Jet Stream Velocity from Azipod on Stadsgården

A Master Thesis by Viking Alexander Schumacher

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Stadsgården, Stockholm
Viking Glory

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length, $L_{OA}$</td>
<td>220</td>
<td>m</td>
</tr>
<tr>
<td>Beam, $B$</td>
<td>35.5</td>
<td>m</td>
</tr>
<tr>
<td>Draught, $T$</td>
<td>6.8</td>
<td>m</td>
</tr>
<tr>
<td>Gross Tonnage</td>
<td>63 000</td>
<td>-</td>
</tr>
<tr>
<td>Passenger Capacity</td>
<td>2 800</td>
<td>-</td>
</tr>
<tr>
<td>Propeller Diameter, $D_p$</td>
<td>5.3</td>
<td>m</td>
</tr>
</tbody>
</table>

Turku-Åland-Stockholm Delivery: 2021
Azipod

360° Rotational Capability
Project Overview
World Association for Waterborne Transport Infrastructure

Guidelines for Protecting Berthing Structures from Scour Caused by Ships
Propulsion on Viking Glory

2 Azipods
Max Output: 7.885 MW each
Tractor Configuration
Initial Jet Stream Velocity

PIANC:
\[ V_0 = 1.6nD_p\sqrt{K_T} \]

Semi-Empirical:
\[ V_0 = 1.33nD_p\sqrt{K_T} \]

Glory:
\[ V_0 = 9.74 \text{ m/s} \]
Jet Stream Distribution

PIANC:
\[ V_{\text{axis}} = V_0 \text{ for } \frac{x}{D_p} < 1.9 \]
\[ V_{\text{axis}} = 1.9V_0\left(\frac{x}{D_p}\right)^{-1} \text{ for } \frac{x}{D_p} > 1.9 \]

Semi-Empirical:
\[ V_{\text{max}} = AV_0\left(\frac{x}{D_p}\right)^a \]
Jet Stream Distribution

Flow Velocity using German Method (Thrusters). Engine Power 7885kW
Compared with Viking Grace

Loa: 218m  Beam: 31.8m
Compared with Viking Grace

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Draught</strong></td>
<td>6.8</td>
<td>m</td>
</tr>
<tr>
<td><strong>Stern Thruster Diameter,</strong> $D_p$</td>
<td>1.31</td>
<td>m</td>
</tr>
<tr>
<td><strong>Prop. From Bottom, $h_p$</strong></td>
<td>7.3</td>
<td>m</td>
</tr>
<tr>
<td><strong>Stern Thruster Power, $P$</strong></td>
<td>1700</td>
<td>kW</td>
</tr>
<tr>
<td><strong>Ship Centerline to Tube End</strong></td>
<td>1.73</td>
<td>m</td>
</tr>
<tr>
<td><strong>Dist. to Quay Wall, $L$</strong></td>
<td>15</td>
<td>m</td>
</tr>
</tbody>
</table>
Compared with Viking Grace

Glory:
\[ V_{L=9.5} = 9.74 \text{ m/s} \]

Grace:
\[ V_{L=15} = 2.43 \text{ m/s} \]
Correspondence with ABB

**Average flow velocity in Bollard Pull conditions**

**Flow Velocity using German Method (Thrusters). Engine Power 7885kW**
Stadsgården

Box Caisson Launched: November 19, 1907
Existing quay
Current Status of Stadsgården

Multi-beam
Current Status of Stadsgården

Dives 2017
Berthing Structures: Failure
Recommended Action

• Detailed Survey of Quay Wall in Affected Area
  • Junctions
  • Toe of Apron

• Installation of Steel Plates and/or Current Deflectors

• Extension of Fenders

• Operational Guidelines
  • Discuss with Pilot
  • Flow Detector Warning System
Designed quay repair and strengthening
Uncertainties with PIANC Report 180

• No chapter for Azipods
• Natural currents not taken into account
• Multiple prop.
• No limit between ”free propagation” and ”restricted propagation”
• Wall friction ignored
• Focus on scour, no erosion warning
• Equations for thruster and not prop. with rudder
• Error of ±20%
Thanks!

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