Technical Comments

Comment on "Experimental Investigation of a Cylindrical Resonator"

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IN a recent and interesting paper, Wu et al.[1] have described experiments on what may be termed as an axisymmetrical configuration of a Hartmann-Sprenger tube. The purpose of this Note is to comment on the theoretical and experimental values of the frequency reported by these authors.

First of all, it can be noted that, neglecting boundary effects, the flow in a segment of the axisymmetrical configuration is equivalent to the flow in a tapered Hartmann-Sprenger tube. This latter configuration has been investigated by several authors[2,3] and it has been found that the oscillation frequency of a tube with infinite tapering ratio is roughly 50% higher than that of an untapered tube. The ratio of the acoustical frequency given by the authors for their configuration ($f=c/2.615\ r_o$) to the acoustical frequency of an untapered tube ($f=c/4\ r_o$) where r_o represents the tube length in that case, is $4/2.615=1.530$, in close agreement with the ratio experimentally found with tapered Hartmann-Sprenger tubes.

The dependance of the frequency with the pressure ratio observed by Wu et al. may be explained in the following way: the cycle of a resonator is made of four waves, an incident compression wave (or shock wave), a reflected compression wave, an incident expansion wave, and a reflected expansion wave. For an untapered Hartmann-Sprenger tube, Maresca[4] has shown that the frequency *decreases* with increasing pressure ratio π if the flow oscillations are at their maximum amplitude, that is, when the limit cycle described in Ref. 5 is reached. In that case, the amplitude of the pressure oscillation Δp is increasing with π. This means that the frequency decreases with increasing amplitude Δp. In the tube fixed coordinates, the speed of the incident shock is supersonic and increases with Δp, whereas, the speed of the reflected shock is subsonic and decreases with Δp. The *average* speed of these two waves decreases only very slightly with Δp. What causes the frequency to decrease is that the time required for the expansion phase of the cycle increases with Δp. For a pressure ratio of 2 for instance, the frequency is about 12% lower than the acoustical frequency. This trend will very likely not be affected by the tapering of the tube. Now, in the experiments reported by Wu et al. (see their Fig. 5) above the critical pressure ratio of 3.76, the pressure amplitude Δp decreases with increasing π and this explains the increase of frequency observed with increasing pressure ratio.

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Reply by Authors to E. Brocher and C. Maresca

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E. BROCHER and C. Maresca have attempted to explain the frequency characteristics of the cylindrical cavity resonator by reasoning that a decrease in pressure amplitude leads to a reduction in the duration of the expansion phase of the resonant cycle. In other words, the period of outflow at the mouth of the resonator is reduced which in turn leads to higher oscillation frequencies. This interpretation appears to be the correct one.

However, considering a segment of the cylindrical resonator to be equivalent to a tapered tube resonator is not strictly valid since it is well known that in the latter, reflected waves will be generated at the walls as the shock propagates inwards.[1] For the cylindrical cavity resonator, no such reflections should occur, at least in the ideal case. This is the reason for examining such a configuration in the first place. Ideally, the converging cylindrical shock can achieve significantly greater shock amplification over its plane wave counterpart. The present investigation shows some promise in this regard.

References

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