Eigenfrequency shift of railway wheels due to wear

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Introduction

The squealing noise emitted by railway vehicles has a high acoustic level and narrow frequency spectrum ([1],[3]). This suggests that only few eigenforms are involved and therefore the modal characteristics of the wheel have to be studied in detail. The wheel diameter changes due to wear and regular maintenance reprofiling which influences the eigenfrequencies of the wheel [2]. The finite element (FE) modal analysis and the associated experimental validations, as well as first steps for identifying the squealing eigenform are presented.

Wheel type

The wheel considered in this analysis is the one of the driving trailer of a suburban train. It has a diameter which can be between 760mm and 820mm and a weight varying from 180kg 260kg according to the diameter.

Validation of the FE model of a separate wheel

In order to study how the wheel diameter reduction affects the modal characteristics of the wheel, the FE model has to be reliable for the maximal as well as for the minimal diameter. The simulations of a new and of a completely worn wheel have been validated (Table 1) by laboratory measurements performed with a laser scanning vibrometer (Figure 1). Attention has been paid to consider the appropriate boundary conditions in the FE analysis.

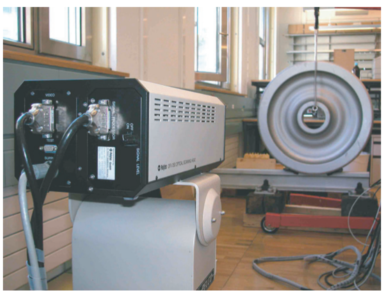

Figure 1: Measurement setup. Foreground the Laser Scanning Vibrometer's Head (Polytec PSV300), background the wheel.

	FE	Measurement
Wheel 820mm	3882 Hz	3953 Hz
Wheel 820mm	4756 Hz	4838 Hz
Wheel 820mm	4079 Hz	4091 Hz
Wheel 760mm	3501 Hz	3497 Hz
Wheel 760mm	4256 Hz	4267 Hz
Wheel 760mm	4939 Hz	4966 Hz

Table 1: Some results for the new and the worn wheels.

Validation of the FE model of the mounted wheel

The boundary conditions of a mounted wheel have been considered in the FE analysis. The associated measurements, performed on a mounted wheel, validated the FE calculations. (Figure 2).

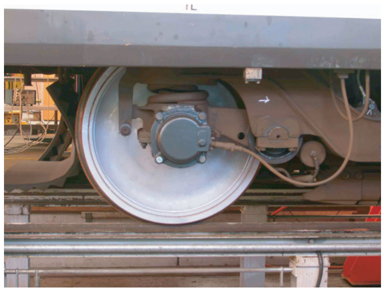

Figure 2: Measurement performed on a mounted wheel. Special painting has been applied to improve laser reflection.

The frequencies considered were up to 6000 Hz as typically the squealing occurs between 3000 Hz and 5000 Hz (Figure 3).

Frequency shift due to wheel diameter reduction

The validated FE model has been used for studying the frequency shift occurring as the wheel diameter reduces. The diameters considered were 820mm, 800mm, 780mm and 760mm. Starting from the results for a wheel with a diameter of 820mm the eigenforms have been followed in order to see the frequency shift (Figure 4).

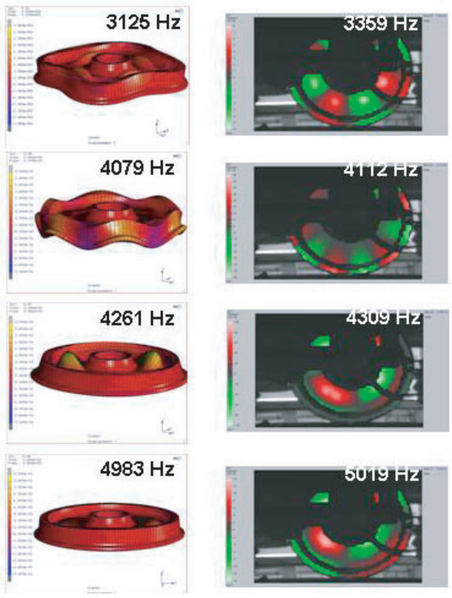

Figure 3: Left FE simulation. Right Measurements.

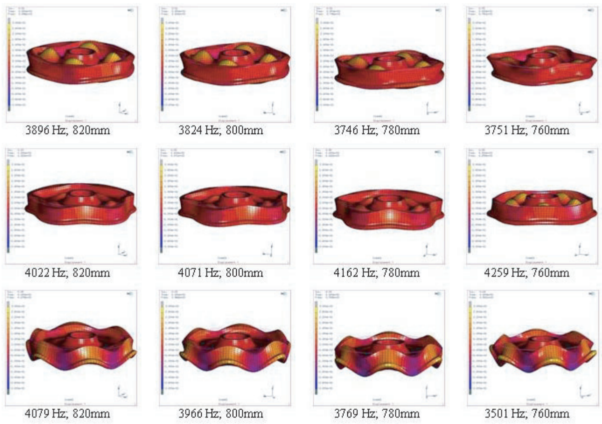

Figure 4: Example of three different eigenforms (vertical) with the associated eigenfrequencies at the considered diameters (horizontal).

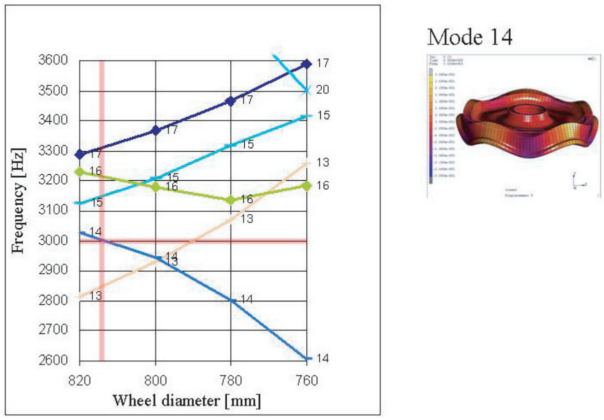

Figure 5: The vertical and horizontal lines identify the coordinates of the squealing wheel.

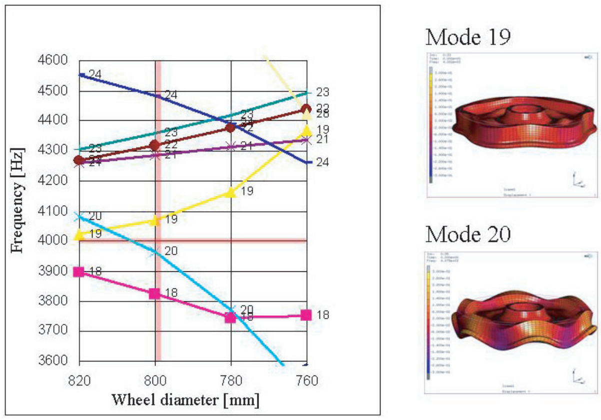

Figure 6: The vertical and horizontal lines identify the coordinates of the squealing wheel.

Identification of the squealing eigenform

On a first campaign of measurements, the wheel diameter of all the considered type of wheels have been measured. It has been possible to identify two squealing wheels of two different trains with a squealing frequency of 3kHz and 4kHz and a diameter of 814mm and 797mm respectively. These data have then been introduced in the plots of the eigenfrequency versus wheel diameter (Figures 5 and 6).

Conclusions and further research

With this approach it should be possible to experimentally identify the squealing eigenforms and to determine if the wheel diameter plays a significant role in the occurrence of train squealing. At the moment the measurements are not sufficient for making definitive conclusions, but further measurement are planned.

Acknowledgements

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