Measurement of sound and flow fields in an organ pipe using a scanning laser Doppler vibrometer

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Introduction

Sound production in organ pipes is a complex matter involving interactions between flow fields and sound waves. Until now, this mechanism has not entirely been understood. In this paper, the complex interaction between the flow and the sound field in the instrument is investigated by using a scanning laser vibrometer [1]. The measurement results are compared with measurements of two more traditional optical techniques (PIV and Schlieren photography).

Measurement set-up

In order to study the flow in organ pipes by means of optical measuring techniques, a transparent copy of a representative, realistic organ pipe was built. A portable compressor was used in conjunction with a continuous servo valve to generate a certain pressure wave at the inlet organ pipe. The LDV is placed in front of the organ pipe model and a rigid block is used to reflect the laser light (see Figure 1). Note that in contrast to Schlieren photography and PIV no seeding particles nor high density gas had to be used in the set-up.

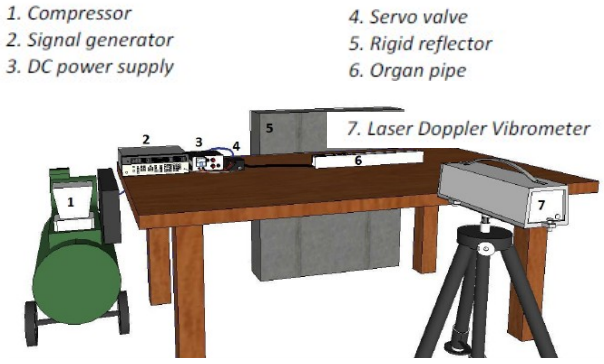

Fig. 1 Schematic set-up of the scanning LDV measurements.

Measurement results

The visualization of the pressure field for the transient stage of sound production are given in Figure 2-top. The LDV measurement clearly shows how the vortex impinging on the labium is split up in an over and under-pressure on the upper and lower part of the labium respectively. This generates a pressure wave that travels along the pipe (this will be shown in more detail in the full paper). The reflection of the wave at the pipe end results in a standing sound wave (see Figure 2-bottom). Note that the standing acoustical wave is not a one-dimensional wave. Because of the opening on top near the mouthpiece the top part of the standing wave agrees to a fully open pipe standing wave, while the lower part agrees with a standing wave of an open-closed tube.

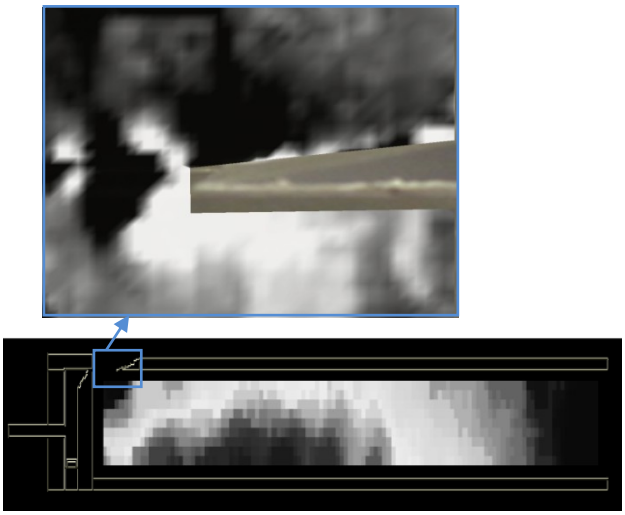

Fig. 2 measurements of the pressure waves near the organ pipe mouthpiece at one time instance (top) and standing wave in the tube (bottom).

References

[1] Vanherzeele J, Brouns M, Castellini P, et al., Flow characterization using a laser Doppler vibrometer, OPTICS AND LASERS IN ENGINEERING Volume: 45 Issue: 1 Pages: 19-26 Published: JAN 2007.