

The largest discrepancy between measurements and predictions is the level which is over an order of magnitude smaller in the predictions than the measurements even when assuming a lossless model.

Discussion

The results show that the current model for the acoustic source is unusable and is clearly excluding an important physical process. The strong asymmetry in the measured pressure signal dictates that the model for the acoustic source must have a dependency on something other than the symmetric motion of the holes. The asymmetry is too weak from friction and small errors in centring the hole motion.

The velocity gradients in the downstream jet lead to a relatively weak source density distributed over a fairly large volume compared to the size of the hole. On the upstream side, the velocity gradients associated with sucking the air into the hole are located very close to the hole entrance leading to a much stronger source density and a significant proportion of the acoustic energy being radiated into the hole. There will be a partial reflection at the junction between the moving and stationary holes and at the exit but this is clearly a mechanism for introducing asymmetry into the simulated pressure signal. It can also be modelled in a form simple enough to be included in the control model subject to determining some empirical information from supporting numerical simulations and measurements.

A physical mechanism for the large difference in level would appear to follow from the upstream plenum and the holes acting as a Helmholtz resonator. The equation [2]:

$$f = \frac{1}{2\pi} \sqrt{\frac{c^2 S}{Al}} \quad (3)$$

with end corrections neglected gives a resonance of 64 Hz which is well inside the intended operating range of the transducer. Again, this can probably be modelled in a form simple enough to use in the control model subject to determining supporting empirical information from numerical simulations and measurements.

Conclusions

Despite the transducer operating at less than 0.1 Mach number and the holes moving several orders of magnitude slower than the air through them, an initial acoustic model based on quasi-steady incompressible flow was inappropriate because of the presence of an acoustic resonance.

Work is currently underway to develop an alternative acoustic model for the control scheme using empirical data determined from numerical simulations using a compressible low Mach number approach.

References

- [1] A. Jakob, M. Möser. Nonlinear models of electro pneumatic transducers for use in feedforward active noise control schemes, Proceedings of ACTIVE 2006, Adelaide, Australia
- [2] A.P. Dowling, J.E. Ffowcs Williams. Sound and sources of sound, Ellis Horwood, 1983
- [3] J. Kim, P. Moin, Application of a fractional-step method to incompressible Navier-Stokes equations, J. Comp. Phys., 59, 308-323, 1985

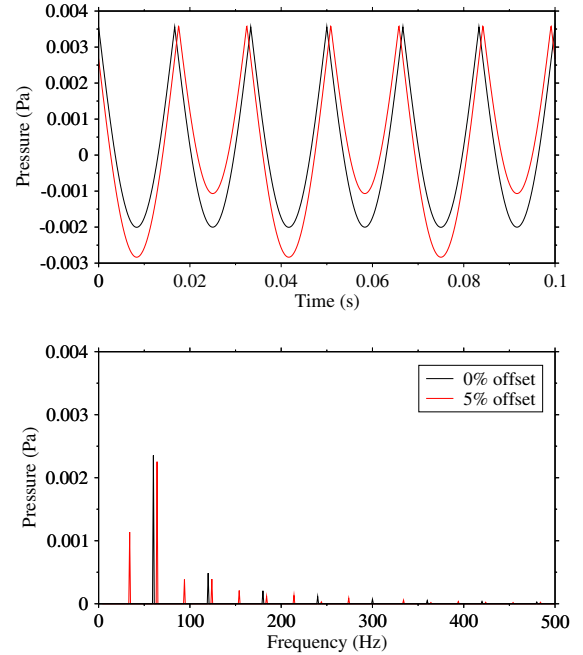


Figure 4: Predictions at 30Hz and 30% movement.

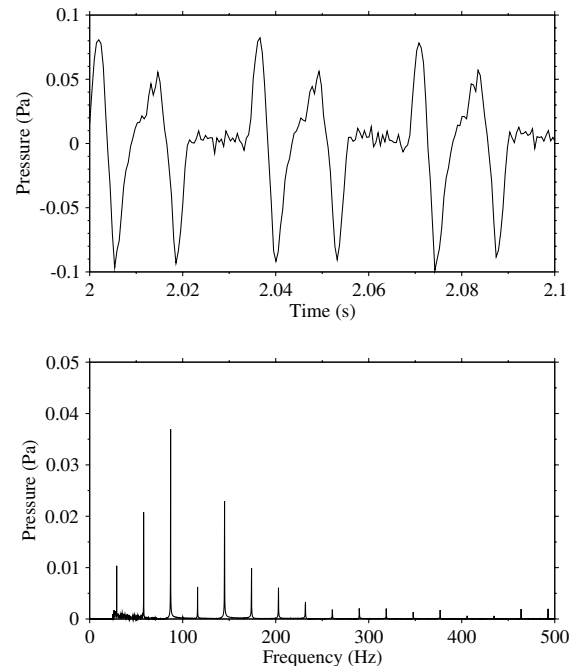


Figure 5: Measurements at 30Hz and 30% movement.