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A study of airborne wear particles generated from organic railway brake pads and brake discs

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ABSTRACT

Brake pads on wheel-mounted disc brakes are often used in rail transport due to their good thermal properties and robustness. During braking, both the disc and the pads are worn. This wear process generates particles that may become airborne and thus affect human health. The long term purpose of 'Airborne particles in Rail transport' project is to gain knowledge on the wear mechanisms in order to find means of controlling the number and size distribution of airborne particles. In this regard, a series of full-scale field tests and laboratory tests with a pin-on-disc machine have been conducted. The morphology and the matter of particles, along with their size distribution and concentration, have been studied. The validity of results from the pin-on-disc simulation has been verified by the field test results. Results show an ultra-fine peak for particles with a diameter size around 100 nm in diameter, a dominant fine peak for particles with a size of around 350 nm in diameter, and a coarse peak with a size of 3–7 μm in diameter. Materials such as iron, copper, aluminum, chromium, cobalt, antimony, and zinc have been detected in the nano-sized particles.

1. Introduction

The main concerns about airborne wear particles are environmental. Health effects of the inhaled nano-sized particles have been studied extensively but most studies have been focused on combustion processes [1]. Only a few studies have been carried out to investigate the emission of wear particles in rail transport.

Gustafsson recently presented a review of these works [2]. Furthermore, investigations in the Stockholm [3], London [4] and Budapest [5] underground systems have shown particle mass concentrations in the range of 300–1000 $\mu g/m^3$ much higher than the upper limit for urban traffic in the EU, which is 50 $\mu g/m^3$ per day [6].

The purpose of the research presented in this paper is to experimentally evaluate the number, concentration, size distribution, morphology, and element analysis of airborne wear particles from typical organic brake pads. A series of field tests and their simulations on a pin-on-disc machine using the same sliding velocity and contact pressure have been performed.

2. Experiment set-up

Two different set-ups were considered for the experiments. A series of full-scale field tests were performed with a Regina X54 test train. The main reason for conducting the pin-on-disc laboratory tests was to clarify the results from the field test (e.g., to be able to distinguish the airborne wear particles that originate from the brake disc from other particles in the surrounding environment).

In both field and laboratory tests, typical organic brake pads (Becorit 950-1) were tested against steel brake discs. The chemical compositions of these braking components are reported in [7]. Airborne wear particles were collected on filters during testing and subsequently analysed with a scanning electron microscope (SEM) and energy-dispersive X-ray spectroscopy (EDX).

2.1. Field tests

A Regina X54 train was equipped with particle measurement instruments at two different sampling points. The field tests were conducted in normal traffic conditions on a regular Swedish intercity track over the course of three days.

The test route is shown in Fig. 1. The maximum allowable operational speed of the train was 200 km/h when both mechanical and electrical brakes were active (although the speed was reduced to 180 km/h when the electrical brake was deactivated on purpose). The train followed normal traffic operation when it was on the main

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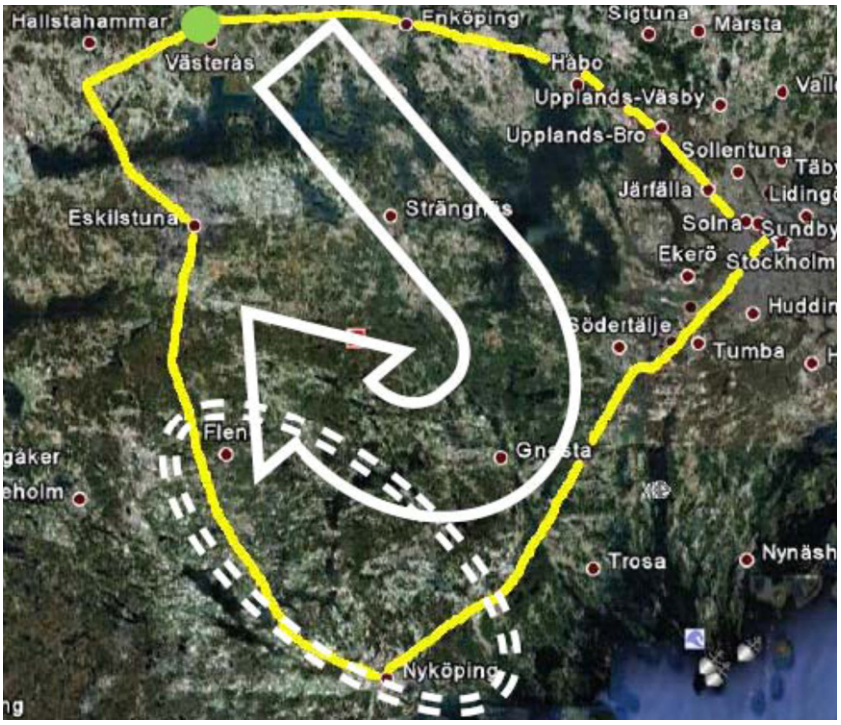

Fig. 1. Field test route, with the industrial track between Nyköping and Flen highlighted.

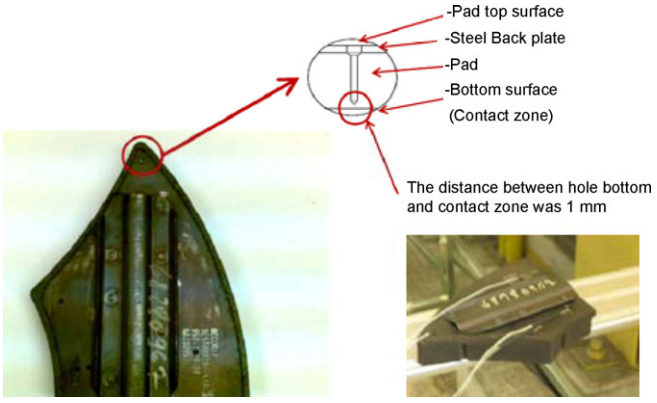

Fig. 2. Thermocouples positions in the brake pad (main brake pad).

track. Some tests were conducted on an industrial track, where the maximum operational speed was only 90 km/h. As that area was rather isolated from disturbance and noise, most of the data was gathered from that region. The climatic conditions of this route during test runs are reported in [7].

The compact brake caliper used was RZS, and Becorit 950-1 was used as the brake pads. The brake disc was made from steel. The train's weight was 62,500 kg and the brake percentage was 150% during operation. The test train was equipped with measurement devices to measure and record speed, and total electrical and mechanical brake force on each axle. The data acquisition frequency was 10 Hz. Fig. 2 shows four K-type thermocouples inserted in the main brake pad. Particles generated from pad-disc contact were investigated by particle measurement devices.

Two sets of DustTrak, Grimm and P-Trak were used in two different sampling points (see Fig. 3). One sampling point was located 145 mm far from the main brake pad. During braking, it was highly exposed to the particles generated by the main brake pad. We refer

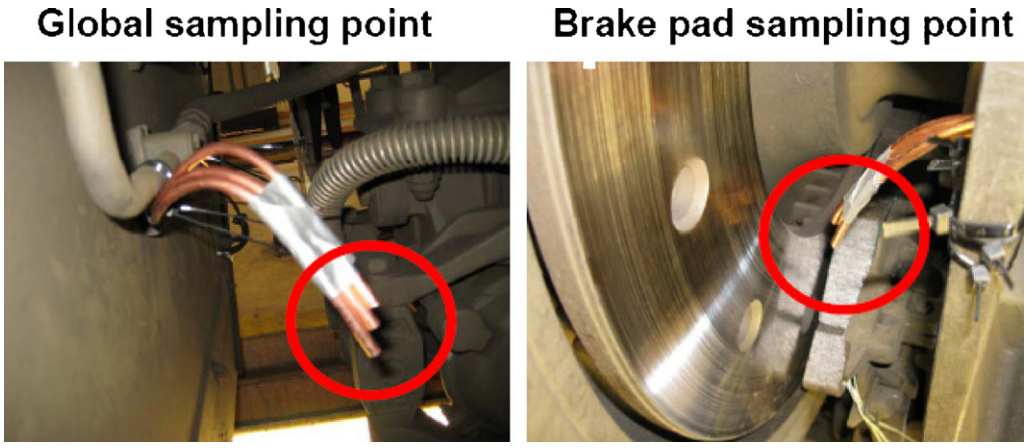

Fig. 3. Two sampling points, brake pad sampling point (right) and global sampling point (left).