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How to include several acoustic characteristics in the design of woodwind instruments?

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Abstract

When manufacturers design woodwind instruments, they must simultaneously adjust multiple aspects of the resonator response. The same resonator is used to play several notes by opening or closing tone-holes, and, for some instruments, the same fingering is used to play several registers. From an acoustic point of view, it means that several characteristics of the input impedance must be simultaneously adjusted: at least the first two resonance frequencies of each fingering. The acoustic models can predict the input impedance from the geometry of an instrument with good confidence. This suggests the possibility to solve the inverse problem through optimization algorithm: obtain the geometry having the desired input impedance. However, this inverse problem necessitates the optimization of several acoustic characteristics by modifying dozens geometric parameters (radius and position of the tone holes, chimney height, etc). A specific strategy is therefore necessary to solve this problem. A collaboration between manufacturers from Buffet Crampon and acousticians led to the development of an optimization tool to aid in the design of new woodwind instruments. The strategy adopted in this tool will be presented and applied to an illustrative problem: the construction of a pentatonic clarinet.

Keywords: wind instrument, optimization, virtual prototyping