Corrosion and abrasion of steel walls in the cargo space of trailing suction hopper dredgers

13/11/2013
Introduction

The steel plating of the cargo hold of a trailing suction hopper dredger suffers from excessive wear.

The presentation will describe:

• Trailing suction hopper dredger and the concerned area
• Problem definition – Wear of cargo hold plating
• Causes and damage mechanism
• Methods to mitigate or resolve the wear problem
• Conclusion
Introduction – Trailing suction hopper dredger

Trailing hopper suction dredger:
• Trailing a drag head over the seabed
• Removal of top layer seabed and sucking material into the vessel’s cargo/hopper hold
• Discharging dredged material by bottom doors, floating line or rainbow nozzle
Introduction – Trailing suction hopper dredger

Cross section of a TSHD cargo hold

Top view on TSHD cargo hold
Problem definition – Wear of cargo hold plating

The vessel’s integrity fails due to wear of structural members:

• **Locally f.e.** wear of plating which cause holes and possible leakages.
  wear of welds which initiates cracks in welds & plating
• **Globally f.e.** wear of plates and primary stiffening causing buckling of plate fields.

Wear of structural steel members is mainly caused by corrosion and in particular cases by abrasion or galvanic corrosion.
Problem definition – Wear of cargo hold plating

In order to limit and control the wear of the ship’s structural members, international regulating bodies require:

• Protection of the metal structures by an efficient painting system. The quality of the paint system depends on the structure’s exposure and risk of corrosion.

• Protection against corrosion by a cathodic protection system; sacrificial anodes impressed current system

• The thickness of the steel structure is to be measured on a regular basis (2.5/5 Year). Thickness below a set limit requires repairs
Problem definition – Wear of cargo hold plating

Example thickness readings
Cargo hold plating

Table with allowable % wastage per location

<table>
<thead>
<tr>
<th>Group of items</th>
<th>Description of items</th>
<th>Isolated area</th>
<th>Item</th>
<th>Group</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECK ZONE (1)</td>
<td>Hatch coaming, underdeck girder web, underdeck girder flange</td>
<td>25</td>
<td>20</td>
<td>10</td>
<td>10</td>
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<tr>
<td>2</td>
<td>Upperdeck plating, deck stringer plates and sheer strakes</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>10</td>
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<tr>
<td>3</td>
<td>Deck longitudinals, web, flange</td>
<td>30</td>
<td>20</td>
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<td>25</td>
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<td>NEUTRAL AXIS ZONE (1)</td>
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<td>15</td>
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<td>4</td>
<td>Side shell plating</td>
<td>25</td>
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<td>5</td>
<td>&quot;Tweendeck hatch girder web</td>
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<td>&quot;Tweendeck plating</td>
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<td>7</td>
<td>&quot;Tweendeck longitudinals web</td>
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</tbody>
</table>
Problem definition – Wear of cargo hold plating

Due to the nature of the cargo (soil & water mixture), the cargo hold of a THSD is unprotected against wear.

On a regular base, large quantities of structural elements are to be repaired due to exceeding of the wastage criteria.
Causes and damage mechanisms

Causes of wear: Corrosion vs Abrasion.

Strong indicators that base mechanism is corrosion:

- The water-wind strake wears approximately twice as much as the lower sections, which are permanently submerged.

- Plate thickness reduction goes faster in tropics. Temperature strongly influenced corrosion, but has no influence on the abrasion.

- No difference in thickness reduction is noticed in areas where there’s a lot of turbulence and consequentially abrasion; near loading points or plate strake at overflow level.

Abrasion of sand cargo is not the base mechanism for wear, but certainly accelerates the corrosion by removing the oxide layer on top the structural elements.

After 10 Year service:
- P17.5mm -> wear 2.2mm
- P15 mm -> wear 1.2mm
Methods to mitigate and/or resolve

Additional plate thickness

In addition to the plate thickness required for structural reasons, a few millimeters of plate thickness is added to compensate for future wear.

Down side of this solution is:

- higher capex of the vessel
- dead weight loss
- difficult to predict future wear and which margin is to be foreseen

Example: 12mm required+3mm wear margin
Methods to mitigate and/or resolve
Renewal of plate strokes.

Down side of this solution is:
Expensive solution due to presence of internals stiffening, auxiliary equipment, cleaning of tanks, etc.
Methods to mitigate and/or resolve

Reducing the span of stiffeners:

Installation of additional stiffening in between two existing stiffeners; locally strengthening and globally restoring or increasing of the moment of interia of the plate field.

Down side of this solution are:
• a lot of welding works in compartments
• tank cleaning
• dead weight losses
• limited safety margin for future wear
Methods to mitigate and/or resolve

Wear plates:
Wearing plates welded on the existing worn structural plates.

Down side of this solution:
- Plates should not participate in the longitudinal strength of the ship
- Dead weigh loss (approx. half of the thickness can be worn).
- Issues with corrosion in between structural and wearing plating.
Methods to mitigate and/or resolve

Wear resistant coatings.

Down side of these solutions are:

• These coatings require strong anchor profile for good adhesion; SA2 ½ grit blasting in covered newbuilding hall very cumbersome.
• Large impact on production progress
• Once slightly damaged by impact or cutting, the painting peel’s off easily.
Methods to mitigate and/or resolve

Cathodic protection against corrosion by sacrificial anodes or ICCP systems.

Down side of these solutions are:

- Sacrificial anodes have limited effect once covered with sticky soil
- ICCP systems are too fragile for use in a cargo hold and have a limited life time.
Methods to mitigate and/or resolve

FEM calculations

The Bureau Veritas class notation “Veristar Hull” prescribes repairs of plate wear, not based on general rules, but based on FEM calculation for a particular area on particular vessel. If the tensions in plate field with reduced thickness do not exceed the limit, no repairs are to be executed.

Down side of this solution:
• A lot of engineering hours are required to build up and to maintain the calculation model.
Conclusion

In order to avoid extensive repairs of cargo hold plating, a combination of previously described methods seems to be best answer. The combination is determined by type of vessel and considered area in the cargo hold.

Or are there new solutions? …suggested by material experts?