Diffraction of shocks, a useful benchmark for compressible CFD codes and the complexity introduced by convex walls

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To establish a benchmark by which to measure the performance of the vast numbers of compressible flow research codes in use at the time Takayama and Inoue (1991) first proposed using the case of a shock diffracting over a 90° corner at the 18th International Symposium on Shocks. The very variable and in some cases rather indifferent results were subsequently published by Takayama and Inoue (1991) in Shock Waves.

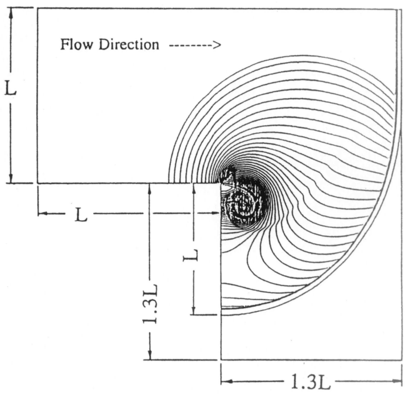

Figure 1. Diffraction benchmark geometry Takayama and Inoue (1991)

This benchmark is still a very useful tool for validating current CFD codes for compressible flows as it contains a number of features with contrasting simulation requirements. The basic benchmark geometry is illustrated in Fig. 1 consisting of an 'L' shaped domain with a Mach 1.5 shock generated at the left-hand most inlet boundary.

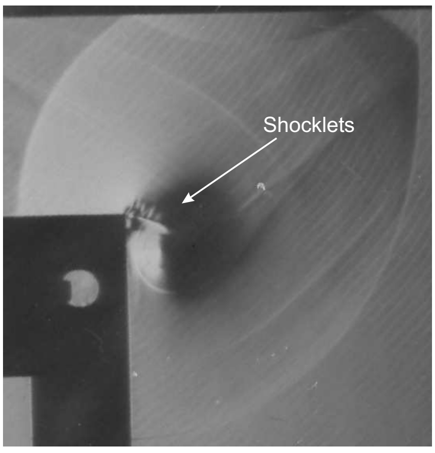

Figure 2. Mach 1.5 shock diffracting around a 90° corner Skews (1967)

Fig. 2 shows a shadowgraph image of a Mach 1.502 shock diffracting around a 90° corner, in which a series of shocklets are clearly identified on a shear layer. The shocklets are a weak flow feature which forms as the flow relative to the shear layer is repeatedly accelerate to supersonic flow and then becomes subsonic across a weak shock. The ability of a numerical code to model these weak features where so many strong features exist, is a relatively rigorous test of a code. The presence of the shear layer also introduces a metastable element into the numerical field which can rapidly degenerate into a non-physical series of discrete vortex elements if perturbed.

The diffraction of shocks around planar walls is very well understood and it is this that makes it such a good benchmark. Recent efforts have looked at shock diffraction around convex walls and a number of flow features have been identified which still need to be adequately explained. Fig. 3 shows a Mach 1.52 shock diffracting around a 30° faceted wall.

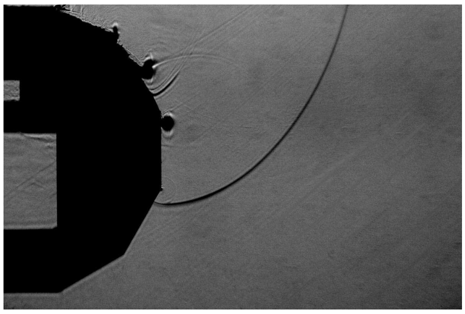

Figure 3. Mach 1.52 shock diffracting around a 30° faceted wall Law et al. (2007)

Many features in the flow in Fig. 3 are similar to those encountered in the benchmark case. Of particular interest in the current study are the near wall features. This work is ongoing.

References

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