Influence of impurities between train wheels and wheel damper on the effectiveness of the damper

Martin Fehndrich

Bochumer Verein Verkehrstechnik GmbH, 44793 Bochum, Germany, Email: fehndrich@bochumer-verein.de

Introduction

Wheel vibration absorbers by Bochumer Verein Verkehrstechnik (BVV) are successfully used with train wheels for vehicles of the light and heavy rail to avoid curve squeal and to optimise the level reduction of the rolling noise.

Anyhow, curve squeal occurred at individual vehicles in distinct cases.

An investigation of the concerning wheel dampers did not lead to explanatory results. These results could not be reproduced by measurements at similar wheels on the test stand, either.

As working hypothesis, we assumed that impurities on the contact surface of wheel and damper had reduced the damping behaviour. Measurements with a layer of a model dirt are presented. They can explain the effect, as the damping of the wheel was reduced clearly.

Therefore, we developed new dampers, which are insensitive to such dirt layers. The effectiveness of the new damper can be shown on the basis of test results conducted during rides with trams in different cities.

Einfluß von Verunreinigungen zwischen Schienenrädern und Radschallabsorbern auf die Wirksamkeit der Absorber

Radschallabsorber der Bochumer Verein Verkehrstechnik GmbH werden erfolgreich bei Rädern von Schienenfahrzeugen des Nah- und Fernverkehrs zur Vermeidung des Kurvenkreischens bzw. zur Pegelreduzierung der Rollgeräusche eingesetzt.

In Einzelfällen ist es im Einsatz bei einzelnen Fahrzeugen zu Kurvenkreischen gekommen.

Eine Untersuchung der verwendeten Radschallabsorber ergab dabei keinerlei Auffälligkeiten, die das erklären können. Auch durch Messungen an einigen Rädern auf dem Prüfstand konnten diese Ergebnisse nicht reproduziert werden.

Eine daraufhin aufgestellte Arbeitshypothese ist, dass Verunreinigungen der Radoberfläche an der Anlagestelle zum Absorber dessen Wirkung reduziert hat.

Es werden Messungen mit einer Modellschmutzschicht vorgestellt, die den Effekt erklären und bei der die Absorberwirkung am Rad deutlich reduziert wird. Daraufhin wurden neue Absorber entwickelt, die gegen solche Schmutzschichten unempfindlich sind. Die Wirksamkeit der neuen Absorber wird anhand der Ergebnisse von Probefahrten gezeigt.

Wheel vibration absorbers

The BVV absorbers consist of a sandwich structure with layer of metal and elastomer (see Fig. 1). Absorbers against curve squeal are optimised to the wheel's two lowest axial eigenmodes, with two and three knot lines (Mode(2,0) and mode(3,0)).

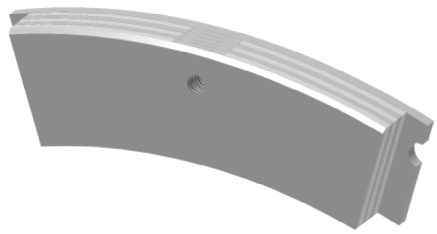

Figure 1: Wheel vibration absorbers

The damping behaviour is shown by a transfer function which is the relation of force induced by a shaker and the acceleration measured with an accelerometer (see. Fig. 2–8). It is shown at a dB-scale based on 9,81 m/(s²N).

The transfer functions are measured at the test stand in the factory (Fig. 6-8) or at the vehicle of the operator (Fig. 2-5).

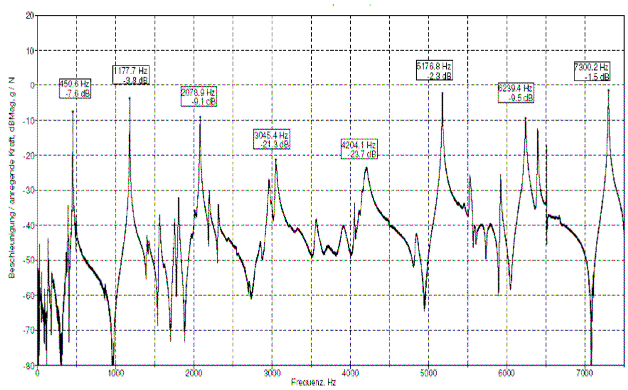

Figure 2: transfer function undamped wheel operator A

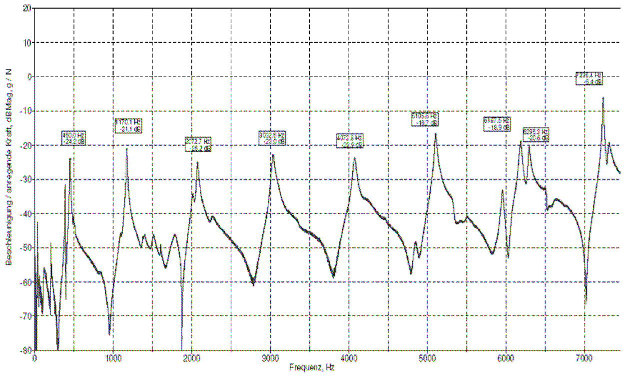

Figure 3: transfer function damped wheel operator A

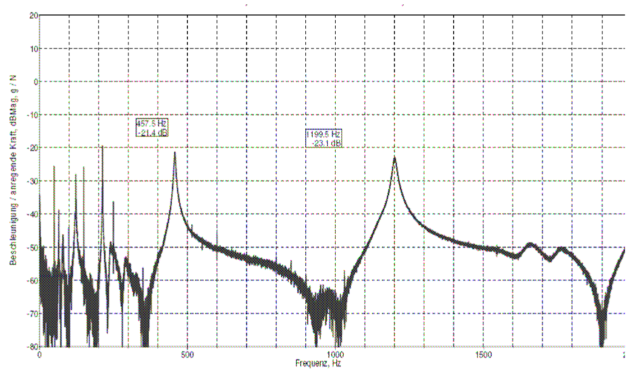

Figure 5: transfer function measured after cleaning the contact surface of the wheel, measured at vehicle of operator A. Maximal peak level of mode(3,0) resonance is –23.1 dB.

Possible problems at some Operators

Few cityline operator (solid wheels, wheel set load 10-11 t) observed sometimes a dissatisfying level of curve squeal at individual vehicles in distinct cases. The measurement of the transfer function of a wheel indicated a reduced damping of mode(3,0) (~ 1200 Hz). This reduction wasn't observed for the same damper disconnected from the vehicle and assembled on a test wheel in the laboratory.

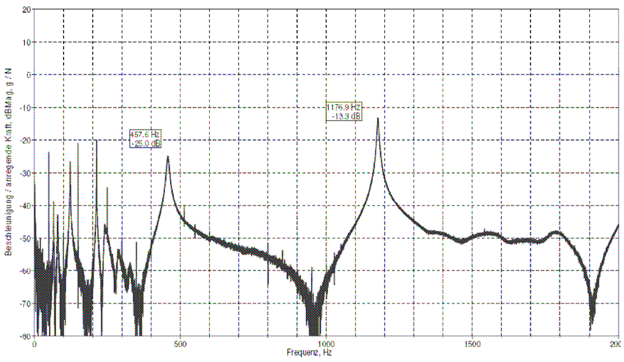

Figure 4: the wheel's transfer function at the vehicle (operator A) before reassembling. Maximal peak level of mode(3,0) resonance is –13.3 dB.

This leads to the first practical solution, the reduction wasn't observed after cleaning the contact surface of wheel and damper and reassembling the damper at the wheel at the vehicle.

Working Hypothesis

As working hypothesis we assume, that there are impurities ("dirt") on the contact surface. This impurities reduce the contact of damper and wheel, making them less efficient.

Model dirt – corrosion preventive coating

Testing different kind of dirt's we ended up with a "good" model dirt, a corrosion preventive coating, with low viscosity, which is normally used to protect wheels on sea transports.

This coating was painted on the contact surface between damper and a solid wheel before attaching the damper. The wheel is normally equipped with two kind of damper. One kind of damper optimised for mode(2,0), the other to damp mode(3,0). In the transfer function the damping of mode (3,0) is reduced (see Figures 6 and 7, for Peak values see table 1).

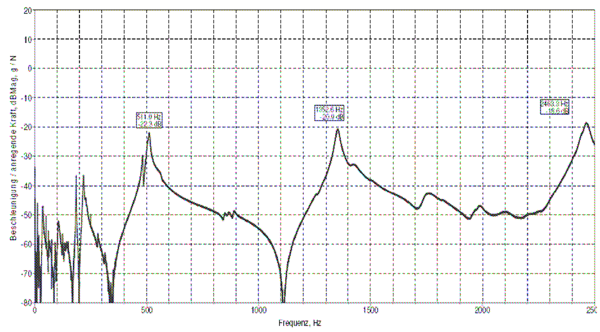

Figure 6: the wheel's transfer function at test stand (wheel for operator B) original damper (see no. 2 in table 1)

The damping of mode(2,0) is only little reduced, the same is true for the higher modes (4,0), (5,0) etc. which seem not influenced by the impurity layer.

However the reduced damping is still much better than the wheel without any damper (compare table 1, no. 1).

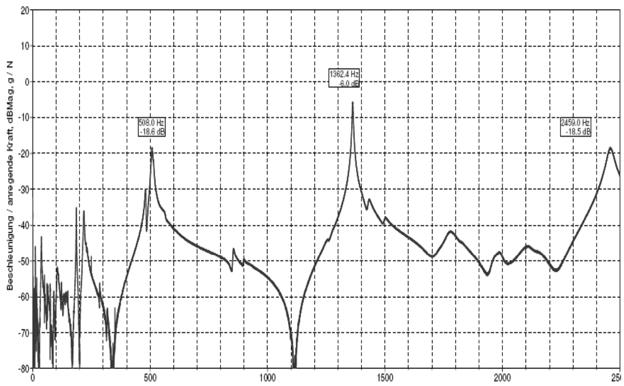

Figure 7: the wheel's transfer function at test stand (wheel for operator B) original damper with impurities painted on contact surface (see no. 3 in table 1)

New non-sensitive damper

Too make this effect less probable, new damper were developed, which should avoid this behaviour for mode(3,0). This new damper were tested the same way with the model-dirt. The damper for mode(2,0) weren't changed, since that mode wasn't much influenced by this impurities.

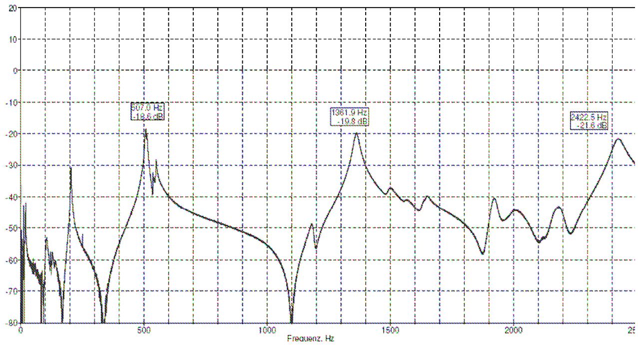

Figure 8: the wheel's transfer function at test stand (wheel for operator B) with new developed damper with impurities painted on contact surface (see no. 7 in table 1)

Accelerance [dB Re g/N]		Maximal peak Level for first three axial Modes		
		500 Hz	1300 Hz	2400 Hz
1	not damped	-0.2	+0.2	+13.6
2	old/clean	-22.3	-20.9	-18.6
3	old/unclean	-18.6	-6.0	-18.5
4	old/clean	-21.4	-22.1	-19.5
5	old/clean	-21.0	-19.0	-19.6
6	new/clean	-24.0	-21.0	-22.4
7	new/unclean	-18.6	-19.8	-21.6
8	old/unclean	-18.0	-6.9	-18.2

Table 1: Maximal Peak Level of the transfer function. The numbering of measurements is shown chronologically.

Test drive

The new damper were tested on a vehicle of operator B and compared to the current damping system. There were two testing days (nights). The test curve was chosen by the operator as "squealing" and is located in a tunnel to be weather independent. Microphones were near the wheels of the very first wheel set in the front of the vehicle. On day 1 we only used the test vehicle before changing the damper (constellation table 2, line no. 2). At first the test speed was chosen by going with different speed levels up to 50 km/h and choosing the loudest level. The subjectively chosen test speed was 45 km/h.

There were always three drives with this speed. On day 2 we used a reference vehicle too. At the test vehicle the damper of the wheels at the first half were changed to the new type. The reference vehicle had slightly other wheels, an other bogie and a different damping system (all non BVV). It is used as a reference for squealing.

Variant		Averaged acoustic Level	
		L_{Aeq} [dB(A)]	L_{AFmax} [dB(A)]
1	New damper	108.8	114.1
2	Old damper	110.4	117.4
3	Reference veh.	111.9	118.1

Table 2: Averaged Acoustic Level in Curve

Table 2 shows the acoustic level near the inner wheels while going through the test curve with 45 km/h. Each Line shows the arithmetic average of the three levels L of three drives. Average time for L_{Aeq} is 10s.

The level of the drives with the wheels damped with the new damper (table 2, line 1) are lower than the level of the reference drives with old damper (table 2, line 2) and significant lower than drives without BVV damping (reference vehicle, table 2, line 3). Real squealing only occurred with the reference vehicle. The level of the test vehicle contains higher contributions of non-squeal noise (rumbling).

With similar absorber for operator A we got similar results during a test drive.

This shows that the new damper work sufficient and it indicates an improvement to the current damper.

Conclusion

Impurities between absorber and wheel can reduce the effectiveness of wheel vibration absorbers. The effect is significant and reproducible for a found special "dirt" and mode(3,0). It is not clear, why almost only mode(3,0) is concerned. A damper was developed where the effect was reduced significantly and almost vanishes.