Unique full-scale bollard pull test of large DP vessel newbuilding with six Azipod® CZ thrusters

Ole Jacob Irgens & Kimmo Kokkila
ABB OY
Azipod® Six Thruster Configuration
Accommodation / work barge – Bollard pull test analysis

Ole Jacob Irgens, VP Sales, Thruster products
Agenda

Introduction
CFD Analysis and Cavitation Tunnel Test
Bollard Pull Test in China
Bollard Pull Test Results and Reflections
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Introduction
Introduction

Subject vessel is DP3 accommodation / work barge | The propulsion system

- 115.5m in length
- Breadth of 34m and depth of 9.1m. The maximum draft is 6.1m
- The vessel was built in China and will be delivered this year
- Hull shape is basic pram type

- Three thrusters in the stern/ bow respectively
- Side thrusters positioned ahead of center thruster
- Bollard pull requirement was 30 tons per thruster
The thruster selection

Specification called for a thruster with 1.8MW capacity to achieve the 30t bollard pull
The vessels has 6 thrusters, three in the bow and three in the stern
  • Side thrusters positioned ahead of center thrusters
ABB was selected based on performance predictions
Based on reference data it concluded there could be a 3-4% thrust loss for the side thrusters due to the configuration
As a result the power rating was increased to 1.9MW

AZIPOD® CZ980
  – Pushing podded thruster with a ducted propeller
  – PM motor
  – Prop dia. 2.4m
  – RPM is 301 at max power of 1.9MW
CFD Analysis and Cavitation Tunnel Test
CFD Analysis to Verify Thruster Selection

1.8MW was used for the CFD analysis

<table>
<thead>
<tr>
<th>CZ980 Thrusters at 1.8 MW</th>
<th>Thrust (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP condition pod thrust</td>
<td>33.4</td>
</tr>
<tr>
<td>Hull related thrust deduction at BP condition</td>
<td>0.96</td>
</tr>
<tr>
<td>Vessel BP w/ thrust deduction</td>
<td>32.5</td>
</tr>
</tbody>
</table>

Based on reference data

The corresponding BP thrust for side thrusters at 1.9MW would be ~ 34.5 tonnes.

With the hull related thrust deduction the thrust would then be ~ 33.4 tonnes.
## CFD Analysis to Verify Thruster Selection

### Impact of Ocean Current at 1.8MW Power

<table>
<thead>
<tr>
<th>Current direction</th>
<th>Current velocity (m/s)</th>
<th>Pod open water thrust (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the front</td>
<td>0.1</td>
<td>33.1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>30.1</td>
</tr>
<tr>
<td>From the rear</td>
<td>0.1</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>37.6</td>
</tr>
<tr>
<td>Side</td>
<td>0.1</td>
<td>33.2</td>
</tr>
<tr>
<td>Opposite side</td>
<td>0.1</td>
<td>33</td>
</tr>
</tbody>
</table>
Cavitation Test for Nozzle Propeller

Thruster power of 1.9MW

Margin before thrust breakdown at max power (yellow line)
Bollard Pull Test in China
Sli d e 11

Bollard Pull Test Preparations

ABB recommendations based on ITS2002 Bullard Pull trial code
– Current, waves, water depth, water density
– Testing protocol, time and frequency
– Load cell arrangement and calibration
– Towing length
– Orientation of the vessel
Bollard Pull Test Conditions
COSCO Zhoushan Shipyard July 26th 2017

Measured bollard pull over 10 minutes for each test

4 tests completed as follows,

1) Centre pod in the bow (#5)
2) Side pods in the bow (#4,6)
3) Centre pod in the stern (#2)
4) Side pods in the stern (#1,3)
Bollard Pull Test Conditions

Ocean Currents

For Azipod® Thrusters 1-3 the towing line was attached to the stern.

For Azipod® Thrusters 4-6 the towing line was attached to the bow with the vessel backing out.
Bollard Pull Test Results and Reflections
### Bollard Pull Test Results

#### Test 1 – Centre pod in the bow

<table>
<thead>
<tr>
<th>Pod</th>
<th>Static bollard pull (t)</th>
<th>Sustained bollard pull (t)</th>
<th>Average RPM</th>
<th>Current Average (kn)</th>
<th>Current direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pod #5</td>
<td>34.7</td>
<td>31.6</td>
<td>305</td>
<td>0.6</td>
<td>Ahead/port side</td>
</tr>
</tbody>
</table>

- Vessel backing out with towing line fastened in the bow.
- Sustained BP of 31.6 tons and Static BP of 34.7 tons
  - Impact from varying head current ~ -1-1.5 tons.
- Higher RPM value due to the head current.
## Bollard Pull Test Results

### Test 2 – Side pods in the bow

<table>
<thead>
<tr>
<th>Pod</th>
<th>Static bollard pull (t)</th>
<th>Sustained bollard pull (t)</th>
<th>Average RPM</th>
<th>Current Average (kn)</th>
<th>Current direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pod # 4/6</td>
<td>33.1</td>
<td>32.4</td>
<td>302/ 307</td>
<td>0.3</td>
<td>Ahead/port side</td>
</tr>
</tbody>
</table>

- Vessel backing out with towing line fastened in the bow.
- Sustained BP of 32.4 tons.
  - Impact from varying head current ~ -0.3-1 tons.
- Static BP of 33.1 tons.
- Higher RPM value due to head current
# Bollard Pull Test Results

## Test 3 – Center pod in the stern

<table>
<thead>
<tr>
<th>Pod</th>
<th>Static bollard pull (t)</th>
<th>Sustained bollard pull (t)</th>
<th>Average RPM</th>
<th>Current Average (kn)</th>
<th>Current direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pod # 5</td>
<td>37.2</td>
<td>35.9</td>
<td>298</td>
<td>1.1</td>
<td>Stern/port side</td>
</tr>
</tbody>
</table>

- Vessel moving forward with towing line fastened in the stern.
- Sustained BP of 35.9 tons.
  - Impact from varying head current ~ +2-3 tons.
- Static BP of 37.2 tons
- Lower RPM value due to the current from behind.
Bollard Pull Test Results

Test 4 – Side pods in the stern

<table>
<thead>
<tr>
<th>Pod</th>
<th>Static bollard pull (t)</th>
<th>Sustained bollard pull (t)</th>
<th>Average RPM</th>
<th>Current Average (kn)</th>
<th>Current direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pod # 1/3</td>
<td>34.1</td>
<td>31.7</td>
<td>302/ 299</td>
<td>0.9</td>
<td>Stern/port side</td>
</tr>
</tbody>
</table>

- Vessel moving forward with towing line fastened in the stern.
- Sustained BP of 31.7 tons.
  - Impact from varying head current ~ +1-1.5 tons.
    Misalignment of the vessel relative to the towing line led to a few low data points bringing down the average sustained BP figure.
- Static BP of 34.1 tons
Bollard Pull Test Reflections
Alignment Issues of the Vessel Respective of the Towing Line

Azipod® No 1 and 3

Bringing down the sustained BP value
### Summary of Results with Thrust Deductions for Current Impact

<table>
<thead>
<tr>
<th>Pod #</th>
<th>Static bollard pull (t)</th>
<th>Current Impact (t)</th>
<th>Calibrated Static BP (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34.1</td>
<td>-2-2.5</td>
<td>~ 32.1</td>
</tr>
<tr>
<td>2</td>
<td>37.2</td>
<td>-2-2.5</td>
<td>~ 35.0</td>
</tr>
<tr>
<td>3</td>
<td>34.1</td>
<td>-2-2.5</td>
<td>~ 32.1</td>
</tr>
<tr>
<td>4</td>
<td>33.1</td>
<td>+0.1-0.5</td>
<td>~ 33.3</td>
</tr>
<tr>
<td>5</td>
<td>34.7</td>
<td>+0.5-1</td>
<td>~ 35.5</td>
</tr>
<tr>
<td>6</td>
<td>33.1</td>
<td>+0.1-0.5</td>
<td>~ 33.3</td>
</tr>
</tbody>
</table>
Conclusions
All thrusters met the Bollard Pull Requirement

- The current had an impact during the test
- Alignment issues of the vessel during parts of test #4 affected the sustained bollard pull values for Pods #1/3
- Calibrating the Static Bollard Pull results with the thrust deductions from the current gives a consistent picture
- It seems like the side thruster position had higher than expected impact on the thrust. The reduction was more in the order of 6%.
- Measured thrust from the bow thrusters was higher than the stern thrusters due to hull shape

<table>
<thead>
<tr>
<th>Thruster #</th>
<th>Static bollard pull (t)</th>
<th>Current Impact (t)</th>
<th>Calibrated Static BP (t)</th>
<th>BP Estimate from CFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34.1</td>
<td>-2-2.5</td>
<td>~ 32.1</td>
<td>33.4</td>
</tr>
<tr>
<td>2</td>
<td>37.2</td>
<td>-2-2.5</td>
<td>~ 35.0</td>
<td></td>
</tr>
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