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Quellenseparation bei fahrenden Zügen mit Hilfe von Schalldruck- und Schallschnellemessungen

Summary

Tracked vehicles give rise to various sound sources with differing characteristics, depending on the particular vehicle and its condition. In order to improve the accuracy of sound propagation predictions of railroad cars, a differentiated description of these sources is of great importance. In this respect, it is essential to be able to assess the individual partial sources as a function of height. Until now, the only method of separating the sources geometrically has been with the array technique. Here, the sound pressure is determined simultaneously with multiple microphones. The technique is quite demanding with respect to technical equipment as well as the data analysis. Within the framework of this dissertation an alternative method is presented. The method was developed with a goal of being able to measure the partial sources with reduced effort, respectively lower costs. The method was developed with a view of applying it to moving railroad cars and was tested with numerous field measurements; however it may also be employed to measure other complex sound sources, whether stationary or in motion.

The measurement technique is based on the combination of a sound pressure transducer and two sound velocity transducers, all of which are positioned at one point. The velocity transducers are thus employed as directional microphones. Thanks to their directional characteristics they allow a focusing toward the region of the desired source. From the three measurement signals six independent acoustical quantities may be obtained, namely the sound pressure level, two sound intensities and three sound velocity levels. Based on the level differences between these quantities the centre of sound propagation may be derived and in a temporal diagram the sound sources may be localized at various heights along the vehicle surface. In the data analysis the signals are integrated over a selected time segment of the pass-by and are then applied to a system of propagation equations which simulate the pass-by numerically. Considering the measurement uncertainties, simulation calculations show that this over-determined equation system for sound intensity transducers can be solved successfully for situations having up to 15 dB(A) difference between the partial sources. The source strength of the stronger primary source can thus be determined with a standard deviation of 0.4 dB(A) and the secondary source with an uncertainty of 1.6 dB(A). The source positions can be identified with a standard uncertainty of 0.2 respectively 0.9 m. The method is not recommended for separating three or more sources as the uncertainty increases notably. Nevertheless, the test calculations show that even in such complex situations the total sound power as well as the centred of propagation can be modelled correctly by assuming only two sources.

With a separation into two source regions, the respective sound powers can be determined with accuracy and a resolution comparable to that obtained by the array method. The separation into only two partial sources appears acceptable for the present application, since a separation of the sources in the top region from that of the dominating rolling noise is usually sufficient. An exact source localization is less successful with the present method than with the array method. Compared to the dimensions of the vehicle, a relatively large zone of uncertainty remains for the weaker source. Therefore, the successful application of the method requires an a priori knowledge of the position of the sound sources under investigation, which however is normally the case for tracked vehicles. The method presented here thus cannot fully replace the array method but offers a viable alternative for many problems.

Thesis can be ordered at:

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