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DAMPING OF RAILWAY BRAKE SQUEAL

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INTRODUCTION

This work was carried out in cooperation with the Danish State Railways. The aim of the project was to find methods to prevent or to damp the brake squeal typical for a certain Danish type of passenger coach. The present paper describes a series of experiments on increasing the damping of the railway wheel.

BRAKE SQUEAL

Brake squeal is an intense, high-pitched noise occurring with some types of railway coaches supplied with tread brakes and cast iron brake blocks. The sound pressure level of brake squeal is of the order 90-105 dB re 20 µPa at 6.5 m distance from the wheel and consists mainly of a pure tone in the range 4.5-5 kHz. Brake squeal occurs randomly and only during the last stage of a stop when the speed is low. In dry weather and when wheels and brake blocks are hot from previous stops, brake squeal occurs most frequently. The brake squeal is mainly emitted from the wheel disk (the web). When squealing the web performs a simple vibrational mode with the rim and the hub fixed, with no radial nodes and maximum amplitude at about r = 220 mm. This mode, where the entire web vibrates in phase, is an effective radiator. The loss factor of this mode is about $\eta = 10^{-3}$.

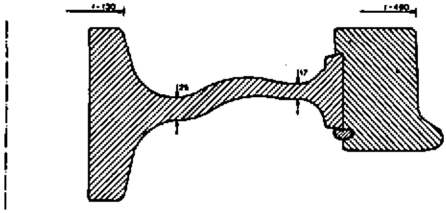

Fig. 1 Section of railway wheel

LABORATORY EXPERIMENTS

In the laboratory a number of different damping devices were tested. A railway wheel was equipped with a set of worn-in brake blocks, which were mounted in a fixture allowing a certain brake pressure to be applied. The wheel rim was excited radially with constant force by an electrodynamic exciter energized by a 1/3 octave filtered pink noise signal. The acceleration level was measured in three points normal to the web. The attenuation of a certain damping device was expressed as the difference between the acceleration level measured without any damping and the level obtained with the same exciting force and the device in place.

Absorbers

In one experiment six vibration absorbers were mounted equally spaced on the web at r = 230 mm. The absorbers were made from 8 mm steel plate, cut to seven fixed-free beams each $8 \times 9 \times 30\ mm^3$. The absorbers were damped by application of an 0.5 mm viscoelastic foil (IAMA VS) and a constraining layer of 0.8 mm steel. The application of the viscoelastic damping increased the attenuation of the absorbers from about 5 dB to 10 dB at 4-5 kHz. Six 8 mm machine screws, glued to the web, served as mountings. The total weight of six absorbers inclusive mountings was 2 kg.

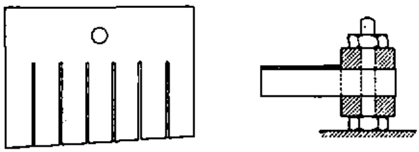

Fig. 2 Vibration absorber

Viscoelastic damping ring

In another experiment an 0.5 mm viscoelastic foil and a constraining layer of 15-20 mm polyester were applied in a ring between r = 190 mm and r = 250 mm. The polyester was filled with dried and screened fine gravel to increase the elasticity modulus. The weight of the entire damping ring was 3 kg.

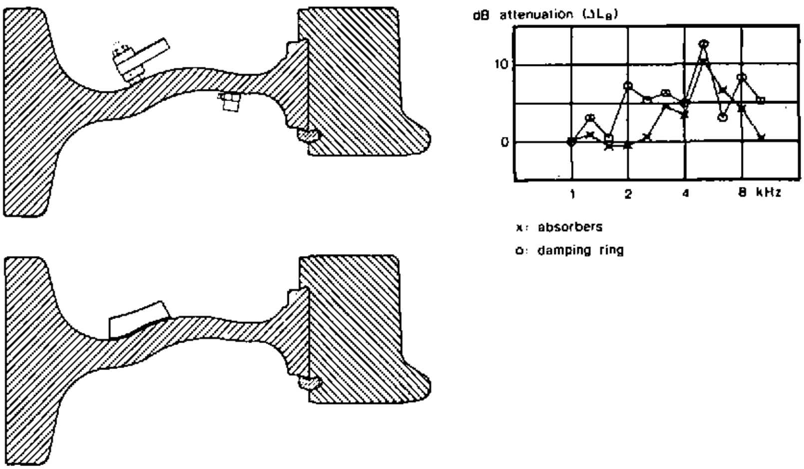

Fig. 3 Laboratory experiments and results

EXPERIMENTS WITH A PULLED COACH

After the laboratory experiments the damping devices were mounted alternately on one wheel set of a two-bogie coach. The other wheel set of this bogie was supplied with asbestos brake blocks (Jurid 82) to prevent these wheels from squealing. All wheels of the second bogie were untouched. The coach was pulled with drawn brakes at a speed of 4 km/h, and the sound pressure level was measured 0.7 m from the wheel. The attenuation of the damping devices was expressed as the difference between the sound pressure level measured without any damping and the level obtained with the device in place. These two measurements were performed immediately after each other.

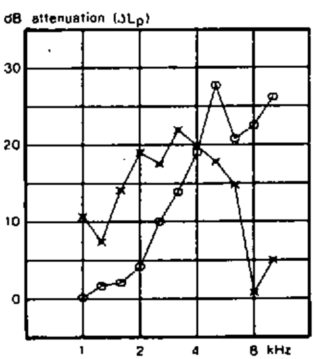

Fig. 4 Results from experiments with a pulled coach

Only the periods where the wheels squealed or showed a tendency to squeal were analyzed. The total integration time including several squeals was about one minute.

CONCLUDING REMARKS

In the laboratory experiments attenuations of about 10 dB were obtained at 4 and 5 kHz whereas in the experiments with a pulled coach values of about 20 dB were reached. These results indicate that the applied damping does not only attenuate the vibrations of the web and consequently the emitted noise but that it also acts upon the force exciting the vibrations. This leads to the assumption that brake squeal is caused by a positive feedback mechanism: An initial variation of the brake pressure due to e.g. wheel surface roughness causes the web to vibrate, which in turn causes a further variation of the brake pressure and so on until a stable squealing state is reached. With this sort of noise generating mechanism a small increase of the system loss factor will result in a large noise reduction.

REFERENCE

A report about the experiments is scheduled to be published by the Danish Acoustical Institute within this year.