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Investigating oboe manufacturing consistency by comparing the acoustical properties of five nominally identical instruments

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Introduction

- What is consistency?

*“With a **hand-built** guitar, you want every guitar to be different and have its **own sound**. But with a **production model**, you want to **standardize** shape, quality, and performance”* Glen Dominick, Senior Manufacturing Engineer, Fender

→ Increasing the ability to produce instruments that have the exact same qualities is a constant aim for large scale musical instrument manufacturers

- Our methodology

Combination of acoustical measurements, geometrical observation and perceptive testing of instruments of the same model:

- Acoustics: Input impedance
- Geometry: Bore profile, holes and pads, potential leaks
- Perception: Discrimination tests (2-AFC) in playing situation

→ Already shown its efficiency for comparing two Pearl River low cost trumpets (Applied Acoustics, 2010)

Introduction

- Oboes under test: Five Howarth S10 student oboes
 - Body made from African Blackwood
 - Thumbplate system
 - Closed hole model with all covered holes

- Are these oboes acoustically, geometrically and/or perceptively different?



First stage – pilot playing test

- Preliminary blindfold playing test by one amateur oboist (me!) suggested there were small but perceptible differences in the playing properties of the five oboes.
- Differences most apparent when trying to play notes at the higher end of the instrument's range, in particular F6.
- Five oboes ranked by oboist in terms of how easy it was to produce F6 cleanly.
- Easiest and hardest to play instruments (oboes A and C) selected for use in larger scale playing test.

Discrimination playing test

- Protocol

- 2 alternative forced choice (2-AFC) with two S10 oboes
- 9 musicians: 4 professionals, 4 intermediates, 1 beginner
- Free to play, 30 sec, 20 trials
- Being considered as able to discriminate the two instruments if number of correct answers at least 16 out of 20 (1% significance level).

- Results

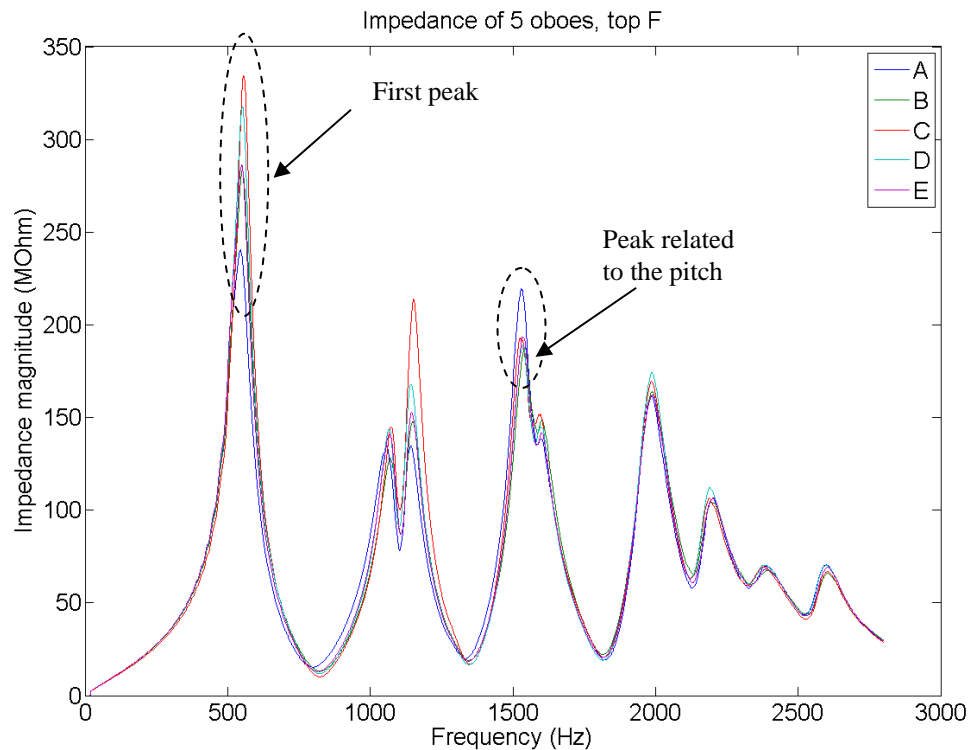
- 6 musicians out of 9 were unable to discriminate the two oboes (all achieved 12 or less correct answers).
- 2 musicians out of 9 were able to discriminate the two oboes by comparing the top F (F6) playability (19 or more correct answers).
- 1 musician out of 9 was able to discriminate the two oboes just by playing in the lower register of the instruments (16 correct answers). He commented that oboe C had a brighter sound than oboe A.

Input impedance

- Input impedance measurements carried out on the five oboes using BIAS system with custom-made adapter.
- Measurements made for every note from Bb3 to F6.
- 32 fingering combinations applied per instrument.
- $32 \times 5 = 160$ sets of impedance data in total !

Acoustical differences for F6

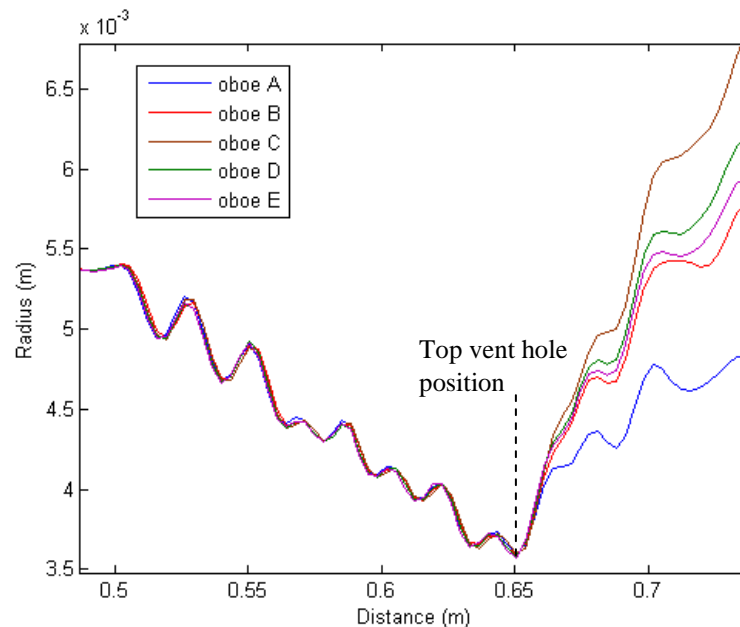
- Impedance magnitudes for the F6 fingering



→ Noticeable differences between the 5 oboes. What are the physical causes of this difference?

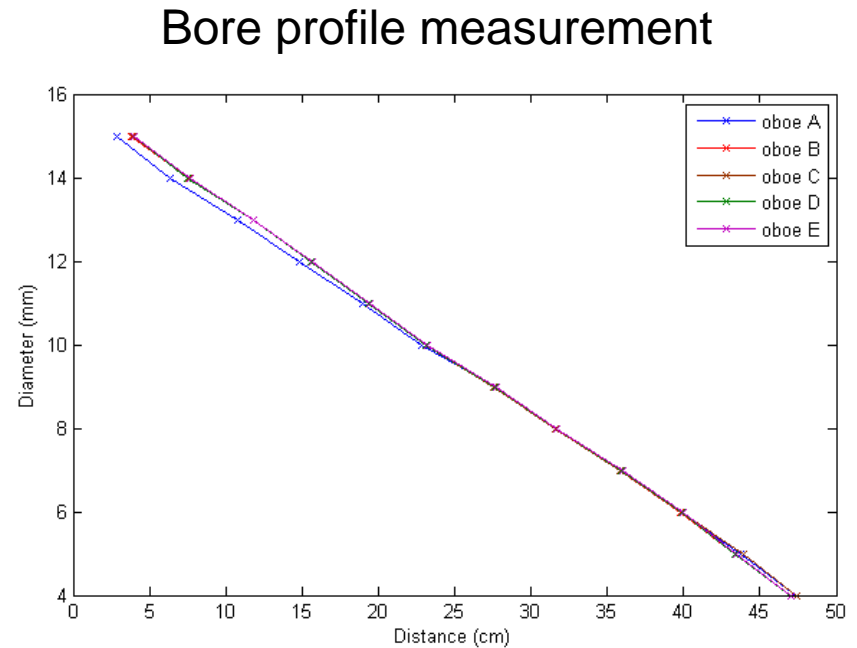
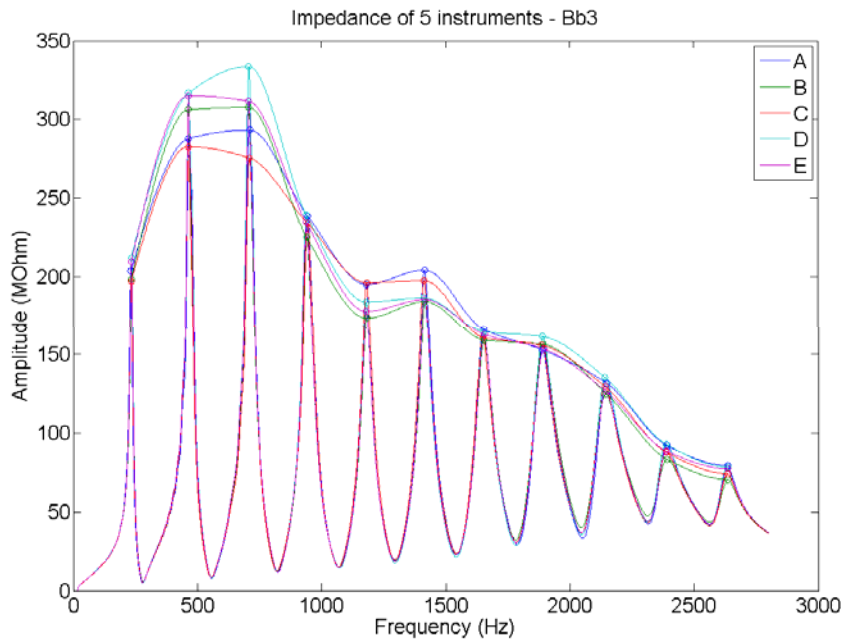
Geometrical differences affecting certain notes

- Fingerings used for notes [(C#5, D5, D#5) , (C#6, D6, D#6, E6, F6)] have an open vent hole in the top joint.
- Reflectometry shows differences in the height of the pad.



Acoustical and geometrical differences for other notes

- Differences for Bb3 fingering



Differences in the impedance partially explained by discrepancies in the bore profiles.

Conclusion

- These five instruments are perceived and measured as being very similar.
- Noticeable differences for several notes, due to the adjustment of the height of the top vent hole. Most clearly perceptible for F6.
- Small differences in the low register, partly related to differences in the bore profiles.