Experimental investigation of flow control devices for the reduction of transonic buffeting on rocket afterbodies

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In the optimization of launch vehicles, the phenomenon of transonic buffeting plays an important role since it generates high structural loads on the launcher propulsion system (nozzle). The cause of transonic buffeting is the reattachment of the shear layer on the nozzle; see Figure 1. This investigation is aimed at studying the flow field around a rocket after-body in transonic conditions with emphasis on the buffeting phenomenon.

Furthermore flow control devices are investigated that reduce the buffeting phenomenon. In the current investigation chevrons are used that generate stream-wise vortices which interact with the large span-wise vortices that are already present in the shear layer, causing the large span-wise vortices responsible for buffeting to be broken down into small-scale vortices.

In the experiments a blow down wind tunnel was used that generates a Mach 0.7 transonic flow. The wind tunnel model features a cone-cylinder fore-body; see Figure 2. At the base a cylindrical after-body is placed to simulate the presence of the nozzle and the exhaust flow. Velocity measurements have been performed by means of planar PIV and statistical and time resolved data are acquired at 500 Hz and 10 kHz respectively.

From the statistical analysis it is found that the addition of the chevron devices causes a downstream shift of the reattachment location. Furthermore it was found that the maximum backflow velocity in the separated region is increased when compared to a clean configuration. The influence of the chevron devices on the rms velocity fluctuations is minimal.

From the time resolved measurements it is observed that for the clean configuration, the region where back flow occurs grows and shrinks in an oscillatory manner. When the chevron devices are added it is found that in one case, where the chevrons are relatively large, the behavior remains and the back-flow magnitude is increased. For the smaller chevrons it is observed that the oscillating behavior is reduced. From Fourier analysis a characteristic frequency around 450 Hz is found for the freshly separated shear layer. When moving further downstream it is found that this peak is reduced.