OPTICAL STUDIES OF THE FLOW START-UP PROCESS IN CONVERGENT-DIVERGENT NOZZLES INITIATED BY BURSTING A DIAGPHRAM MOUNTED IN THE NOZZLE THROAT

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A large number of studies have been performed in the past to investigate the flow start-up through DeLaval nozzles. But in all of these studies, the flow was initiated some distance upstream from the nozzle so that a
well formed shock entered the nozzle from the upstream side. No such studies ware known for initiating the flow by bursting a diaphragm located in the throat of the nozzle. Therefore, the U.S. Army Ballistic Research Laboratory (BRL) in cooperation with the Ernst-Mach-Institut (EMI) initiated optical studies of the flow start-up in convergent-divergent nozzles which have the diaphragm locates in the nozzle throat.

The photographic flow records were evaluated by digitizing the progression of various flow phenomena, e.g., the incident shock, contact surface and recompression shocks, and entering these data into x-t diagrams. The results were summarized in graphs of significant parameters, e.g., shock formation time, flow start-up period, flow expansion angle and shock strength versus the driver pressure ratio. The experimental results were further compared with numerical results obtained with the BRL-Q1D hydrocode.

This study shows that a pressure loss of 10 percent is connected to the presence of a large area discontinuity at the exit plane of the nozzle throat when no divergent nozzle is attached. The results suggest that a 45 degree divergent nozzle may present an acceptable compromise for minimizing these pressure losses by reducing the associated area discontinuities.

This paper will discuss the various flow phenomena observed, the numerical-experimental comparison and the conclusions drawn.