Low-friction coatings on elastomers

M. Rombouts, A. Vanhulsel, B. Verheyde, W. Engelen and D. Havermans

Vlaams Instelling voor Technologisch Onderzoek (VITO), Mol, Belgium
Outline

✓ Introduction

✓ Results
  ✓ Thick coatings by laser cladding
  ✓ Thin coatings by atmospheric plasma treatment

✓ Conclusions and future work
Surface treatment to improve tribological behaviour of elastomer components

- Elastomer components in sealing and sliding applications
- Need to understand and improve the tribological behaviour of elastomers
  - High dry sliding friction → use of lubricants
  - Improved performance (reduce noise, vibrations, etc)
  - Environmental considerations (reduce or eliminate use of grease and lubricants)
- Development of surface treatments and coatings with solid lubricant properties compatible with elastomer materials
  - Laser cladding
  - Atmospheric plasma treatment
Laser cladding - general

- Melting of additive material, mostly powder, by means of a moving laser as heat source.
Laser cladding – type of coating in general

• Coating type: metal or metal-ceramic coatings

• Substrate materials: metals

• Thickness range: mm

• High-performance coatings
  – metallurgical bonding to substrate
  – no porosity
  – low heat input

• Applications: repair, improved corrosion / wear resistance
Laser cladding of polymer coatings

- Thermoplastic (composite) coating: polyamide-based
- Polymer, metal substrates: thermoplastic polyurethane
- Thickness in order of 100 µm
- Average roughness is relatively high
Ball-on-Disc tribotesting @ VITO

Test parameters:

- $F_N = 1$ N
- ball radius = 5 mm
- wear track radius = 5 mm
- rotation speed = 100 mm/s
- unlubricated
- 100Cr6 steel counterface
Frictional behaviour of laser cladded coating

\[ R_{\text{track}} = 5\text{mm}; \ F_N = 1\text{N}; \ v = 100\text{mm/s}; \ R_{\text{ball}} = 5\text{mm} \]

- 40%
Frictional behaviour of laser cladded coating

\[ R_{track} = 5 \text{mm}; \quad F_N = 1 \text{N}; \quad v = 100 \text{mm/s}; \quad R_{ball} = 5 \text{mm} \]

- 80%

- 60%

COF

Distance (m)

TPU substrate

PA 11 coating

PA 11 + 15% PTFE coating
Analysis of wear after tribotesting

Counterface material

TPU

PA11

PA11 + 15% PTFE
Outline

✓ Introduction

✓ Results
  ✓ Thick coatings by laser cladding
  ✓ Thin coatings by atmospheric plasma treatment

✓ Conclusions and future work
Atmospheric plasma technology

- Dielectric barrier discharge (DBD)
- Cold plasma surface engineering technique (surface cleaning, activation, coating)
- Low investment cost
- Continuous, in-line processing
- Easy upscaling
- Injection of all types of precursors (gases, liquid chemicals, dispersions etc)
- Different configurations (PlasmaSpot®, PlasmaLine®, PlasmaZone®)
  - Parallel plate: direct treatment of 2D (web) materials
  - Torch systeem: indirect treatment of complex, 3D components
Setup of atmospheric Plasmaspot®

Carrier gas $\text{N}_2$ (He)

Precursor (from atomiser)

Power supply (75kHz)

Afterglow
Coating type

- Thickness range: nm - µm
- All types of substrate materials: plastics, metals, glass, paper etc
- Coating type: siloxane-based hybrid (organic–inorganic) coatings
- Precursor: (Si-O-R) type e.g. APEO
- Roughness of substrate is followed
- Soft coatings compared to conventional tribological coatings
  - Less severe triboconditions
Typical hardness and E-modulus values

Instrumented indentation test
CSM (continuous stiffness measurement)

<table>
<thead>
<tr>
<th>Material</th>
<th>H (GPa)</th>
<th>E (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>APEO coating</td>
<td>0.8</td>
<td>$10^{10}$</td>
</tr>
<tr>
<td>Bulk PC</td>
<td>0.2</td>
<td>$10^9$</td>
</tr>
<tr>
<td>Bulk LDPE</td>
<td>0.02</td>
<td>$10^8$</td>
</tr>
<tr>
<td>Steel</td>
<td>10</td>
<td>$10^{11}$</td>
</tr>
<tr>
<td>Rubber</td>
<td></td>
<td>$10^6$</td>
</tr>
</tbody>
</table>
SEM/EDX-analysis of APEO coating on HNBR

Plane view SEM
Frictional behaviour of plasma coating

![Graph showing COF (Coefficient of Friction) over cycles for HNBR uncoated and APEO coating, with a decrease of 60%.](image)
Analysis of wear track after tribotesting
Lessons learned & challenges

- Atmospheric plasma and laser cladded coatings show potential as low-friction coating
- Need for tribomapping to identify application areas (e.g. running-in coatings, microtribology)
- Complex (tribological) behaviour of elastomers → selection and interpretation of tests
Thank you for your attention!

Marleen.Rombouts@vito.be