Experimental Methods in Materials for Structural Impact Dynamics

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Characteristics of Structural Impact Dynamics

- Usually involves high rate transient loading on a structure
- Rates are such that both material properties and inertial properties are significant
- Often involves some kind of non-recoverable deformation
- Solutions usually analytically intractable
Historical Techniques in SID Testing

• Development of empirical methods
• Creative and innovative instrumentation techniques
  – Examples – Capacitive velocity measurement (SHB), pressure sensors, etc.
  – Analog recorders – aliasing not an issue
  – Inability to visualize structural response
High Speed Film Cameras

- NAC E-10 16mm high speed film cameras
- 120 m of film in 1 sec
- 0.7 sec to get up to 10,000 frames/sec
- At end, film moving at 75 m/sec
- It took several days to see the results
High Speed Film Cameras

Water Tank Impact Test
High Speed Film Cameras

Water Tank Impact Test Video
High Speed Film Cameras

- 2M frames/sec
- Used to rolls of 35 mm still film
- Rotating lens on a Helium-driven turbine engine
- 40 microsecond recording time
- High intensity flash xenon light source

Cordin Model 330A

Ice Impact Video
Recent Developments

• In the last 20 years two developments have occurred that have significantly changed how we conduct impact testing and other developments have occurred that have changed why we do impact testing

• How:
  – High speed digital video cameras
  – Digital Image Correlation and High Speed Photogrammetry

• Why:
  – Advanced computational modeling techniques which require high quality material property and validation test data
Advances in Measurement Techniques
Example: Open Rotor Test

Open Rotor Test Video
Example: Open Rotor Test

Open Rotor Analysis video
Example: Open Rotor Test

Open Rotor Analysis video
High Speed Photogrammetry

Displacements in Y and Z direction

Quantitative Velocity and Orientation Measurements
Other Developments
High Speed Infra-red Thermal Measurements

T700S/3502 Triaxially Braided Composite
Impact velocity: 190 m/sec
Max temp recorded: 240 C
10000 frames/sec, 156 x 56 pixels

High temperatures during impact will have consequences on new advanced composite impact models
In-Situ Computed Tomography
Advances in Computational Modeling have required advancements in experimental techniques

- Advanced DIC methods:
  - Elevated temperature
  - Very high speed
- Combined stress loading
- Elevated temperature
- High speed infra-red measurements combined with DIC
Advanced Computational Modeling

LS-Dyna MAT224 Failure Surface for Al2024 T3/T351
Artificial Bird Development
SAE G-28 Committee
Simulants for Impact and Ingestion Testing

- The committee has established a set of twelve tests that must be completed to demonstrate that an artificial bird responds in the same way as a real bird.
- The tests range in complexity from relatively simple to very complex.
- It may be possible to perform just a subset of the tests if a bird is being qualified for just non-rotating, or just rotating applications.
- The committee has established a set of documents that are required as shown on a following slide:
  - Main Aerospace Recommended Practice
  - Four slash sheets, each representing one of the levels of the test pyramid
  - One Aerospace Standard Test Method corresponding to each of the twelve tests
- We are currently in the process of developing the Aerospace Standard Test Methods.
G-28 Building Block for Testing

Material, density tests, launching technique

Structural behaviour

Bird related

Component

Sub-Component

Detail

Element

Coupon

Rigid target

Elastic-plastic target

4side/2side

Clamped Plate

Inclined Plate

Normal Edge Inclined Sharp splitter

Hemispherical Leading Edge Skin

Empennage Leading Edge Skin

Static blade assembly

Leading edge assy

Fan

Cascade

Material, density tests, launching technique
ARP 6924 Test Requirements for Qualifying an Artificial Bird for Aircraft Certification Testing

Aerospace Recommended Practice

Slash Sheets

AS XXXX SAE Standard Test Method Measuring the Impact Response of a Soft Body on a Flat Target


AS XXXX SAE Standard Test Method Measuring the Impact Response of a Soft Body on and Inclined Flat Rigid Target
Questions?