Proceedings of The Institute of Acoustics 4E1

MATERIAL VIBRATION AND ITS INFLUENCE ON PERFORMANCE OF WIND INSTRUMENTS

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Wind players have often suggested that alternative materials or finishes should be used in the manufacture of brass instruments in order to attain enhanced musical qualities. Engineers and scientists have generally opposed the musicians' view, believing that choice of material does not affect the musical qualities of the instrument and that players are probably influenced by the wealth of apparently unsubstantiated claims made by manufacturers. Much of the published data which aims to prove one view or the other are suspect in their interpretation. Consequently, a series of experiments has been developed, with the help of other European institutions, to clarify the position.

Boosey and Hawkes required a top quality half-inch bored trombone and to this end, bore shapes had been investigated and modified with respect intonation (1). The next approach was to consider further developments using different materials for bell construction. There are many parameters to consider when choosing materials, but for these initial trials it was thought that the most significant results (if any) would be found by varying the material thickness of the bell flares.

Six brass bells were made on the same mandrel using material of three different thickness and these were compared with several other instruments made by other manufacturers. Professional session players indicated a preference for the prototype B & H trombone with the thinnest bell (2) and on this basis it has been successfully launched as the 937 sovereign studio trombone. The instrument was then used in further experiments, and for this purpose, modified to accept each of the six bells mentioned above.

Knowing that previously published experiments had not shown measurable acoustic differences between different bells, the first approach was to exploit modern techniques in an attempt to detect such differences.

1. Acoustic Measurements

Recordings were made of the sounds produced when a professional played the instrument with the different bells. On analysis, the variability between different tests was greater than the differences between instruments. In order to overcome this difficulty associated with the 'human factor', the impedance of the trombone and bell combination was measured at Surrey University using their speaker driven apparatus (3). The results were again inconclusive.

2. Holography

The same player and instruments were subjected to holographic interferometry to detect the degree of bell vibration. A human player created too much movement obliterating the interferograms, and similar negative results were obtained with pulsed laser techniques. However when an artificial acoustic driver was used to produce time-averaged interferograms, analysis showed a mathematical relationship between the amplitude of vibration of bells of different thickness (4). The strongest resonances were found in the 250 Hz region, with a considerably reduced amplitude for the thicker bells. These results have more recently been confirmed by other techniques (5,6).

3. Artificial Driving

Using a siren, Wogram (7) has produced some of the most realistic steady state trombone spectra. Unfortunately his published results with various bells did not separate the effects due to thickness, chemical composition, or finish.

When his apparatus was used in conjunction with the six bells under study, pressure levels of 90 dB could be obtained on-axis at a bell radius from the rim. The sound at this position was recorded for each of the bells, and a second channel used to record the sound (7 dB lower) through an artificial ear at the normal players' position. For each bell, the notes $B\flat_1$ (58 Hz), $B\flat_2$ (116 Hz) and F_4 (349 Hz) were recorded. The notes were later analysed (up to the tenth harmonic) from which it may be concluded that:

a) The thickness of the bell makes no measurable difference to the spectrum of sound when measured on-axis close to the bell rim.

b) A significant difference in spectra is shown at the players' ear position when bells of different thickness are attached.

c) This difference is demonstrated as (i) a relative increase of the second harmonic of $B\flat_2$ (i.e. at approx. 232 Hz) and, (ii) a relative increase of the fourth harmonic of $B\flat_1$.

d) The note F_4 shows no significant difference for the various bells.

The results so far indicate that the bell thickness (and therefore other parameters affecting the bell vibration) has a significant effect on the sound spectrum measured at the players' ear position. This effect probably radiates from the material itself. Both the holographic an acoustic measurements demonstrate a difference between the various bells. It is likely that such a difference is perceived by the player and therefore is worthy of further investigation.

The assistance of the following is gratefully acknowledged: A. Lincoln, Prosig; B. Clarkson, I.S.V.R.; J. Bousher, Surrey University; K. Wogram, P.T.B. Braunschweig; and The National Physical Laboratory.

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