Design Optimization and Validation Through FE Analysis of Parallel Motion Fender

Vikas K. Sheth\textsuperscript{1} Chandresh Motka\textsuperscript{2}
\textsuperscript{1} P.G. student \textsuperscript{2} Assistant Professor
\textsuperscript{1,2} Kalol Institute of Technology & Research Centre

Abstract— In port area the problem of handling of large vessels at river bank is arises from many years. Many research has been gone throw in this area and one of the generalize solution has been found by using fender. A fender is the interface between a ship and the shore facilities. Generally, its main objective is to protect the ship’s hull from damage. In some cases it’s the shore facilities that require protection against impact of the ship. But the failure of fender is new problem that faces by the designer because of the heavy impact of the ship. This work regarding to the redesigning of the parallel motion fender that fails under torsion arm and give the probable solution for remove this problem. For achieving optimize parallel motion fender we use spring with outside guide to give it sufficient stiffness and move it parallel. Here force is applied at 0°, 10° and 20°.

Key Words: Ship, Parallel Motion Fender, Torque Tube, Torque pin, Spring, Optimization

I. INTRODUCTION

It was once stated, some years ago, “there is a simple reason to use fenders: it is just too expensive not to do so”. Although it may be a rather pragmatic and one-sided view, there certainly is a germ of truth in the statement. In addition to the financial aspect, safety is probably an even more important reason to install fenders. Nowadays it is common practice to apply fender assemblies comprising energy-absorbing rubber elements in ports which have to accommodate large vessels. However, port authorities have an approach which is both commercial and practical; therefore, if conditions allow (relatively small vessels, mild environments conditions), ports may optimize for the installation of low cost fenders and/or apply locally available material. Wooden fenders, rubber tyres or the like are therefore still regularly encountered all over the world, even in major ports. Parallel Motion Fenders were conceived to overcome the shortcomings of conventional fenders. A parallel motion fender consists of a fender panel, similar to a conventional panel but backed by only a single fender unit (or pair of units mounted together) at its center. To support the fender panel and to restrain it so that it is always vertical, it is mounted on a pair of arms which project from a torsion tube. The connection between the arms and the panel is hinged and the torsion tube itself is mounted on hinges.

II. PROBLEM DEFINITION

Base on review, there is no work done regarding to failure of fender. From literature survey, we can say that parallel motion fender widely used because of its functional and operational accuracy than other type of fender. But in conventional parallel motion fender main load bearing element is torque arm which sustain the entire jerk and impact load. Due to heavy loading, torque arm often fails.

In this work, our aim is to use parallel motion fender with spring to increase stiffness and guide support to move complete parallel during compression.

III. MODEL OF PARALLEL MOTION FENDER

![Model of Parallel Motion Fender](image1)

IV. MESHING OF PARALLEL MOTION FENDER

![Meshing of Parallel Motion Fender](image2)

- No. of nodes: 231599
- No. of elements: 56833
- Type of mesh: Hexa (Solid 186)

V. APPLY SHIP FORCE

![Apply Transient Force](image3)

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VI. RESULT OF PM FENDER (FOR 0 DEGREE ANGLE SHIP IMPACT) EQUIVALENT (VON-MISES) STRESS

![Result of PM Fender (For 0 Degree Angle Ship Impact)](image)

**Fig. 5:** Result of PM Fender (For 0 Degree Angle Ship Impact)

VII. RESULT OF PM FENDER (FOR 10 DEGREE ANGLE SHIP IMPACT) EQUIVALENT (VON-MISES) STRESS

![Result of PM Fender (For 10 Degree Angle Ship Impact)](image)

**Fig. 6:** Result of PM Fender (For 10 Degree Angle Ship Impact)

VIII. RESULT OF PM FENDER (FOR 20 DEGREE ANGLE SHIP IMPACT) EQUIVALENT (VON-MISES) STRESS

![Result of PM Fender (For 20 Degree Angle Ship Impact)](image)

**Fig. 7:** Result of PM Fender (For 20 Degree Angle Ship Impact)

IX. RESULT & DISCUSSION

<table>
<thead>
<tr>
<th>At Torque Arm Attachment</th>
<th>0 Degree</th>
<th>10 Degree</th>
<th>20 Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material ST 52 – 355 MPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Von Misses Stresses(MPa)</td>
<td>228.69</td>
<td>449.96</td>
<td>699.04</td>
</tr>
<tr>
<td>Factor of Safety</td>
<td>1.46</td>
<td>0.74</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**Table. 1: results**

From this result we can say that maximum stresses occur at the torque arm attachment and minimum life is also generated at the torque arm. For 0 degree ship impact, fender is capable for sustaining load. For 10 degree and 20 degree ship impact, fender is not capable to sustain load and minimum life is generated at the torque arm. so in next chapter we modify design and try to reduce stresses and increase life of parallel motion fender.

X. MODIFICATION

![Parallel Motion Fender Using Spring Attachment](image)

**Fig. 8:** Parallel Motion Fender using spring attachment

![View of Spring Attachment](image)

**Fig. 9:** View of Spring Attachment

In Parallel Motion Fender When the ship strikes a Fender First Cone Fender absorb shock energy when the limit of cone fender is complete. It transmit it load to upper damper but in some cases when the ship strikes only upper surface of the Parallel Motion Fender Upper Damper absorb more energy and its compression movement is more than lower Damper which restrict the parallel movement so we put spring mechanism for uniformly guide.

As shown in fig.8 four helical springs are attached to upper and lower flange. These four springs are guided by upper and lower guided hollow shaft in such a way that buckling of spring will not produce. Also these guide help to move parallel (close to vertical) to parallel motion fender so we can also reduce buckling and bending effects which produced in the parallel motion fender with torque tube mechanism.
XI. APPLY TRANSIENT FORCE

Fig. 10: apply transient force using spring attachment

XII. RESULTS OF PM FENDER USING SPRING ATTACHMENT (0 DEGREE STRIKE ANGLE)

Fig. 11: von-mises stress (0 degree strike angle)

XIII. RESULTS OF PM FENDER USING SPRING ATTACHMENT (10 DEGREE STRIKE ANGLE)

Fig. 12: von-mises stress (10 degree strike angle)

XIV. RESULTS OF PM FENDER USING SPRING ATTACHMENT (20 DEGREE STRIKE ANGLE)

Fig. 13: von-mises stress (20 degree strike angle)

XV. RESULT OF PARALLEL MOTION FENDER USING SPRING ATTACHMENT

<table>
<thead>
<tr>
<th>At Circular attachment</th>
<th>0 Degree</th>
<th>10 Degree</th>
<th>20 Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material St 52 – 355 MPa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Von Mises Stress (MPA)</td>
<td>64.325</td>
<td>69.415</td>
<td>72.396</td>
</tr>
<tr>
<td>F.O.S</td>
<td>5.5188</td>
<td>5.1141</td>
<td>4.9035</td>
</tr>
</tbody>
</table>

Table 2: results

As shown above, the analysis has been performed for the force applied at normal direction to the frontal panel, 0 degree 10 degree and 20 degree. The static analysis and has been performed for all 3 cases. The stress value is coming less than the allowable stress value (72.396 Mpa – force applied on 20 degree, worst case). After modify design, the stress value is coming much less than the existing design.

XVI. CONCLUSIONS

In the present work Nonlinear Static analysis of Parallel Motion fender has been carried out in ANSYS work bench for Impact loading that shows Torque arm pin is the most critical part for the Fender life.

Analysis has been carried out for the new model with spring support where torque tube mechanism is complete removed and we use spring to give it sufficient stiffness and guide to move it parallel. Another advantage is that it is easy to construct and no critical part like pin in torque tube attachment.

Through Analysis it would be conclude that modified model for the fender is better than the old model of PM fender with torque tube attachment because stress value is coming much less than the allowable stress value (72.396 MPa – force applied on 20 degree, worst case). In this design we increase factor of safety up to 5.5188 at 0 degree impact loading.

REFERENCES

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