Time-frequency Analysis of Sound and Vibration of Harmonica Reed Blown by Wind Tunnel

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This research investigates the vibrational behavior of harmonica reeds from the Tombo and Butterfly brands. We conducted the experiments by letting the reeds oscillate in a wind tunnel with varying flow rates and different blowing scenarios (single or dual reed). Using a Laser Doppler Vibrometer (LDV), we measured the spectrum and investigated the amplitude ratios between the fundamental frequency and its harmonics, revealing distinct characteristics in the reeds. The signal processing is by fast Fourier transformation and short-time fast Fourier transformation. Furthermore, we observed the frequency drift of the fundamental frequency with changes in flow rate. The research discussed two small peaks located approximately ±4 to 5 Hz away from the fundamental frequency during dual-reed blowing. With a comprehensive analysis throughout the entire blowing period, the transient responses of the reeds provided insights into the damping ratio. In contrast, the steady-state response showed us a musical attribute, i.e., beating, with dual-reed blowing. The theory and simulation of the reeds' resonant frequency were based on the Euler-Bernoulli Beam Theory, but the results did not match well. The discrepancy led us to discover significant reed deformation and thickness variations, requiring further corrections using advanced models based on large deformation theory and functionally graded materials.