Spall Experiments in Convergent Geometry Using the Atlas Pulsed Power Facility

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- ☐ **Four spall experiments have been performed using Atlas**
- ☐ **Purpose was to investigate damage in convergent geometry**
- ☐ **Impact pressures ranged between 45 kbars – 110 kbars**
- ☐ **Diagnostics included VISAR and axial and radial radiographs**
- ☐ **Targets were recovered for post-metallurgical analysis**

Atlas: 24 Megajoules of Stored Energy, 30 MA of Peak Current delivered in 4.5 μ s

Spall: “What is it, and how does it occur?”

Consider a free-flying impactor striking a target
The x-t plot describes the chronology of events

- At impact ($x = 0, t = 0$), oppositely propagating shocks are produced.
- At t_1, t_2 these shocks release off the free surfaces and propagate back into the target, where they intersect.
- At this “spall plane” the material is put into a state of tension.
- If the tensile stress exceeds a threshold (Σ), then voids begin to form. These voids can coalesce to produce damage or fracture.

Investigating spall using a gas gun: A thin flyer is launched to shock the target. $\delta/W \ll 1$ mitigates release waves being generated from the edge of the flyer.

Gas-gun spall experiment on copper target using teflon impactor at a nominal stress of 60 kbar.

Johnson et. al., JAP, 86 4892 (1999).

Ringing behavior is due to internal wave reflections, indicating spall has occurred.

Atlas geometry offers a unique environment for investigating damage

- **Liner** serves as the flyer
- **VISAR** views inner surface of target
- **Momentum traps** (not shown) mitigate release waves

Spall Liner/Target Cassette Assembly with CMU containing dual VISAR probes and axial x-ray fluor.

Atlas spall experiments were the first to incorporate momentum traps in convergent geometry

Momentum traps are used to Mitigate 2-D effects resulting from radial release waves.

Compressive waves are transmitted, while tensile waves are not.

Side on radiographic view of liner and target prior to impact ($26.1 \mu\text{s}$) shows excellent symmetry

Late-time radial radiograph shows motion of inner target surface, and region of spalled aluminum

Axial Dynamic Radiographs

VISAR is used to infer spall strength, Σ , and the degree of damage, R

Diagnostic Complement

- Point VISAR (2 points)
 - compare center of target to edge to determine shock uniformity
 - measure free surface velocity
- Radiography
 - attempt to differentiate spalled material
 - correlate with VISAR signal
 - 4 axial views
 - 3 radial views
- Standard machine diagnostics

Post metallurgical analysis of void size and distribution in the vicinity of the spall plane indicates damage depends upon shock amplitude, shape, duration, and material purity

**Voids are
created in
material**

*Shock
Amplitude
Effect*

*Shock
Duration
Effect*