious adhesion problems mainly during autumn months create leaves on the track [1,10–12]. Another common contaminant is oil or wheel flange grease [1,8] and natural layer called third body [13] made up of a mixture of dust, wear particles and other contaminant. Investigation of the behavior of such contaminants in the wheel–rail contact is essential for an understanding of low adhesion problems.

Various experimental methods and models have been used during last decades. Next to field measurements [14] laboratory experiments are of great importance in the research in tribology of the wheel–rail contact. The most accurate experimental model uses a full-scale wheel–rail test rig [15] with real geometry and kinematics. The wheel on rail model has been also applied in a reduced scale [13,16]. A rail is often replaced by a disc in full-scale test rigs [15,18]. The most widely used is a twin-disc approach at different scales. A small scale allows cutting specimens from real rail and wheel [2,4,5,7,8,11,19]. To incorporate a real dynamic of contact, testing with scaled boogie and wheel set has also been carried out [6,20–22]. Recently a new twin-disc test method with continuously variable creep was developed which allows measuring a creep curve in a single run [23]. In this way the creep curve parameters can be determined from large amount of data. This work has been focused on low levels of creep. For simulation of a

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wheel–rail contact a Mini-Traction-Machine in ball-on-disc configuration has also been used [10,24]. Another approach assumes a pure sliding condition in pin-on-disc [1,25,26] and ball-on-disc [27] configuration.

Sanding is a classic and the most important method how to increase adhesion in contaminated wheel–rail contact. On the other hand, sanding is connected with higher wear of wheel and rail. An effect of sanding on adhesion recovery has been studied by several authors [11,19,28–31]. The effect of sanding is influenced by various sanding parameters which are mainly particle size of sand [28–30], sanding rate [28,29] and wheel slip [28–30].

It has been also stated that sand may act as a solid lubricant within the meaning of a reduction of adhesion under dry conditions [28,31]. Moreover, excessive sanding may cause an electric insulation between train and rails [28,31,32] which may negatively affect functionality of a railway track circuits that are used for detection of trains. Using electric voltage measurements partial and full lubrication regimes during sanding under dry conditions were identified [28]. Above the certain sanding rate no direct metal to metal contact occur which indicates formation of a coating of crushed and compacted sand in the contact. As the feed rate increases the adhesion coefficient during sanding decreases; nevertheless the coefficient is recovered to the same level at some time after the sanding. Sanding causes severe wear of wheel and rail. It was shown that sanding increases wear by factors between 2 and 10 [19]. The wear was higher under wet conditions because of higher entraining capacity of wet discs [19].

Besides sanding, friction modifiers or solid particles are used to increase adhesion in contaminated contact [7,12,33] and to control lateral forces and specific wear regimes such as short pitch corrugation [34–36]. Moreover, hydrophobic products as a combatant for low adhesion were tested [37].

Low adhesion is a serious problem in railway traffic and sanding is still the most important method how to overcome the issues connected with poor contact conditions. On the other hand, sanding is connected with higher wear and may bring other problems when an excessive amount of sand is used. So the information about proper sanding parameters for various contact conditions is highly required for optimization of the sanding process.

Sanding rate is one of the most important parameter. Although a number of studies that deals with the effect of sanding have been published, only several of them are focused on the effect of sanding parameters. Especially an effect of sanding rate under different contact conditions has been insufficiently described yet.

The present paper is focused on the experimental study of the sanding process in simulated wheel–rail contact. The main aim of this paper is to investigate the effect of sanding rate on adhesion recovery in contaminated wheel/rail contact under various contact conditions. Common contaminants like water, grease and leaves have been used. For the purposes of this study a new twin-disc machine has been developed.

2. Material and methods

2.1. Test apparatus

A scheme of the new twin-disc machine is shown in Fig. 1 and its photographs are shown in Fig. 2. The experimental machine consists of main frame and secondary frame for the drive system. Major components include two discs of the same diameter situated in the main frame. The discs are placed in a contamination chamber, which enables application of contaminants and provides protection from pollution. Each of these discs is independently driven by 15 kW AC motor with gearbox. Torque from drive in secondary frame is transmitted using a drive shaft. Frequency converters together with control software are used to set up various rolling speed and slip. The slip in the contact is achieved by different rotational speed of the discs and is calculated

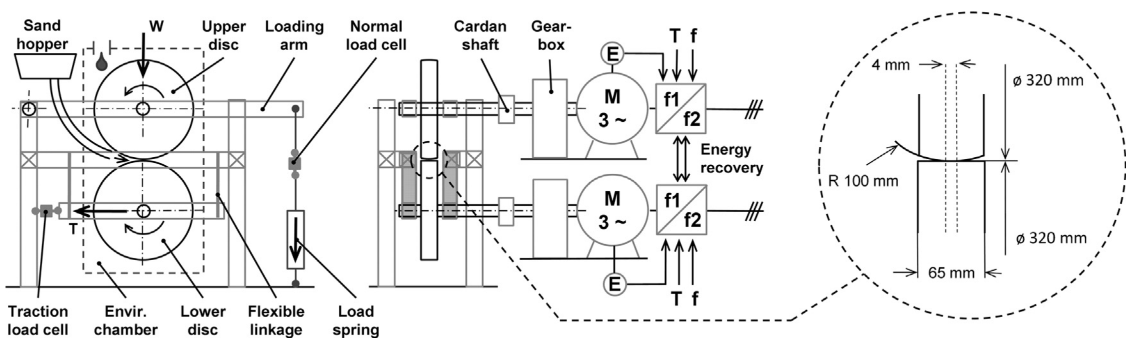

Fig. 1. Schematic representation of twin-disc machine.

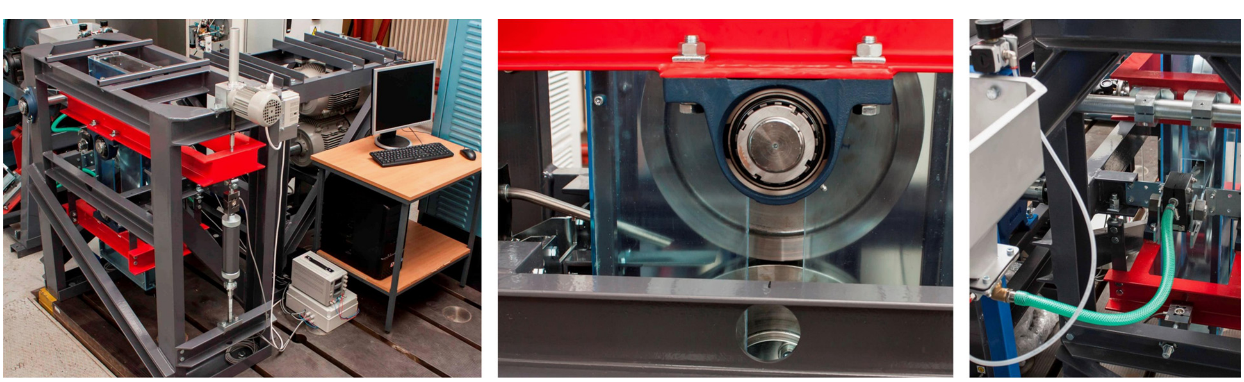

Fig. 2. Photographs of twin-disc machine with detailed views on sanding aplication.