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ABSTRACT

PRESENTATION

PAPER

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# MEASURING WHEEL-RAIL WEAR IN REAL OPERATION USING THERMAL IMAGING

It is impossible to directly observe wheel-rail interface during real operation of a rail vehicle and measure its instantaneous wear index. The idea to tackle the problem was to utilize thermography, which allows us to identify the thermal fields distribution as well as to read temperature values in the wheel-rail interface basing on infrared radiation emissions of regions adjacent to the contact area. The temperature increase stands for a change of internal energy of molecules constituting the wheel, which in this case is supplied by frictional heat, which in turn can be associated with frictional wear of wheel-rail pair. On this basis, a novel method was formulated to measure the instantaneous wear of wheel and rail using non-contact thermography measurements. So far, only qualitative approaches have been made to determine the type and location of wheel-rail contact. Reading contact parameters based on the temperature of the surface that has just left the contact, and not the temperature of the contact itself, required the development of a new approach to indirect measurements. The macroscopic temperature of the contacting bodies changes with relatively high inertia (increasing with their dimensions and the value of specific heat), but the temperature in the contact area itself changes rapidly and takes on higher values than in the surrounding material. It is called flash temperature and its trace can be observed even at some distance after leaving the contact area on the wheel circumference. The flash temperature value depends, among others, on: distance to the contact area, physical properties (such as coefficient of heat distribution between bodies, thermal conductivity, convection, radiation, specific heat, etc.) and ambient conditions. Another challenge are polished surfaces of wheels and rails resulting in low emissivity coefficient, around 0,20, giving uncertain results. In this case the concavity effect of the wheel-rail pair was used so the measured local effective emissivity coefficient was confirmed around 0,92.

The relation of the observed temperature in the vicinity of wheel-rail contact and instantaneous wear intensity is evident, but impossible to read directly. Thus, there was a need to elaborate dedicated algorithm to identify the wheel-rail wear intensity basing on data derived from thermograms. The reference dataset to teach the algorithm was the measured signal of friction work between wheel and rail obtained on a laboratory roller rig built especially for this purpose. The laboratory test rig enables recreation of real wheel-rail interaction range (rolling speed, lateral displacement, angle of attack between the wheel on the rail and vertical load) and also takes into account the operating conditions (air flow, ambient temperature, presence of third bodies and pollutants such as sand, water, oxides, wear products etc.). Numerous test runs were performed to teach the algorithm to correctly recognize the instantaneous intensity of wheel-rail wear.

The target measurement system consists of two FLIR A700 cameras (one per one wheel of a wheelset), GPS (for recording speed and correlating thermograms with track topology) and a PC gathering recordings. A low-floor tram was selected for test object as trams produce considerably high wear regimes on rails due to small radius horizontal curves and lower, general maintenance level than regular railways. The analyses had to exclude material from passages through switches and crossings, where the deformation of the wheel and rail material is also responsible for generating heat.

The performed real operation tests proved the plausibility of the adopted methodology as the algorithm produced higher wear index values in locations potentially prone to high wear (traction, braking, tight curve negotiation, rapid changes of contact position on wheel etc.) and low on well maintained tangent track sections with steady position of the wheelset. The algorithm is supplemented by a classificator (from another study of the team) enabling to automatically determine the type and location of wheel-rail contact to better understand the causes of observed wear index values. Another advantage of the developed measurement system is the ability to indicate the location and operating conditions for which the wheel climbs onto the rail, which implies an increased risk of derailment.

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