End-of-Line Inspection for Annoying Noises in Automobiles: A Methodology Using Spherical Beamforming

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ABSTRACT

The competitiveness of the automotive industry has driven manufacturers to focus on craftsmanship as a way of differentiating themselves in a market of reliable and durable vehicles. Annoying noises, more commonly referred to as buzzes, squeaks and rattles (BSRs), can occur when incidental impacts and friction occur between moving parts. According to *J.D. Powers, 2007 Initial Quality Survey*, annoying noises such as squeaks and rattles reflect about 6.5% of all customer satisfaction issues. Annoying noise issues represent a tremendous cost to the automotive industry due to warranty (estimated at over $300 million per year). However, the hidden cost of lost sales due to poor perception of vehicle quality and durability looms even larger.

This dissertation seeks to establish the feasibility of a new acoustic imaging inspection methodology for detection and classification of annoying noises in vehicle cabins using spherical beamforming technology. The approach is to evaluate localization accuracy using a series of designed experiments to establish the sensitivity of the system to both source-based and plant environmental factors at their operating limits. The key finding of this research is the relative insensitivity of the system to plant environmental factors such as ambient temperature, microphone sensitivity changes and channel over load events, when compared to source-specific factors such as the frequency of the sound and its location relative to reflective surfaces inside

the vehicle cabin. This conclusion suggests that spherical beamforming systems can provide precise localization data in the plant environment, as long as the incident sound frequency is evaluated at levels over 300Hz.

This dissertation provides statistically significant data on the behavior of spherical beamforming systems in complex enclosures which have been previously unavailable in the research community. The modeling of the individual factors in the reproducibility of source locations enables the identification of conditions for system use and provides the potential for data conditioning. The potential for automating the acoustic inspection process brings many industrial benefits including warranty cost reduction and increased customer satisfaction, as well as the ability to reduce tailpipe emissions from redundant assessments at the assembly plant.