Experimental Quantification of Drag Change of Commercial Coatings Under the Effect of Surface Roughness and Soft Fouling

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The 19th ICMCF, June 25-29, 2018
Melbourne, Florida, USA
Objectives of the study

- Coated disks with soft fouling
  - Photos of disks before and after exposure to fouling;
  - % fouling coverage assessment;
  - Identification of main species;
  - Torque (drag) measurements

- Clean (Unfouled) coated disks
  - Photos of clean disks
  - Roughness measurements using TQC hull roughness and Optical Laser Gauge
  - Torque (drag) measurements

Target species
- from Port of Gothenburg (Sweden)

Drag Penalties
- Paint types;
- Paint roughness;
- Paint types + soft fouling;
- Paint roughness + soft fouling
Experimental studies and methods
A campaign of rotating disk experiments

FR types
- Clean

In acrylic tank
- Controlled env.

Saltholmen marina
- Natural env.

Biocide containing
- Clean

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Foul-release (FR) type coated disks

- 4-types FR coating replicates with laboratory smooth application finish;

- Surface roughness (Rt50) measurements by TQC hull roughness gauge;

- A campaign of rotating disk measurements.

FR-A: D=300mm
Rt50: 43≈48 μm

FR-B
Rt50: 48≈60 μm

FR-C
Rt50: 75≈87 μm

FR-D
PVC reference

Rt50 (50)
Sample length = 50 mm
Absorption spectra of pigments (based on Navicula) have been foundation for selection of LED wavelength;

- *Chl a* and *Chl c* in Navicula absorb light in blue region (400-490nm) and red regions (620-750nm);
- White light was also added.
Deployment of FR coated disks for fouling growth in Saltholmen marina

Foul release coatings

FR-A
FR-D
FR-C
FR-B

Biocidal coatings

BAC-A rough
BAC-B smooth
BAC-A smooth

Deployment of FR coated disks for fouling growth in Saltholmen marina
Biocidal antifouling coated disks

- 2-types of biocidal antifouling coating replicates (BAC-A and BAC-B) with laboratory smooth application finish;

- Additionally, BAC-A type replicates only have undergone rough application finish;

- Surface roughness measurements by TQC hull roughness gauge;

- A campaign of rotating disk measurements with clean BAC coated disks were carried out;

- Measurements of Cu and Zn concentrations were done by XRF spectrometry;

Rt50: BAC-A smooth - 73≈80 μm
Rt50: BAC-B - 72≈90 μm
Rt50: BAC-A rough - 116≈123 μm
Preliminary results show that Cu concentration in coatings is 6700 to 9600 μg/cm², whereas Zn results are under 900 μg/cm².

The method utilizing a handheld XRF analyser has been developed for the in-situ measurement of release of metallic biocides from antifouling paints, Ytreberg et al. (2017).
Fouling coverage estimations (ImageJ) and identification of species

Laboratory fouling (1.5-month-old)

<table>
<thead>
<tr>
<th>PVC</th>
<th>FR-A</th>
<th>FR-B</th>
<th>FR-C</th>
<th>FR-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>99% fouling coverage</td>
<td>?%</td>
<td>81%</td>
<td>48%</td>
<td>96%</td>
</tr>
</tbody>
</table>
Fouling coverage estimations (ImageJ) and identification of species

Field fouling (1-month-old)

FR-A 82%
FR-B 88%
FR-C 86%
FR-D 64%
Torque measurement results

\[ C_m = \frac{4M}{\rho r_0^5 (\phi \omega)^2} \]

\( C_m \) = moment coefficient  
\( M \) = torque of one side of a disk  
\( r_0 \) = radius of the disk  
\( \omega \) = angular velocity  
\( \rho \) = density of the fluid.
Fouling before/after the rotating disk tests (Lab fouling)

Before

After
Fouling before/after the rotating disk tests

Field fouling (1-month-old)
Preliminary concluding remarks

- Fouling pressure for field fouling was greater than lab fouling;
- Biology tests will reveal the fouling community structure for the lab and field grown fouling species;
- During tests, FR-B type deployed at the port developed heavy fouling;
- Looking at the Cm trend, both lab and field fouling was easily removed from FR-B types;
- The rate of removal was high for field fouled tested disks;
References

Berkeleya, diatom that aggregates and looks like a filamentous algae