Sustainable Asset Life Cycle Management:

Optimising Maintenance Strategies in the Process Industry to Maximise the environmental performance of Assets

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Content of the presentation

- Problem Statement
- Objective
- Prior work in this field
- Research approach
- Maintenance Strategies
- Life Cycle Management
- New Asset Life Cycle and Maintenance Strategy Model
- Case Studies in the South African process industry
- Optimized Maintenance Strategies
- Conclusion
Problem Statement

- Environmental implications were not taken into account prior to the 1980s in the process industry
  - Especially in developing countries
- Maintenance strategies focussed on:
  - Maintainability
  - Reliability
  - Cost

- Total life cycle cost and environmental liabilities were consequently not taken into account

Short term focus

Long term focus
Objective

- Total life cycle of assets
  - Must accommodate environmental impacts of assets

Importance of Objective
- To ensure a company’s environmental credibility is acceptable to all its stakeholders
Prior work in this field

- Literature review
  - Maintenance strategies do not make provision for environmental impacts of assets during maintenance cycles
  - Absence of environmental considerations in design of the life cycles of assets

- Limitations and key assumptions of this research
  - Do not want to change Maintenance Strategies or redefine them
  - Do not change the life cycle phases of assets

- Integrate LCM into Maintenance Strategies and Asset Life Cycles to optimize the environmental performance of assets
Research approach

- Case Study approach in the Process Industry of South Africa
- Maintenance Management environment and evaluate the current state of strategies towards environmental impacts of assets
- Recommendations and best practices will be proposed to be implemented in process industries
Maintenance Strategies

- **Run-to-failure**
  - Run asset to failure and then repair it

- **Preventive Maintenance**
  - Fixed interval (repair, overhaul, replace) regardless its condition at that time

- **Predictive Maintenance**
  - Measure condition to assess when it will fail and take action to avoid the consequences of failure

- **Proactive Maintenance**
  - Monitor and correction of root causes to asset failures
Life Cycle Management of Assets

- Classic definition of Life Cycle Management (LCM)
  - Considers the product life in a holistic way with the aim of achieving maximum product performance

- Therefore, with respect to assets
  - Considers the asset life in a holistic way with the aim of achieving maximum asset performance

- From the perspectives
  - Optimal cost
  - Maximised environmental performance
  - Social beneficiation
New integrated Asset Life Cycle Management model

<table>
<thead>
<tr>
<th>Future Requirements</th>
<th>(Holistic Optimisation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>(Cost)</td>
</tr>
<tr>
<td>Safety</td>
<td>(Products, Consumers and Industrial Safety)</td>
</tr>
<tr>
<td>Environmental Soundness</td>
<td>(Raw materials, Fuels, Emissions, Waste)</td>
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</tbody>
</table>

- Detailed Design
- Construction
- Operations /Maintenance
- De-commissioning

- Maintenance Strategies
  - Run-to-failure
  - Preventative Maintenance
  - Predictive Maintenance
  - Pro-active Maintenance

- LCC; LCA; LCE

- Pre-Manufacturing
- Operations /Maintenance
- Product Usage
- Product Disposal
- Asset Life Cycle
- LCM Tools
- Product Life Cycle
Case study 1: Surface Bed Cracking

- **Major Problems:**
  - No maintenance strategy was followed
  - LCM tools were not incorporated into the design phase of the life cycle of the asset
    - Reconstruction of slabs where expansion joints should have been

- **Safety:**
  - All cracks resulted in tripping hazards in the area

- **Efficiency:**
  - No maintenance resulted that slabs could not be repaired and had to be demolished
Case study 1:
Surface Bed Cracking

EXISTING SLAB: (6m x 6m)
Construction Cost : R3600 x 36m^2 = R129 600.00
Construction Joints: R133/m x 24m = R3 192.00
Crack Sealing: R100/m x 12m = R1 200.00

Construction Cost: R3600 x 36m^2 = R129 600.00
Construction Joints: R133/m x 24m = R3 192.00
Crack Sealing: R100/m x 12m = R1 200.00

R129 600 R3 192 R1 200
R129 600 R3 192 R1 200
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

= R272 367

REHAB SLAB: (3m x 3m)
Construction Cost : R5 600 x 36m^2 = R201 600.00
Construction Joints: R133/m x 48m = R6 384.00

Construction Cost: R5 600 x 36m^2 = R201 600.00
Construction Joints: R133/m x 48m = R6 384.00

R207 984 R6 384
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

= R214 368

\[ \therefore \frac{R214 368}{R272 376} = 21\%\]  

Costs are shown in present South African Rands: 1 AUD = 4.7 ZAR
Case study 2: Relining of an evaporation pond

- **Major Problems:**
  - Maintenance strategy was run-to-failure
  - The sludge in the pond could not be removed without damaging the liner
  - The old design had a herringbone system underneath the liner
    - Constructed in the soil
Case study 2: Relining of an evaporation pond

➢ Safety:
  • Vacuum of sludge out of pond
    – Dangerous working environment

➢ Efficiency:
  • No maintenance could be done on the liner
    – Due to sludge built up
  • Could not remove sludge without damaging the liner
  • Leaks in the liner could only be traced when entering the herringbone
Case study 2: Relining of an evaporation pond

OLD DESIGN:
Construction Cost: R6.5mil
Rehabilitation Cost: R3.0mil

\[
\begin{array}{cccccccccccccccccccc}
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 & 20 \\
R6.5mil & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 & 20 \\
Rehabilitation = R3.0mil & & & & \quad & & & & & & & & & & & & & & & & \quad & R16mil
\end{array}
\]

NEW DESIGN:
Construction Cost: R8.0mil
Clean-out cost for basin: R200 000.00

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\begin{array}{cccccccccccccccccccc}
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 & 20 \\
R8.0mil & R200 000.00 & R200 000.00 & R200 000.00 & R200 000.00 & = R8.6mil
\end{array}
\]

\[
\begin{align*}
\therefore \quad \frac{R8.6mil}{R16mil} &= 46\% \\
\end{align*}
\]

Costs are shown in present South African Rands: 1 AUD = 4.7 ZAR
Optimized Maintenance Strategies

Proactive Maintenance

• Focus on the most cost-effective way to manage the failure mode of an asset
• Be more proactive in terms of environmental risks
• Design cost will initially be higher but the LCC for the total life cycle of the asset will be lower.

Predictive Maintenance

• Focus on the most cost-effective way to manage the failure mode of an asset
• Predict environmental risks
• Design cost will initially be higher but the LCC for the total life cycle of the asset will be lower
• Predictive measures will be designed into the asset from the beginning of the asset life cycle
Conclusions

- Maintenance Managers and environmental experts have input into design
  - Cost may initially be higher but life cycle cost will be lower over total life cycle
- More strict legislation
  - “green products”
- The model ensures
  - Maintenance Strategies + LCM tools = Long term sustainability of assets & Lower total life cycle cost
- Therefore
  - Give a holistic view of assets’ environmental performances, safety and efficiency from design phase to disposal phase
    - Cradle-to-grave principle
South African on-going LCM activities

Closure and (limited) questions