Car Dumper Replacement Study

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Abstract

ASPEC was engaged to carry out a combined Order of Magnitude/Pre-feasibility study for the replacement of an ageing twin cell car dumper. The car dumper had already begun to experience fatigue cracking, necessitating regular inspections and repairs. Options considered in the study included combinations of partial and full cell refurbishment, replacement with like-for-like and upgraded cell designs, replacement with a single cell tandem car dumper design and the option of keeping refurbished or new cells on site as rotable spares. The findings of the study would also be used in the development of a program to change-out other car dumpers as they approached the end of their design lives.

1. Introduction

ASPEC carried out a combined Order-of-magnitude/Pre-feasibility study for the replacement of an ageing twin cell car dumper. The client was operating a number of other car dumpers with the same design so the study findings were to be used in the development of a program to change out the other car dumpers as they approached the end of their design lives. The study had to consider a host of factors for determining the best option to carry forward, as follows:

- Future operating changes such as an increasingly wet ore (causing higher dumping loads) and the potential introduction of Battery Electric Locomotives.
- Costs associated with ongoing crack/corrosion repairs, in-situ refurbishment, like-for-like replacement and replacement with an upgraded design (necessitating changes to the car dumper facility).
- Shutdown durations associated with the various strategies for maintaining the availability of the car dumper.

2. Options Analysis

A total of ten options were considered in the study after consultation with the client and project stakeholders. Key parameters for each option were as follows:

- Car dumper life extension time
- Fatigue failure resistance following option implementation
- Car dumper availability following option implementation
- Capital cost for the option
- Lost production costs
- Capital cost for implementing the option in a change-out program for multiple car dumpers
- Shutdown duration
- Total project duration
- Option fatal flaws

Cost and duration estimate strategies varied depending on the option. For the option that involved doing nothing and continuing to repair the car dumper as required, costs and durations were calculated using a Fatigue Useful Life approach. For all other options, ASPEC produced order-of-magnitude cost estimates and high level project schedules.

3. Fatigue Useful Life Modelling

An invaluable tool used in the study of the car dumper replacement options was Fatigue Useful Life Modelling (FULS). This spreadsheet based calculation tool, developed in-house by ASPEC Engineering, incorporates a fatigue life calculator in combination with repair cost, repair difficulty and repair downtime forecasts to model cost projections associated with the continued operation of ageing fatigue-failure prone machinery. Ideally, and as was the case in this study, the cost and downtime parameters are based on real, client supplied data, thus allowing for accurate operational predictions.

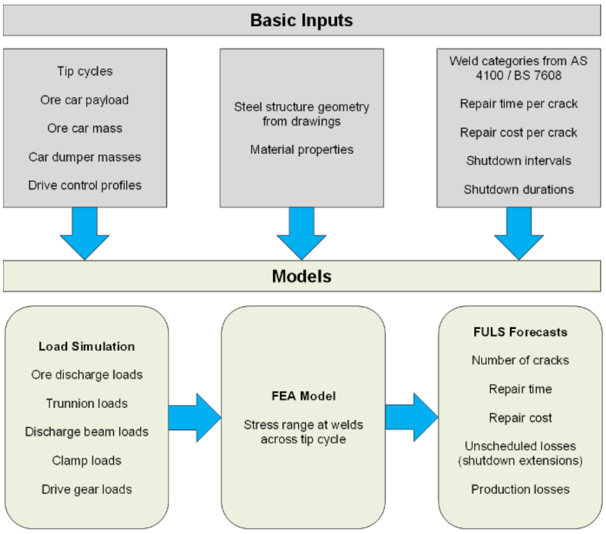

Figure 1 – FULS flow chart.

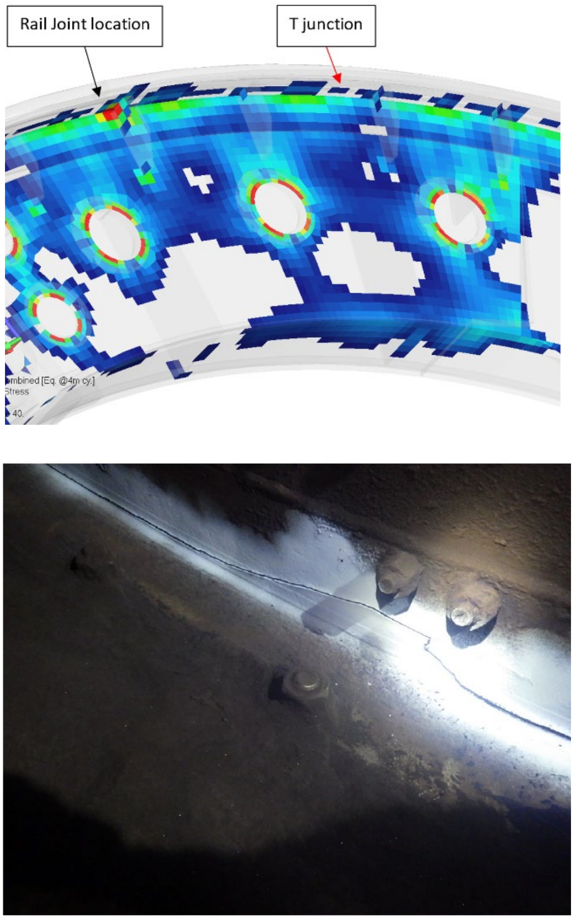

Figure 2 - FULS model damage ratio plot (top) showing areas on the car dumper end ring structure with low fatigue lives (red areas). The photo at bottom shows a circumferential crack running along the fillet of a rolled T-section in the car dumper end ring.

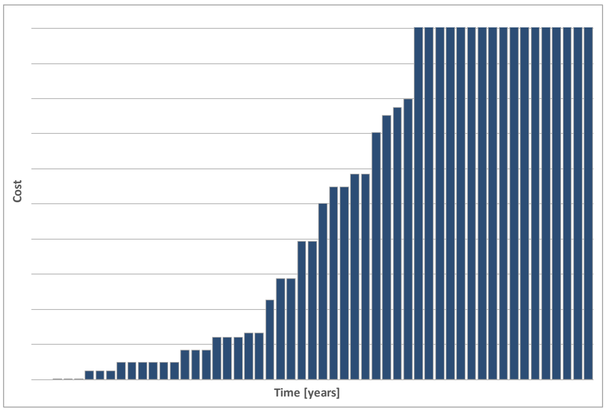

Figure 3 – Calculated car dumper repair cost timeline (includes production losses) from the FULS analysis.

4. Order-of-magnitude Cost Estimates and Project Schedules

ASPEC developed order-of-magnitude cost and duration estimates based on historical car dumper maintenance and repair data supplied by the client and on ASPEC's own experience on infrastructure projects with a similar scope. 3D models were produced to aid in this exercise by defining project battery limits, planning site utilization, determining equipment hire requirements and planning the detailed car dumper cell change-out workflow.

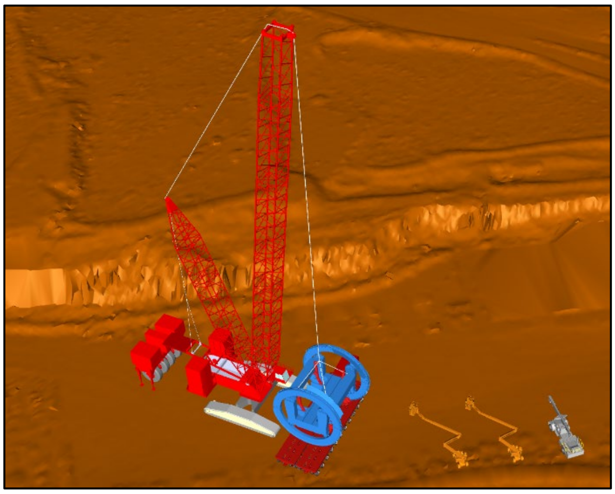

Figure 4 – Navisworks model of cell replacement procedure used in the development of costing and scheduling estimates.

5. Multi-Criteria Assessment

A weighted multi-criteria assessment (MCA) of all identified options was conducted based on the following six key criteria:

1. Less impact on operations / higher reliability
2. Lower capital cost
3. Lower technical risk

4. Longer car dumper lifespan
5. Shorter upgrade timeframe
6. The inclusion of a rotable spare

An assessment of the weighted importance of each criterion was made by comparing its perceived importance against another criterion on a one-on-one basis. A summation of the scores for each criterion was then the basis of that criterion's weighting. Each criterion was given an overall relative score, taking into consideration option costs and durations. Based on these scores, and the weighted importance of each criteria, a weighted total score was calculated. A higher weighted score indicated a more preferrable option. The best option exhibited the best combination of value and cost.

Is the criterion below more, equally, or less important than the criterion to the right? Score as follows: - More = 1 - Equally = 0.5 - Less = 0		Criteria						Total / Resulting Weighted Importance
		Less Impact on Operations / Higher Reliability	Lower Capital Cost	Lower Technical Risk	Longer Lifespan	Shorter Upgrade Timeframe	Includes Rotable spare	
Criteria	Less Impact on Operations / Higher Reliability	-	1	0.5	0.5	0.5	0.5	20%
	Lower Capital Cost	0	-	0	0	0	0.5	3%
	Lower Technical Risk	0.5	1	-	0.5	0.5	0.5	20%
	Longer Lifespan	0.5	1	0.5	-	0.5	0.5	20%
	Shorter Upgrade Timeframe	0.5	1	0.5	0.5	-	1	23%
	Includes Rotable spare	0.5	0.5	0.5	0.5	0	-	13%

Figure 5 – MCA weighted importance matrix.

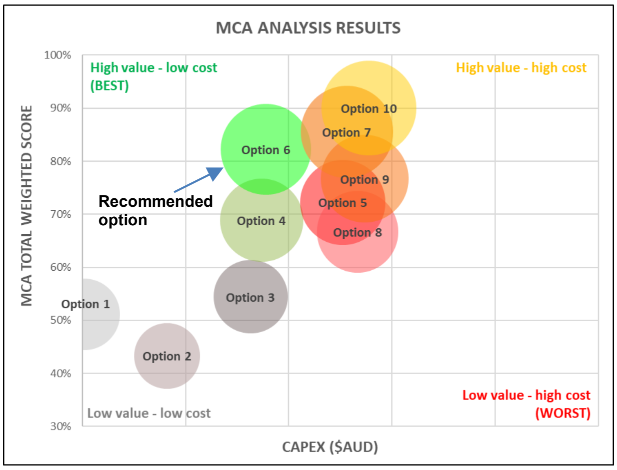

Figure 6 – MCA outcomes versus capital costs.

6. Conclusion

The study resulted in the selection of the option that:

- Displayed the best combination and balance of value and capital cost, where the biggest driver of cost was lost production time
- Effectively addressed future structural fatigue concerns
- Enhanced overall car dumper facility reliability heading forward
- Accommodated potential future operational requirements

The options assessment utilised ASPEC's FULS modelling to predict costs associated with the ongoing repairs of the car dumper beyond its design fatigue life.

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