SEVERE CASING AND IMPELLER EROSION: ANALYSIS AND RESOLUTION

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Author Biographies

❖ Professional Experiences

2005 – Present : Flowserve Flow Solution Group

- Senior Technical Services - Saudi – Arabia
- Technical Services - Netherlands (responsible Africa French and English Speaking countries )
- EMA Central Engineering Group - Netherlands
- Technical Services Engineer - France

❖ Education

- Master of Science in Mechanical Engineering (Universite Orleans / Ecole Polytechnique de Montreal)
- Master’s Degree Physics (Universite de Tours)
Agenda

- **Introduction**
  - Background information
  - Design data

- **Failure Analysis**
  - Erosion pattern location
  - Fluid analysis
  - Operating condition
  - Flow path identification

- **New Design**
  - Impeller backplate improvement
  - Axial thrust evaluation

- **Conclusion**
Introduction

Background Information

- Pumps have been in service for 3 years without showing any performance degradation
- After mechanical seal failure, pump brought to maintenance shop for overhaul
- After dismantling severe erosion patterns on the backside of the impeller and cover at wear ring location
- No erosion pattern on front side of the impeller
## Design Data

<table>
<thead>
<tr>
<th>Service</th>
<th>Units</th>
<th>Rated Discharge Pressure</th>
<th>Efficiency</th>
<th>Temperature</th>
<th>Speed</th>
<th>Capacity at BEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produced Water</td>
<td>2100 (Usgpm)</td>
<td>146.5 (Psig)</td>
<td>72 (%)</td>
<td>115 (deg F)</td>
<td>3575 Rpm</td>
<td>2144 (Usgpm)</td>
</tr>
<tr>
<td>Rated Head</td>
<td>211 (Ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated Suction Pressure</td>
<td>53.5 (Psig)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Introduction

Design Data

- Mechanical seal plan 32/62
- Flushing with external clean source, sea water in this particular case
Failure Analysis

Erosion Pattern Location

- No erosion damage on the front side
- Severe fish skin erosion
- Impeller back at wearing neck
- Cover inner side
### Fluid Analysis

<table>
<thead>
<tr>
<th>Sample Id</th>
<th>Sample Point</th>
<th>TSS Hydrocarbon mg/l</th>
<th>TSS Non-Hydrocarbon mg/l</th>
<th>Total TSS mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location 1</td>
<td>Water outlet from Train 3</td>
<td>54</td>
<td>36.4</td>
<td>90.4</td>
</tr>
<tr>
<td>Location 2</td>
<td>Water outlet from Train 4</td>
<td>81</td>
<td>24.7</td>
<td>105.7</td>
</tr>
</tbody>
</table>

- Pump datasheet indicate no TSS in the pumped medium
- Actual fluid analysis revealed at least 100 ppm
- Well sand particles and hard particles
Failure Analysis

Operating Condition

- Tdh @ operating condition
- Total diff pressure = 114 Psi
- Total diff head = 258 ft

Main Discharge pressure around 170 psi g
Failure Analysis

Operating Condition

- If there is any discontinuity in the flow path it will accelerate wear at these locations.

- Leakage flow on front and back shroud has higher impinging energy.
Operation far from BEP will result in:

- Amplification of known hydraulic phenomenon
- Pump fluid will transfer more energy to wall surface
- High turbulence in narrow clearance area
Failure Analysis

Flow Path Identification

An analysis of the leakage flow path study done by Flowserve in a more severe abrasive service environment has demonstrated:

- Particle diameter plays an important role, only particles with smallest diameter enter the back shroud chamber
- A portion of the flow entering in the back shroud chamber is trapped, thus particles suspended are trapped in this chamber resulting in an accelerated erosion damage
Failure Analysis

Flow Path Identification

- Erosion damage is more severe when operating off BEP with a high impinging energy thus resulting in a more severe erosion rate.

- Current design suggests a dead zone on the back side of the impeller and cover.
- Trapped particles will remain and won’t be flushed.
- Therefore increased erosion rate.
Upgraded Design

Improvement of the back side of the impeller

Original Design

Upgraded Design
Upgraded Design

Improvement of the back side of the impeller

- Increase of the back side area
- Bigger area = lower flow velocity, turbulence reduction
- Impeller balancing holes size increased and location changed
- Trapped particles will be centrifuged toward suction
Upgraded Design

Axial Thrust Evaluation

- Back wearing OD change
- Axial Thrust evaluation
- Suitability of existing thrust bearings

**Axial Thrust = Back Thrust – Front Thrust**

<table>
<thead>
<tr>
<th>Axial Thrust (N)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing design</td>
<td>1456</td>
</tr>
<tr>
<td>Upgraded design</td>
<td>8300</td>
</tr>
</tbody>
</table>

Still suitable for existing thrust bearings which can bear resulting thrust
Lesson Learned

- Original pump Design is a proven design with an extensive installed base.
- Severe erosion found on this equipment after 3 years of operation has demonstrated the sensitivity of the design (impeller back shroud and cover) related to the pumped medium.
- These erosions patterns have not been observed in a clean liquid application, with no suspended solids.
- Erosion took place thanks to small particles size, where turbulence at the impeller back shroud and cover was extremely high resulting in a higher erosive action.
- Hard solids particles are impinging in the rear close running clearances.
Conclusion

Improvement

- Design Enhancement has been implemented, main target was to reduce the turbulence level by increasing the back side of the impeller and cover area thus reducing local velocity and allowing hard particles to be flushed away.
- Pumps back to operation for a year

Financial Impact

- 12 Upgraded units
- Capex of 950 K dollars
- Expected life time 40 years