Characterization of nano-coefficient of friction of oleophobic and superhydrophobic coatings on 316LSS in harsh conditions

SPEAKER
Mr. Hamza Shams
DHA Suffa University
hamza.shams@dsu.edu.pk
Tel: +92-21-35244853 | Ext. 157
Mob: +92-345-2184377

Research Supervisor
Dr. Sajid Saleem
ASSISTANT PROFESSOR
NUST-PNEC, Karachi

Co-Advisor
Dr. Salman Nisar
ASSISTANT PROFESSOR
NUST-PNEC, Karachi

Team Mentor
Kanza Basit
LECTURER
NUST-PNEC, Karachi
Scheme of Presentation

• Published Research Titles
• Introduction
• Research Question
• Literature Review
• Objectives
• Experimental Methodology
• Results and Discussion
• Conclusion
• References
Published Papers in National Conferences

- “Evaluation of Commercial Oleophobic Coatings for Aerospace Applications in Harsh Environments” – ICASE 2015 (Published in IEEE Xplore)
- “Validation of Temperature Sensitivity of Superhydrophobic Surfaces as applied on 316L SS” – NED-AMPE 2015 (Published in Local Proceedings)
Introduction

• Oleophobic coatings or oil-repellent coatings has little literature available on them with regard to applications. The concept is new for applications with metals in long-lasting self-cleaning, corrosion resistant, abrasion resistant and lubrication applications.

• Our investigation is regarding the resistance these coatings offer to the metal surface when exposed to control testing parameters like erosion by sand.

• “Coefficient of Friction (COF) or µ” is a useful tool to understand this behavior at nano-scale. By using difference in µ, we have established a structured research methodology to understand how changes in µ can be used as formative principle to define coating’s application areas.

• Lateral Force Microscopy (LFM) is a well-established technique that has been used for this investigation. Friction differences have been used to compare multiple coatings under same testing parameters.
Introduction

Oleophobic Coatings for Stainless Steel

Photographer: Brocken Inaglory

Source: Palomar Technologies Website
Introduction

• Lateral Force Microscopy (LFM)
  – In 1987, AFM was first modified to measure both normal and friction forces and this equipment is known as ‘Friction Force Microscope (FFM)’ or ‘Lateral Force Microscope (LFM)’.
  – Since its introduction, various calibrating techniques have been introduced.
  – One of the easiest and direct method to calibrate LFM was designed in 2007.
  – It consisted of a small glass fiber fixed at one end to a substrate and which can be bent laterally with the LFM tip at the other end.
  – It allows direct conversion of photodiode signal to force.
Introduction

• Lateral Force Microscopy (LFM)
  – Lateral image is obtained using tip’s torsional deflection IV
  – Topography image is made using Vertical Deflection Difference.
  – Forward-Pass (FP) LFM image shows a raised amplitude between 1 and 2 due to friction difference. This amplitude is reversed in the Backward-Pass (BP).
  – There is NO change in other portions of the graph since lateral signal on topography in FP and BP remains the same.
Introduction

• **Why do we desire this in 316L SS?**
  
  – 316L SS is highly susceptible to pitted corrosion because of chloride ions in saline environments
  
  – The oleophobic barrier can enhance its application characteristics with minimal treatment. Moreover, this treatment can be done in-situ since the coatings are widely available in Aerosol and Suspensions.
  
  – However, 316L SS is not only used in marine environments but has versatile structural applications.
  
  – Hence, we’re evaluating them under Sand-Storm conditions.
Scope of this Study

316L Stainless Steel

COMMON APPLICATIONS
- Chemical and Petrochemical Processing - pressure vessels, tanks, heat exchangers, piping systems, flanges, fittings, valves and pumps
- Food and Beverage Processing
- Marine
- Medical
- Petroleum Refining
- Pharmaceutical Processing
- Power Generation - Nuclear
- Pulp and Paper
- Textiles
- Water Treatment

316L Stainless Steel Shaft Forged Marine Propeller Shaft
Brand Name: Symmen
Process Map: Forging + Heat Treatment (N + T) + Machining
Coating: Black Oxide

Image Source: Alibaba.com
Research Question

Characterization of nano coefficient of friction through LFM of oleophobic coatings applied on 316L SS

Order of $10^{-9}$

μ

Lateral Force Microscopy

Oil-Repellent (Also Superhydrophobic)

Marine Stainless Steel
Literature Review

• During 1991, amorphous C-Si coatings containing hydrogen were formed and tested on steel. The $\mu$ was found to decrease with increase in carbon content \textsuperscript{VI}

• Amorphous hydrocarbon coatings have great tribological properties as tested in 1998 to develop a time and load dependent empirical model for fatigue phenomenon \textsuperscript{VII}

• Formation of super hydrophobic coatings and study the contact angle at which hydrophobic behavior is observed started in the 2000s \textsuperscript{VIII}

• In the field of orthodontic, coated and non coated wires are studied for $\mu$ in wet conditions \textsuperscript{IX, X}
Literature Review

• Due to pitting corrosion in 316L SS, perforation of equipment is caused \textsuperscript{XI}

• The electrochemical behavior of Stainless Steel in aqueous NaCl solution is researched widely in the past \textsuperscript{XI-XVII}

• Effect of Bicarbonate ions, effect of 2-mercaptobenzimidazole (MBI) on the pitting corrosion of 316L SS in NaCl solutions were investigated in the past \textsuperscript{XI, XIV}

• Critical appraisal of the main electrochemical techniques and evaluation methods used in tribo-corrosion research were also presented \textsuperscript{XII}

• To diminish the effect of pitting in Stainless steel and to protect the equipment from perforation, it is treated with sulfate, chromate, bicarbonate and phosphate ions \textsuperscript{XVIII, XIX}
Literature Review

• In 2014, mechanical durability and stability of a-C:Ag nanocomposite coatings deposited on 316L stainless steel substrates were investigated with respect to Ag content. The $\mu$ was found to reduce significantly with Ag content $^{XX}$

• In early 2015, austenitic powder metallurgy stainless steel sintered in a nitrogen atmosphere was investigated for tribological applications. Wear rate increases rapidly in dry condition as experiment starts and then stagnates whereas in lubricated conditions wear rate decreases $^{XXI}$

• Recently tribological properties of hard coatings (W-S-C) were tested and it was found that the $\mu$ decreased independent of the coating composition or mechanical properties $^{XXII}$
Objectives

• To find a repeatable method to obtain $\mu$ values from a given sample of 316L SS using LFM imaging technique.
• Using the repeatable method evaluate the $\mu$ value of the sample at 03 instances that is after grinding, after coating and after the testing procedure (sandblasting).
• Validate the images through reverse imaging or backward scanning, removing any anomalous reading in the procedure and obtaining an average.
• Use Amantons’ Friction Laws to evaluate $\mu$ results (B. Bhushan, 2006).
• Discuss failure characteristics of the coated surface in relation to the testing procedure it has undergone.
Experimental Methodology

1. 316L SS Sample
2. Cutting
3. Grinding
4. LFM for COF
5. Application of Coating
6. Controlled Sandblasting
**Experimental Methodology**

- Peeled Rod of 316L SS was cut using Metallographic Cutter to the sample size.
- The samples were then faced using Lathe Machine.
- Faced samples were grinded using Metallographic Grinder of emery papers grit size 120, 240, 320, 600 and 800.
- Grinded samples were scanned by Lateral Force Microscopy (LFM).
- Samples were coated with 3x different types of Oleophobic Coatings. (Each sample with a different coating)
- Samples were rescanned by LFM.
- Samples were exposed to sandblasting conditions.
- Samples were rescanned by LFM.
Testing Parameters

• Sample Cutting (Cut-off Wheel 54A25 – $\text{Al}_2\text{O}_3$ Resin)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel Size</td>
<td>250 mm</td>
</tr>
<tr>
<td>Cutting Wheel RPM</td>
<td>3450 @ 60 Hz</td>
</tr>
<tr>
<td>Cutting Time</td>
<td>Till Sample Separates</td>
</tr>
<tr>
<td>Coolant</td>
<td>Tap-Water</td>
</tr>
</tbody>
</table>

$\varnothing$ 25 mm x 8 mm
CUT-SAMPLE
Testing Parameters

- **Sample Facing**

  6 mm IS REMOVED TO A DEPTH OF 4 mm. STEP IS REQUIRED FOR ALIGNING THE SAMPLE INSIDE AFM.

  ![Before](image1.jpg) ![After](image2.jpg)
# Testing Parameters

- **Surface Grinding (Grit Sizes 120, 240, 320, 600 and 800)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revolutions per Minute (RPM)</td>
<td>200 Clockwise</td>
</tr>
<tr>
<td>Variable Normal Force</td>
<td>≤ 10 N</td>
</tr>
<tr>
<td>Specimen Mover RPM</td>
<td>200 Anticlockwise</td>
</tr>
<tr>
<td>Grinding Time Per Grit Size</td>
<td>≈ 60 Seconds ± 10%</td>
</tr>
</tbody>
</table>

GRINDED SPECIMEN
Testing Parameters

• Coating Methodology
  – Aerosol can was kept at a distance of 8 inches from the sample surface and coated in 02 continuous lateral strokes.
  • EnduroShield and NeverWet have a Base-Coat application followed by a Top Coat. Base Coat is dried for 60 minutes before Top-Coat is applied as per the Manufacturers’ Instructions.
  • DuPont has only One Coat Application.
  – All Samples were then left to dry overnight (Curing time: 8 hours).
  – Samples were cleaned with Compressed Nitrogen Gas before each LFM Scanning.
Testing Parameters

- **ezAFM Scanning Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Area</td>
<td>10 μm x 10 μm</td>
</tr>
<tr>
<td>Scan Speed</td>
<td>1 μm s⁻¹</td>
</tr>
<tr>
<td>Scan Resolution</td>
<td>256 x 256 Pixels</td>
</tr>
<tr>
<td>Scanning Probe</td>
<td>PPP-LFMR (NANOSENSORS)</td>
</tr>
<tr>
<td>FT</td>
<td>1.98 V</td>
</tr>
<tr>
<td>Probe Torsional Force Constant</td>
<td>12 N/m</td>
</tr>
<tr>
<td>Probe Normal Force Constant</td>
<td>0.2 N/m</td>
</tr>
<tr>
<td>Probe Diameter</td>
<td>7 nm</td>
</tr>
<tr>
<td>Probe Resonance Frequency</td>
<td>23 kHz</td>
</tr>
<tr>
<td>PID Values</td>
<td>30/1/21.5</td>
</tr>
<tr>
<td><em>(Adjust as per requirement and cantilever’s oscillation)</em></td>
<td></td>
</tr>
</tbody>
</table>

All samples were cleaned with N₂ before scanning with LFM.
Testing Parameters

• **Sandblasting**

*(DUE TO ABSENCE OF A VENTURI METER, WE USED CFD TO DESIGN OUR PIPE ASSEMBLY)*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Flow Rate</td>
<td>0.025 m³s⁻¹</td>
</tr>
<tr>
<td>Inlet Diameter</td>
<td>38.10 mm</td>
</tr>
<tr>
<td>Inlet Velocity</td>
<td>22 ms⁻¹</td>
</tr>
<tr>
<td>Outlet Diameter</td>
<td>25.40 mm</td>
</tr>
<tr>
<td>Outlet Velocity</td>
<td>≈ 80 ms⁻¹</td>
</tr>
<tr>
<td>Sandblasting Time</td>
<td>60 s</td>
</tr>
<tr>
<td>Angle of Incidence</td>
<td>90°</td>
</tr>
<tr>
<td>Sand Particle Size</td>
<td>≤ 250 microns</td>
</tr>
</tbody>
</table>

*(Filtered through Size 40 Sieve)*

**Sandblasting Speeds are 200 – 400 ms⁻¹**

SINCE WE ARE SIMULATING SAND-STORM, WE ADJUSTED IT ACCORDING TO THE SAND-STORM DATA FROM A US WEATHER WEBSITE.

REFERENCE: PAINT YOUR CAR (BOOK) AND US DEPARTMENT OF ENERGY WEBSITE
Testing Parameters
Results

• Physical Appearance (Before Sandblasting)

NEVERWET
ENDUROSHIELD
DUPONT
Results

• Observations (Before Sandblasting)
  – NeverWet and DuPont dulled the sample’s surface and a clear-white mist like deposition was observed.
  – EnduroShield enhanced the sample’s surface and the sample retained it’s original metallic color and is somewhat enhanced.
  – Surface looks ‘smooth’ except for in NeverWet where there are some irregularities on the surface.
Results

• Physical Appearance (After Sandblasting)
Results

• Observations (After Sandblasting)
  – Surface no-longer clear and marks of sand-particles impregnation are visible.
  – Surface looks ‘rough’ on observation.
  – NeverWet and DuPont still have the same white, mist like appearance while EnduroShield has lost it’s metallic color.
Results

• Physical Appearance

RUST-OLEUM
NEVERWET
MULTI-SURFACE
LIQUID
REPELLING TREATMENT

BEFORE SANDBLASTING

AFTER SANDBLASTING
Results

• Physical Appearance

ENDUROSHIELD
STAINLESS STEEL
COATING

BEFORE SANDBLASTING

AFTER SANDBLASTING
Results

- Physical Appearance

DUPONT TEFLON DRY-FILM LUBRICANT COATING

BEFORE SANDBLASTING  AFTER SANDBLASTING
Results

RESULT OF NEVERWET GRINDED SPECIMENS

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.412</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.428</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.414</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.420</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.410</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.409</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.411</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.424</td>
<td>0.416</td>
</tr>
</tbody>
</table>
## Results

**RESULT OF NEVERWET COATED SPECIMENS**

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.231</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.262</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.290</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.279</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.272</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.284</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.261</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.288</td>
<td>0.271</td>
</tr>
</tbody>
</table>
### Results

**RESULT OF NEVERWET SANDBLASTED SPECIMENS**

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.330</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.355</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.340</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.361</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.352</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.362</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.334</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.361</td>
<td></td>
</tr>
</tbody>
</table>

**Mean Value:** 0.349
### Results

RESULT OF ENDUROSHIELD GRINDED SPECIMENS

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.421</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.451</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.446</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.432</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.451</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.443</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.442</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.419</td>
<td></td>
</tr>
</tbody>
</table>

Mean Value: 0.438
## Results

RESULT OF ENDUROSHIELD COATED SPECIMENS

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.389</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.404</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.395</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.398</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.417</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.393</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.399</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.398</td>
<td>0.399</td>
</tr>
</tbody>
</table>
## Results

RESULT OF ENDOUSHIELD SANDBLASTED SPECIMENS

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.281</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>1.324</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>1.278</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>1.294</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>1.316</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>1.296</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>1.295</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>1.306</td>
<td>1.299</td>
</tr>
</tbody>
</table>
## Results

**RESULT OF DUPONT GRINDED SPECIMENS**

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.416</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.426</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.421</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.423</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.424</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.432</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.417</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.414</td>
<td>0.422</td>
</tr>
</tbody>
</table>
### Results

RESULT OF DUPONT COATED SPECIMENS

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.196</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.208</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.199</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.215</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.210</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.197</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.201</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.212</td>
<td><strong>0.205</strong></td>
</tr>
</tbody>
</table>
# Results

RESULT OF DUPONT SANDBLASTED SPECIMENS

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Obtained Values</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.451</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.459</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.424</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.438</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.453</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.446</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>0.456</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.446</td>
<td>0.447</td>
</tr>
</tbody>
</table>
Results

- Error % in our Values

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>SI Units</th>
<th>English Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>ASTM D-1505</td>
<td>2150 kg/m³</td>
<td>134 lb/ft³</td>
</tr>
<tr>
<td>Coefficient of Friction, Kinetic (Film-to-Steel)</td>
<td>ASTM D-1894</td>
<td>0.1–0.3</td>
<td></td>
</tr>
<tr>
<td>Refractive Index</td>
<td>ASTM D-542</td>
<td>1.341–1.347</td>
<td></td>
</tr>
<tr>
<td>Solar Transmission</td>
<td>ASTM E-424</td>
<td>96%</td>
<td></td>
</tr>
</tbody>
</table>

Our DuPont Sample Value is **0.205**

THIS IS IN RANGE OF THE MANUFACTURER’S DATASHEET VALUE
Results

<table>
<thead>
<tr>
<th></th>
<th>Grinded Specimen</th>
<th>Coated Specimen</th>
<th>Sandblasted Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>NeverWet</td>
<td>0.416</td>
<td>0.271</td>
<td>0.349</td>
</tr>
<tr>
<td>EnduroShield</td>
<td>0.438</td>
<td>0.399</td>
<td>1.299</td>
</tr>
<tr>
<td>DuPont</td>
<td>0.422</td>
<td>0.205</td>
<td>0.447</td>
</tr>
</tbody>
</table>
Results

• \( \mu \) Values
Results

• Observations (Grinded Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average $\mu$ value of 0.4xx for Grinded Samples.
  – Around 20 major Peaks and Valleys are observed at multiple instances out of 65,536 instances used to plot this surface which is indicative of 0.03% anomalies which may be caused due to left-over dust particles or nano-scale surface scratches.
Results

• \( \mu \) Values
Results

• Observations (NeverWet Coated Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average μ value of 0.27x for NeverWet Coated Surfaces.
  – Number of peaks greatly reduce with minor variations caused due to dust particles on the sample’s surface.
Results

• $\mu$ Values

SURFACE IMAGE RESULT NEVERWET SAMPLES AFTER SANDBLASTING
Results

• Observations (NeverWet Sandblasted Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average $\mu$ value of 0.34x for NeverWet Sandblasted Surface. This shows that $\mu$ value has increased after sandblasting.
  – Number of peaks increase as compared to the coated sample due to change in friction values caused by our sandblasting process.
Results

• $\mu$ Values
Results

• Observations (EnduroShield Coated Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average μ value of 0.39x for EnduroShield Surface.
  – Plot is extremely smooth with minor variations caused due to dust particles on the sample’s surface.
Results

• μ Values

SURFACE IMAGE RESULT ENDOUROSHIELD SAMPLES
AFTER SANDBLASTING
Results

• Observations (EnduroShield Sandblasted Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average μ value of 1.29x for EnduroShield Sandblasted Surface. The μ value has greatly increased.
  – Plot no longer appears to be as smooth as it was after coating stage with number of μ variations much clearly visible in the plot.
Results

• μ Values
Results

• Observations (DuPont Coated Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average μ value of 0.20x for DuPont Coated Surface.
  – Similar to EnduroShield, the surface plot is fairly smooth with minor peaks observed due to inherent dust particles in the sample’s surface.
Results

• $\mu$ Values

SURFACE IMAGE RESULTS DUPONT SAMPLES
AFTER SANDBLASTING
Results

• Observations (DuPont Sandblasted Sample)
  – Average of FL and FN images are used to generate the surface plot on MATLAB.
  – The plot coincides with our average $\mu$ value of 0.44x for DuPont Sandblasted Surface.
  – Surface asperities have greatly increased despite little increase in the $\mu$ value. We attribute these changes to the erosion that took place in this surface on exposure to sand.
  – The surface plot indicates that the surface is no longer smooth and may no longer support oleophobic characteristic.
Conclusions

• The value of \( \mu \) changed drastically during the sandblasting process where Rust-Oleum NeverWet Multi-Surface Treatment showed better resistance to wear than the other two coatings.

• The EnduroShield Stainless Steel Coating had a better surface finish and clear mirror like appearance. However, it was not able to retain it after the sandblasting procedure where the other 02 coatings exhibited better performance.

• The maximum difference in \( \mu \) values before and after sandblasting procedure is also for EnduroShield Stainless Steel coating.

• DuPont Teflon Dry-Film Lubricant Coating had a low \( \mu \) value before and after sandblasting, however its surface plot indicates that the surface structure has been greatly altered after the sand-blasting procedure making it ineffective for our application.

• The \( \mu \) increases when exposed to sandblasting process.
Future Work

• The obtained results can be simulated in VEDA (Virtual Environment for Dynamic AFM), a software suite from NanoHUB. This would validate our obtained results further through analysis.
• Coating method can be refined using a more accurate and repeatable coating technique that doesn’t depend on user’s ability.
• Sea Breeze conditions are yet to be tested for which would add depth to our need to find common-day applications of these coatings.
References


References


References


References


Characterization of nano-coefficient of friction of oleophobic and superhydrophobic coatings on 316LSS in harsh conditions

SPEAKER
Mr. Hamza Shams
DHA Suffa University
hamza.shams@dsu.edu.pk
Tel: +92-21-35244853 | Ext. 157
Mob: +92-345-2184377

Research Supervisor
Dr. Sajid Saleem
ASSISTANT PROFESSOR
NUST-PNEC, Karachi

Co-Advisor
Dr. Salman Nisar
ASSISTANT PROFESSOR
NUST-PNEC, Karachi

Team Mentor
Kanza Basit
LECTURER
NUST-PNEC, Karachi