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MITIGATION OF RAILWAY WHEEL ROLLING NOISE BY USING ADVANCED OPTIMIZATION TECHNIQUES

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Abstract: Rolling noise emitted by railway wheels is a problem that affects human health and limits the expansion of the railway network. This problem is caused by the wheel-rail contact, and it is predominant over the rest of noise sources from the vehicle/track system for the usual speed conditions in urban areas. The minimization of rolling noise through changes on the wheel shape by means of the finite element method is discussed in this work, which focuses on potential shape modifications in existing wheels in the form of an optimal wheel web perforation distribution. Such a modification is a cost-effective solution that can be performed in a relatively short term in already manufactured and operating railway wheels. To this end, two objective functions with different computational costs are studied and analysed with several configurations of a genetic algorithm-based optimizer. Both approaches focus on minimizing rolling noise. Approach 1 is based on the minimization of the area below the sound power vs. frequency curve of the wheel, and thus requires solving the system dynamics. On the other hand, Approach 2 is based on the maximization of the natural frequencies of the wheel in order to shift its resonances out of the excitation range, and therefore it only requires a modal analysis. The acoustic radiation analysis is performed through the computation of the normal surface velocities, using a time-domain approach and including a contact filter applied in the track roughness, considered as excitation. Moreover, the structural requirements for fatigue strength in wheels proposed by the optimizer are ensured according to actual standards. Results using Approach 1 reflect that an optimized distribution of perforations on the web of a railway wheel, can reduce significantly the sound power level in the entire studied frequency domain (0 - 5 kHz). This is related to the high sensitivity of the acoustic radiation response with the perforation pattern. Such a phenomenon appears to have a higher impact on noise minimization than that associated with the reduction of the radiating surface due to perforations. The high reduction of the radiated sound power is primarily due to the fact that certain wheel vibration modes with high acoustic contribution are shifted out of the excitation range corresponding to the contact force, this effect being observed in the best solution of Approach 1. Less significant sound power reduction is obtained with Approach 2, although its associated computational cost is considerably lower.