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THE EFFECT OF SUBSTRATE PARAMETERS ON THE
MORPHOLOGY OF THERMALLY SPRAYED PEEK SPLATS.

Benjamin Paul Withy

A thesis submitted in fulfilment of the requirements
for the degree of Doctor of Philosophy in
Abstract

Thermal spray is a well established technology that is commonly used in the aerospace and automotive industries. This thesis reports on the effect that substrate surface chemistry, morphology and temperature has on the morphology of PEEK single splats on aluminium substrates.

PEEK single splats were deposited by HVAF and plasma spraying on aluminium substrates with 6 different pretreatments. Substrates were either sprayed at room temperature, or 323°C, and a subset of substrates was held at incremental temperatures up to 363°C.

HVAF deposited splats on room temperature substrates showed sensitivity to surface chemistry, with increased circularity and area associated with low levels of hydroxide and chemisorbed water on the aluminium surface. Substrates held at 323°C were more sensitive to substrate morphology, where rough surfaces resulted in decreased circularity and area apparently independent of surface chemistry. Substrate temperature trials revealed a significant step in the results, equating to greater circularity, and lower splat area, perimeter and Feret diameter. This step occurred between 123°C and 163°C, the two points bracketing the glass transition temperature of PEEK (143°C). This result was due to the relaxation of splats deposited on surfaces above 143°C, whilst splats on cooler substrates quench through the glass transition and do not relax.

PEEK splats deposited by plasma spray on room temperature and 323°C substrates showed sensitivity to the amount of hydroxide and chemisorbed water present on the aluminium substrates, with low levels resulting in more circular and larger area splats. Plasma splats did not show the same temperature effects as HVAF splats, thought to be due to the more molten state of plasma splats upon impact compared to the HVAF splats.

The primary conclusions reached were that plasma sprayed polymers were sensitive to surface chemistry, and that as such the surface chemistry of a substrate should be considered when forming plasma spray polymer coatings. It was also concluded that the kinetic energy of particles in HVAF thermal spray contributed significantly to the thermal energy of a particle on impact, allowing for improved splat properties without overheating the particles in flight. Finally it was concluded that substrate temperature is far more important for HVAF thermal spray of polymers than plasma spray of polymers, but that it improves splat properties for both techniques.
for Brooke,
who has made me so happy,
words are not enough.
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The technical staff of the Chemical and Materials Engineering Department who provided varied and valued assistance over the course of my PhD.

The friends who would insist I leave the lab or computer and venture into the world for a coffee or beer at regular intervals.
Owl explained about the Necessary Dorsal Muscles. He has explained this to Pooh and Christopher Robin once before, and had been waiting ever since for a chance to do it again, because it is a thing which you can easily explain twice before anybody knows what you are talking about.

A.A.Milne, *The House at Pooh Corner*.

I love deadlines. I like the whooshing sound they make as they fly by.

Douglas Adams.
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AB</td>
<td>AcidBrite etched</td>
</tr>
<tr>
<td>AFM</td>
<td>Atomic force microscope</td>
</tr>
<tr>
<td>Alm 29</td>
<td>P3 Almeco 29 etched</td>
</tr>
<tr>
<td>B</td>
<td>Boehmitised</td>
</tr>
<tr>
<td>BE</td>
<td>Binding energy</td>
</tr>
<tr>
<td>BT</td>
<td>Boehmitised and thermally treated</td>
</tr>
<tr>
<td>BWI</td>
<td>Boehmitised</td>
</tr>
<tr>
<td>CCD</td>
<td>Charge-coupled device</td>
</tr>
<tr>
<td>DG</td>
<td>Polished and degreased</td>
</tr>
<tr>
<td>E</td>
<td>Etched (with AcidBrite)</td>
</tr>
<tr>
<td>EDS</td>
<td>Energy dispersive spectroscopy</td>
</tr>
<tr>
<td>ERDA</td>
<td>Elastic recoil detection analysis</td>
</tr>
<tr>
<td>ET</td>
<td>Etched and thermally treated</td>
</tr>
<tr>
<td>FPL</td>
<td>Forest Products Laboratory</td>
</tr>
<tr>
<td>FPL</td>
<td>FPL etched</td>
</tr>
<tr>
<td>FTIR</td>
<td>Fourier transform infra-red</td>
</tr>
<tr>
<td>FTIR-RAS</td>
<td>Fourier transform infra-red - reflection absorption spectroscopy</td>
</tr>
<tr>
<td>FWHM</td>
<td>Full width half maximum</td>
</tr>
<tr>
<td>HAF</td>
<td>High velocity air fuel</td>
</tr>
<tr>
<td>HVOF</td>
<td>High velocity oxygen fuel</td>
</tr>
<tr>
<td>K</td>
<td>Sommerfeld flattening criterion</td>
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<tr>
<td>KE</td>
<td>Kinetic energy</td>
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<td>Modified Sommerfeld flattening criterion</td>
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<td>MDPE</td>
<td>Medium density polyethylene</td>
</tr>
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<td>P</td>
<td>Polished</td>
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<td>P2 etched</td>
</tr>
<tr>
<td>PEEK</td>
<td>Poly(aryl ether ether ketone)</td>
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<td>Poly(ethylene terephthalate)</td>
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<td>PMA</td>
<td>Poly(methyl methacrylate)</td>
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<tr>
<td>PPS</td>
<td>Poly(phenylene sulphide)</td>
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<td>PT</td>
<td>Polished and thermally treated</td>
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<tr>
<td>Pzc</td>
<td>Point of zero charge</td>
</tr>
<tr>
<td>Ra</td>
<td>Measure of surface roughness</td>
</tr>
<tr>
<td>RBS</td>
<td>Rutherford backscattering</td>
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<td>SEM</td>
<td>Scanning electron microscope</td>
</tr>
<tr>
<td>Sk</td>
<td>Skewness</td>
</tr>
<tr>
<td>SLPM</td>
<td>Standard litres per minute</td>
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<td>Glass transition temperature</td>
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