Radiation Characteristics of Grand Piano Soundboards in Different Stages of Production

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ABSTRACT

In an on-going project, a series of radiation measurements is taken on two concert grand piano soundboards. The pianos are accompanied during the entire production process. Measurements are performed at seven discrete stages of the instruments' construction. A noninvasive microphone array method is utilized for the present work. The array consists of 105 microphones successively placed parallel to the soundboard, resulting in a total number of 1289 microphones covering the complete surface. The soundboard is excited using an acoustic vibrator at 15 positions associated with string termination points on the bass and main bridge. Sensors at the driving points measure input force and acceleration. Impulse responses are obtained using a sweeped sine technique. The measured sound pressure is back-propagated to the radiating soundboard surface using a minimum energy method. For the final production stage, i.e. the instrument being completely assembled and concert tuned, a different measurement setup is used: utilizing a binaural dummy head within an anechoic chamber, single notes are recorded. The analysis is divided into three parts: First, radiation characteristics are described as radiated power and radiation efficiency (after Suzuki 1986), as well as the ratio of sound pressure and velocity of the soundboard (after Giordano 1998), to be compared to obtained deflection shapes. Impact of the attachment of components, such as bridge and ribs, on the critical frequency range where the coincidence effect occurs can be given. Second, measured sound pressure is forward-propagated into space surrounding the piano and far field radiation patterns are presented for the first resonances, most important for aural impression. Third, binaural measures (interaural level difference, interaural phase difference and binaural quality index) are utilized to connect the obtained physical data to the sensation of directivity and apparent source width as perceived by a player. The empirical findings will contribute to a software tool, based on a real time physical model, to help piano makers estimate the impact of design changes on the generated sound.