SPIFT

New approaches to coating and surface development, by the use of new testing and evaluation methods.
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State of art in rain erosion testing

- Whirling arm tester
  - Strengths
    - Close to reality
    - Proven
    - Recognizable damage
    - Can test small scale system
  - Weaknesses
    - Coarse time steps
    - No way to isolate impacts
    - Rain control
    - Difficult in situ monitoring
      - Water mist
      - No on sample sensors
    - Sample price
What does a good coating need to do?

- Distribute impact energy
  - Thicker layers
    - Expanding shockwave = lower pressure
- Absorbing energy
  - Viscoelastic effects
- High cycle fatigue resistance
- Good adhesion
- Appropriate impact rate compliance
  - Storage Vs. loss modulus
- Environmental stability
  - Temperature
  - Moisture
  - UV
  - Some chemical resistance
Multipel droplet impact

- Moving target
  - $V_{\text{ving}} \gg V_{\text{drop}}$
- Distributed impacts
- No knowledge about each impact
- Time to damage
Single drop impact

- Ideal situation
  - Accelerated single droplets
- Difficult to realize
  - Accelerating a droplet
  - Misting
Single Point Impact Fatigue Testing

• Substituting water drops
  – Polymer pellets
• Known impact location
• Impact speeds similar to droplet impacts
• Controllable impact rate
Single point impact fatigue testing (SPIFT)

- Inspired by the work of G. Prayogo
  - Simulating droplet impact with polymer projectile
- Can mimic speed and energy of droplet
  - 100 m/s to 160 m/s
- Accelerated damage testing
  - 5 impacts per second
  - 1-30 min to damage
- Allows for in-situ damage monitoring
  - Visual with camera
  - Acoustic emission
- Small specimen size
  - cheaper
  - faster
  - more evaluation options
Single point impact fatigue testing

- Inspired by the work of G. Prayogo
  - Simulating droplet impact with polymer projectile
- Can mimic speed and energy of droplet
  - 100 m/s to 160 m/s
- Accelerated damage testing
  - 1-2 impacts per second
  - 1-30 min to damage
- Allows for in-situ damage monitoring
  - Visual with camera
  - Acoustic emission
- Small specimen size
  - cheaper
  - faster
  - more evaluation options
Damage assessment methods

- Insitu methods
  - Camara
  - Acoustic emission
- ex situ methods
  - X-ray tomography
  - Ultrasound scanning
  - Informing FEM Models
Current setup
Current setup
Comparing impact speeds on epoxy coating

Epoxy samples 3x playback speed

165 m/s  149 m/s  138 m/s  121 m/s
SN curves

- Fitted according to ASTM e739
SN curves
Accelerated implementation of materials and surface solutions

• Do you have material problems and need assistance finding the right experts to help you?
• The Fast Track industrial portal can help you rapidly find the right experts and equipment that can help solve your problem
• An expert panel with representatives from DTU, AAU, DTI, FORCE will evaluate your problem and help you how to proceed.
• You can contact us on www.fast-track.nu or contact project manager Kasper T. Therkildsen: +45 40 12 23 76
Highspeed imaging

- Highspeed camera
  - Phantom v2512 fast
- Filmed at
  - 355.000 FPS
Acoustic emission

- Amplitude
- Frequency
- Duration
- Energy
When coating is eroded...
- Frequency goes up
- Duration goes down a lot!
- Energy goes down a little
- Amplitude is unchanged
- Get two AE hits per impact

<table>
<thead>
<tr>
<th>Type</th>
<th>Counts</th>
<th>Av. Freq (kHz)</th>
<th>Duration (µs)</th>
<th>Energy</th>
<th>Amplitude (dB)</th>
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<tr>
<td>Type 1 fully protective</td>
<td>13</td>
<td>7</td>
<td>2065</td>
<td>177</td>
<td>84</td>
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<tr>
<td>Type 2: coating damaged?</td>
<td>8</td>
<td>28</td>
<td>285</td>
<td>161</td>
<td>85</td>
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<tr>
<td>Type 2: coating eroded</td>
<td>8</td>
<td>26</td>
<td>284</td>
<td>135</td>
<td>84</td>
</tr>
</tbody>
</table>
2 ex situ methods

2.1 X-ray tomography

Place the metal pin in the hole and place in the holder parallel to the flat surface to ensure same position

Specimen placed in the 3D X-Ray Tomography
Mechanisms / cracks / delamination
Ultrasound scanning
Modelling (FEM)

CT scans:
Erik Vogeley, COM
Anthony Fraisse, COM

- CT scans of the specimens reveal cracks in gelcoat with ca 45 deg. to the surface
- High shear stresses along the crack paths due to travelling shear wave front, 30 Mpa
- Angles less than 45 are also seen, probably due to traveling of the contact edge