Life Cycle Cost of Surface Coatings used for Corrosion Management

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Abstract

A life cycle cost analysis of surface coatings used for corrosion management is developed for assets consisting of an onshore processing plant, fixed offshore platform and FPSO. The parametric model, based on historical cost data, can predict life cycle cost for a chosen future maintenance schedule. The primary cost drivers are determined, historical cost breakdowns and trends examined and a sensitivity analysis conducted. The primary cost driver is labour costs in external service contracts. Life cycle cost varies linearly with the annual surface area covered by the maintenance campaigns. This study in combination with a model for cost/risk of corrosion failure can determine an annual surface area coverage that would reduce life cycle cost and corrosion risk.

1. Introduction

Continued project growth has resulted in an increasing work load and corrosion management costs have continued to grow significantly over recent years (Figure 1). This project, conducted for a diversified Australian Oil and Gas Producer, determines the life cycle cost of surface coatings used for corrosion management for a sample of assets. The major cost drivers are determined, sensitivity analysis conducted and a parametric model developed. There have been no prior attempts at The Oil and Gas Producer to quantify the life cycle cost of surface coatings on a company-wide level and across multiple assets. By understanding these cost drivers, the benefits of improvements to its corrosion management processes can be quantified.

There are several industry standards available that provide guidance as to how to determine the life cycle cost of an asset/activity, such as AS/NZS 4536 (Committee, 1999), AS IEC 60300.3.3-2005 (Committee, 2005) and ISO 15663:1-3 (ISO, 2000). As each standard covers life cycle cost topics to varying degrees a good life cycle cost analysis should consider guidance from all three standards, to ensure that the results have accounted for all possible factors. Literature review has not found any other articles that have attempted to apply life cycle cost on an asset-wide level to three different asset types using historical data. Past articles are either not related to corrosion maintenance (e.g. (Lee et al., 2006)), use theoretical case studies (Weyers and Goodwin, 1999) or their case study is limited to a single maintenance activity/application (e.g. (Zhou and Nessim, 2011)).

(Suparatchai and Assem, 2004) is notable because it bears strong resemblance to our own study. The authors examined whether the information stored within an Electronic Maintenance Management System (EMMS) is adequate for life cycle cost analysis of assets. The goal was to provide a structural cost breakdown and examine the feasibility of integrating life cycle costing into the EMMS. Several reasons are provided such as data availability, the uncertainty of future prediction factors (e.g. discount rates and service life) and the difficulty of forecasting future operating and maintenance costs. They also state that some assets can have more than ten years' worth of data, and this makes the life cycle cost process cumbersome and tedious. They also suggest that there is inconsistency in the way information is collected and stored within the petroleum industry, sometimes even within the same organization.

The greatest flaw with (Suparatchai and Assem, 2004) lies in their reliance on the pre-existing functions within THE EMMS only. This inherently limits their research because all their data and modelling is limited by what is available in THE EMMS. For example, if data availability is insufficient in THE EMMS the authors should have consulted other information sources then collated the data into their own modelling software. This would have allowed them to consider a larger data sample and ensured that they accounted for all necessary factors.

2. Methodology

The data was collected to complete the following objectives:

1. To determine the life cycle cost of surface coatings used for corrosion management for a sample of The Oil and Gas Producer projects consisting of:
    - Onshore processing facility
    - Offshore fixed platform
    - Floating Production, Storage and Offloading vessel (FPSO)
2. Analysis of historical data to determine variability of life cycle cost over time and across projects.
3. Analysis of the breakdown of cost components over time and overall cost breakdown for each asset based on total cumulative real discounted life cycle costs.
4. Comparison of total cumulative real discounted life cycle cost for each asset against a series of market indicators including ASX All Ordinaries index, The Oil and Gas Producer share price, Cushing oil spot price index and GSCI commodity index.
5. Conduct a sensitivity analysis to determine the robustness of life cycle cost findings.

Three different asset types (fixed offshore, onshore and FPSO) were selected for cost comparison. Cost data was collected for each asset and categorised into one of the following: Internal Labour & Services, Logistics, Materials & Equipment, External Services and Other Costs. External services refer to the labour costs in external service contracts. Data collection was broken up into three stages corresponding to the phases of the life cycle: initial cost, ongoing maintenance cost and future cost. Consequential cost was not included as the Oil and Gas Producer adjusts production from other assets to compensate for shutdown maintenance. This means no actual consequential cost is incurred as the production impact is mitigated. Initial cost refers to the initial fabrication cost spent on surface coatings at the initial fabrication stage of the project. To ensure robustness and reduce bias multiple initial cost proportion estimates were collected. Sensitivity analysis will be conducted later to examine the impact on findings of varying cost proportions.

Ongoing maintenance cost data was sourced from three information systems (Post-2008 EMMS, Pre-2008 EMMS and a legacy EMMS, with correspondingly different interfaces and recorded data fields. To ensure data accuracy a systematic retrieval approach was developed after consultation with staff. This data was cross-verified against other duplicate/ supplementary records for a sample of data collected. When maintenance work needs to be completed a work order or operations order is raised within the information system, and corresponding costs are invoiced back to these orders. All orders and their corresponding costs that had descriptions related to painting, coating or blasting were extracted. Cost items were filtered to remove unrelated items (e.g. unrelated equipment hire, blast walls, blast doors etc.); then summed together using the net present value model.

To estimate future costs a parametric model was developed based on historic cost data to estimate future periodic maintenance cost (e.g. painting campaigns) based on percentage of annual surface area repaired. Periodic future maintenance cost is composed of three components: future average external services, materials & equipment and logistics cost. The future average materials & equipment and logistics are considered fixed amounts based on the average of these cost components over years covered. Using the data collected about external services, the AUD/Hrs and Hrs/m^2 for each year were calculated.

The future average external services component was calculated by taking the averages of these two rates and multiplying it by a proportion of the asset surface area. These future cost components were summed together to determine the periodic future maintenance cost. This periodic future cost was then adjusted to account for the cost escalation of external services and materials & equipment over time. Summing together these series of future periodic costs generates an estimate of the total future cost.

3. Results and Discussion

When examining the findings, an appreciation of the differences between the assets should be considered. The onshore, fixed offshore and FPSO commenced operations in 1984, 1994 and 2006 respectively, and are expected to end by 2045, 2035 and 2025 respectively. Their expected service lives means the assets will essentially be recoated fully several times over – although no asset has had large scale recoating done. The assets were fabricated by the producer and, for the purpose of this review, the surface areas of the fixed offshore and FPSO asset are assumed to be constant whilst the area of the onshore asset may vary with expansion. Typically, a three layer organic coating is used, but different environments pose new challenges. Safety requirements for fixed offshore assets often require additional coatings (e.g. hazard warnings, fire protection). The structural complexity of fixed offshore assets means greater duration is also needed to cover the same surface area as a FPSO.

External services are considered the biggest cost driver of surface coating costs for the assets examined.

3.1 Analysis of historical cost trends

In Figure 1 life cycle cost is compared against movements in the Cushing spot price. Before 2009, Cushing spot prices rose rapidly and peaked at close to 100 dollars per barrel and this drove strong share price performance. However, after 2008 the Cushing spot price dropped considerably. The cost rise from 2008-2012 compared to the cost rise from 2004-2008 shows that for the onshore, offshore and FPSO there was an 82%, 268% and 843% increase respectively. The figures for the FPSO are skewed because it commenced in 2006, so the ramping up of operations likely drove some of the cost rise. However, this skew does not apply to the onshore and fixed offshore asset, yet they also exhibited a substantial rise in 2008-2012 cost. This raises the question of what maintenance campaign would help reduce life cycle cost.

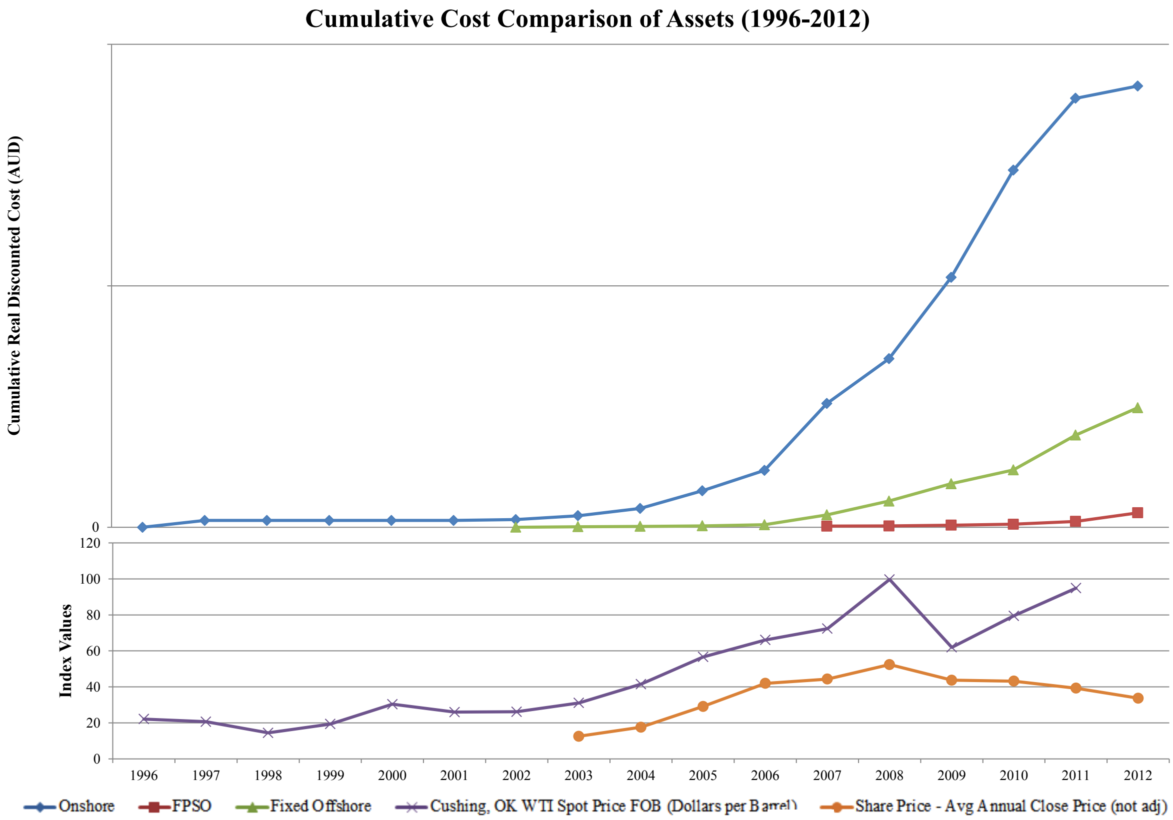

Figure 1: Cumulative cost comparison of assets against market index movements

3.2 Results of the parametric model

The parametric model developed is for cost prediction only and does not account for corrosion risk. The model generates the life cycle cost (excl. initial cost) for a given annual surface area coverage. Consultation with large network of stakeholders revealed the time to complete coating breakdown was agreed to be approximately 12-15 years for the onshore asset and 5-7 years for the fixed offshore and FPSO. To achieve the onshore asset time to recoat about 6-9% of surface area needs to be repaired annual. This coverage varies depending on time to recoat used. Similarly, for the fixed offshore and FPSO about 14-20% of surface area needs to be repaired on an annual basis. In Figure 2, the predicted life cycle cost is generated for a range of annual surface area coverage of 1-20%.

Figure 2 suggests that predicted life cycle cost varies linearly with annual coverage. Varying the cost escalation rate used for external services and materials & equipment by ±5-10% resulted in less than 5% change to life cycle costs. However, the sensitivity does increase with increases in coverage. Although, the model provides cost prediction, finding the coverage that reduces life cycle cost cannot be found without also considering the cost/risk of corrosion failure. Further work can be done to model the relationship between coverage and cost/risk of corrosion failure. Combining these two models would provide an annual coverage that reduces both life cycle cost and corrosion risk.

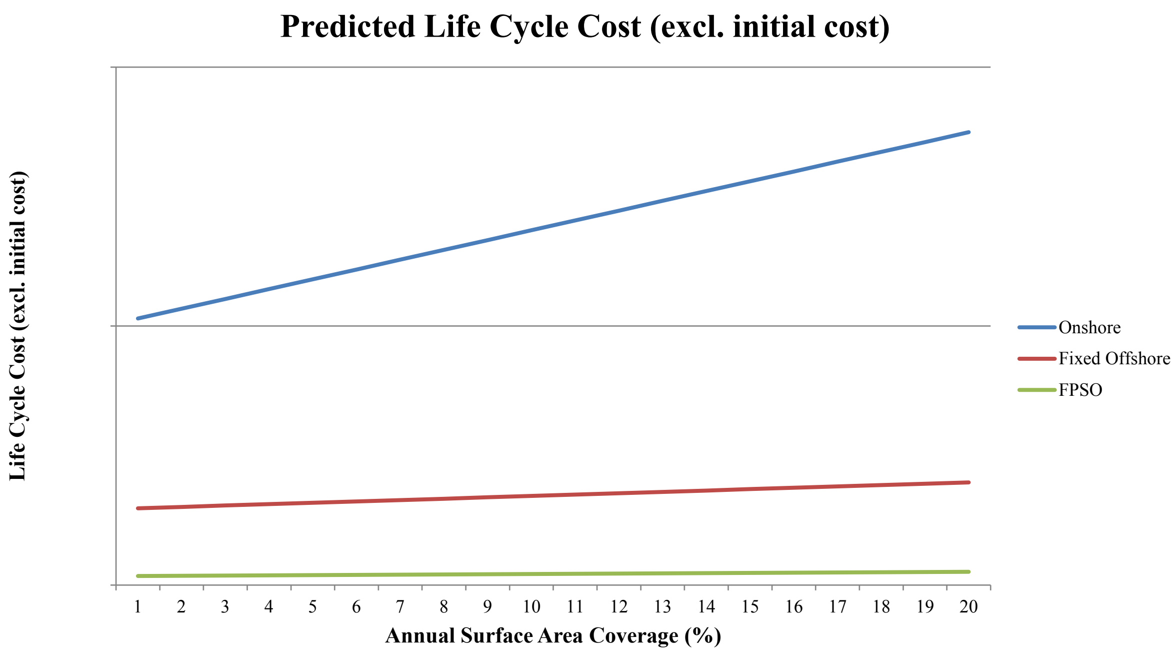

Figure 2: Predicted life cycle cost (excl. initial cost) using parametric model for a range of possible annual surface area coverage

The greatest challenges have been gathering the required data to model life cycle cost. Cost data has not been stored centrally in an easily retrievable form; rather the cost data was spread across multiple information systems and recorded unsystematically. Additional data like surface area, remaining useful life, initial cost proportion, initial fabrication cost and cost escalation rates also proved difficult to find. A large network of stakeholders was consulted including various staff, contractors and vendors. Scheduling meetings and managing their progress proved very time consuming. Some assets were particularly difficult to find data for because of their age (onshore), difficulty estimating surface area (onshore, fixed offshore) and lack of fabrication history (FPSO). Information related to initial cost was particularly difficult to locate for the onshore asset and FPSO.

4. Conclusions and Future Work

The study determined that external services were the primary cost driver. To determine the annual surface area coverage that would reduce life cycle cost a range of coverage inputs was modelled. The results indicate that finding the annual coverage to reduce life cycle cost cannot be done without also considering the cost/risk of corrosion failure. In the future a model that links the cost/risk of corrosion failure to annual coverage can be developed, and when combined together a coverage that reduces both life cycle cost and corrosion risk can be determined. Determining this coverage would provide The Oil and Gas Producer with a guide for the amount of maintenance coating work that needs to be done annually.

5. References

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