Fuel consumption and additive efficiency on a tug vessel

Presented by:
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AGENDA

- Presentation of OCEAN
- Presentation of OpDAQ
- Purpose of monitoring
- Facts and circumstances
- Test results
Ocean Services

Ocean offers a wide range of complementary services in three (3) main areas of activity. The company owns the most important fleet of marine equipment in Eastern Canada.

**Marine works and dredging**
- Over 500 barges
- 30 workboats
- 1 trailing suction hopper dredge

**Naval construction and repair**
- 2 shipyards
- 2 multi-functional workshops
- Engineering team

**Towing and navigation**
- 32 tugs + 1 under construction
- 7 pilot boats
- 1 integrated tug-and-barge
Ocean business locations

- Head office located in the Port of Québec
- Shipyards at l’Isle-aux-Coudres and Bas-Caraquet
Harbour operation and pilot transfer

Ocean performs over 19,000 operations per year
Ocean Navigation

Ocean offers tug-barge transportation suitable for all types of oversized/overweight cargo.
Op | Optimization / Operation

DAQ | Data Acquisition
OUR MISSION

To measure ship performance using high precision tools, innovative approaches and rigorous methods
EXPERTISE

- Fuel Consumption Measurement for Diesel Engines
- Shaft Torque/Power Measurement
- Fuel Efficiency Monitoring
APPLICATIONS

- Technology Evaluation
- Vessel Performance Assessment
- Best Practices Implementations
- Remote Monitoring
MARINE SECTOR EXPERIENCE

- Commercial vessels
- Shipyards
- Coast Guard (USCG & CCG)

OTHER SECTORS

- Remote diesel power plant
- General industrial sector
Achievements
Diminish our ecological footprint

by decreasing our fuel consumption
Impact of the fuel price on environment

Lower fuel price → Same ecological footprint
What Ocean has done so far

1. Have the best maintenance practice
   Ocean implemented a preventive maintenance software and counts on the very best in-house mechanics

2. Reduce tugboat transit speed
   Ocean installed speed monitoring system

3. Renew the fleet
   Ocean renewed 50% of its tug fleet over the last 10 years

4. Improved engine efficiency
   Ocean raised the cetane number in its fuel
How to get a better combustion?
Why increase the cetane number?

ULTRA LOW SULFUR DIESEL FUEL = LOWER CETANE NUMBER
What is the cetane number?

The shorter the ignition delay, the better the combustion
International minimum cetane number

- **EUROPEAN UNION**: 51
  - European Standards Organization

- **CALIFORNIA**: 48
  - California Air Resources Board

- **CANADA**: 40
  - Environment Canada
Cetane number vs NOx reduction

Natural cetane = 40
Natural cetane = 45
Natural cetane = 50

Percent reduction in NOx vs Increase in cetane number due to additives
Our tests

Four (4) different products were tested

- Three (3) cetane boosters
- One (1) oxygen booster

The results show that one of the cetane boosters was more efficient than the others for our operations.
Tests results VS tug operation profile

Distribution of main engine load after 10 years of operation

Equivalent to 25% of burnt fuel

<table>
<thead>
<tr>
<th>% Load</th>
<th>Baseline SFC Ratio</th>
<th>SFC Ratio With Additive</th>
<th>Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.997</td>
<td>0.996</td>
<td>-0.15</td>
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<tr>
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<tr>
<td>15</td>
<td>0.996</td>
<td>0.950</td>
<td>-4.66</td>
</tr>
</tbody>
</table>
Tests results

4.6% of fuel economy

NOx REDUCTION
Impact of the fuel price on environment

Higher fuel price → Smaller ecological footprint
Ocean continuously invests in research and development to find innovative ways to reduce its environmental impact.
None of this would be possible without our partners!
Fuel Additive Evaluation

- Trial Methodology
- Results
Fuel Additive Evaluation

Goal:

To Evaluate the Engine Performance Improvement Related to the Use of a Fuel Additive
Performance Evaluation Parameter

Engine Fuel Consumption ?

Specific Fuel Consumption $\rightarrow \frac{\text{Fuel Consumption rate}}{\text{Shaft Power}}$
Error Sources

1. Instrument error
2. Variations in fuel quality
3. Environmental factors
Error Sources – Measurement Error

Fuel Consumption
Positive displacement flowmeters
  Accuracy 0.1% single line

Shaft Power
Strain gage based torquemeters
  Accuracy: 0.1%

System Accuracy: 0.44%
Hypothesis:

Fuel additive has a potential of 5-10% impact on the fuel efficiency of diesel engines.
Error Sources – Variations in Fuel Quality

2 identical engines with 2 separate fuel tanks

- Port Engine: Treated with additive
- Stbd Engine: Untreated, used as reference
Error Sources – Environmental factors

Wind, waves
Bollard pull

Currents
Power measurement compensates for slow fluctuations

Temperature
Trials performed in similar conditions
Trials – Planning

10 minute steps at 30, 50 and 80% loads
- 5 minutes of stabilization
- 5 minutes of data recording on both engines

4 Repetitions
Trials - Planning

- Baseline without additive
- Trials with additive after 400 running hours
Trials - Installation

SYSTEM INSTALLATION

- 4x Flow meters
- 2x Torque meters
  - Strain gauge installation
  - Calibration
- Cable running
- Monitoring System Setup
Trials

12 steps of 10 minutes as planned
Trials – Analysis

1. Calculate 5 minutes SFC averages for all steps
2. Calculate Treated/Untreated ratio
3. Compare final results to baseline
## Results - Baseline

<table>
<thead>
<tr>
<th>Engine Load (%)</th>
<th>Port Engine (g/kWh)</th>
<th>Stbd Engine (g/kWh)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>237.3</td>
<td>237.9</td>
<td>0.997</td>
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<tr>
<td>50</td>
<td>214.2</td>
<td>214.3</td>
<td>1.000</td>
</tr>
<tr>
<td>80</td>
<td>212.4</td>
<td>213.4</td>
<td>0.996</td>
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</table>
## Results – With Additive

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Culture of Innovation

NEW TECHNOLOGY  MONITORING  ANALYSIS  IMPROVEMENT