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?
Analysing multiple impedance curves

- New representation of impedance peak data
Analysing multiple impedance curves

- New representation of impedance peak data

I Oboe A: notes ([C#5, D5, D#5] ; [C#6, D6, D#6, E6, F6])

II Oboe C: same notes ([C#5, D5, D#5] ; [C#6, D6, D#6, E6, F6])

III Oboes A and C remaining notes, and all notes for oboes B, D and E
Geometrical differences affecting certain notes

- Fingerings used for notes \([ \text{C}\#5, \text{D}5, \text{D}\#5, \text{C}\#6, \text{D}6, \text{D}\#6, \text{E}6, \text{F}6 ]\) 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 first impedance peak, first register fingerings

Smaller differences but 4 groups (oboé A, oboé B, oboé C and oboes D & E)
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.