Evaluate Machinery Using Life Cycle Costing Tools I

While capital costs of new projects attract the most attention of management and vendors, it must be recognized that operating and maintenance (O&M) expenses are also quite significant. Unfortunately, evaluating the cost of a plant asset on a common basis with the capital cost is difficult, so managers tend to give priority to initial cost. Consequently, poor reliability and performance of our machinery equipment do not show up until the plant is actually up and running.

Inexpensive systems are likely to have inferior materials, poor workmanship, and weaker designs. Designers frequently do not opt for redundant equipment because it is "too expensive," even though averting lost production by providing spare machinery, for example, may pay for the initial cost many times over.

Life cycle costing (LCC) is a promising evaluation tool that makes it possible to compare alternatives by quantifying the long-term outlook. In petrochemical operations, for instance, maintenance and downtime costs often exceed the initial equipment cost. LCC identifies and quantifies project costs over the life of the project. It includes future costs of MR&O, downtime, production losses, replacement, decommissioning and incremental operating costs associated with material choice, as well as the initial costs.

Life cycle costing has always been applied in an intuitive way in the form of cost-benefit deliberations. The main value of a formal LCC is that it quantifies life cycle elements so that their relevance can be established and receive appropriate attention. LCC should be applied as early as possible in the life of a project to achieve the greatest benefit.

Unreliable equipment causes significant lost production and waste. However, reliability is frequently a fuzzy concept to project engineers, and they do not know how to address it. Through use of LCC, more-reliable equipment can be justified using a credible analysis acceptable to accountants and business planners.

Increasing the useful lifetime of any system costs money and involves trading against other benefits. Figure 1 illustrates such trade-offs. It shows that life cycle costs and benefits depend on good design integration and support. Hardware is only one factor in the overall picture.

There are twelve steps in the LCC process. The relative importance of each of these steps, and hence their level of application, will vary according to the requirements of a particular LCC analysis. In general a LCC analysis can follows the 12 basic steps outlined in Table 1.

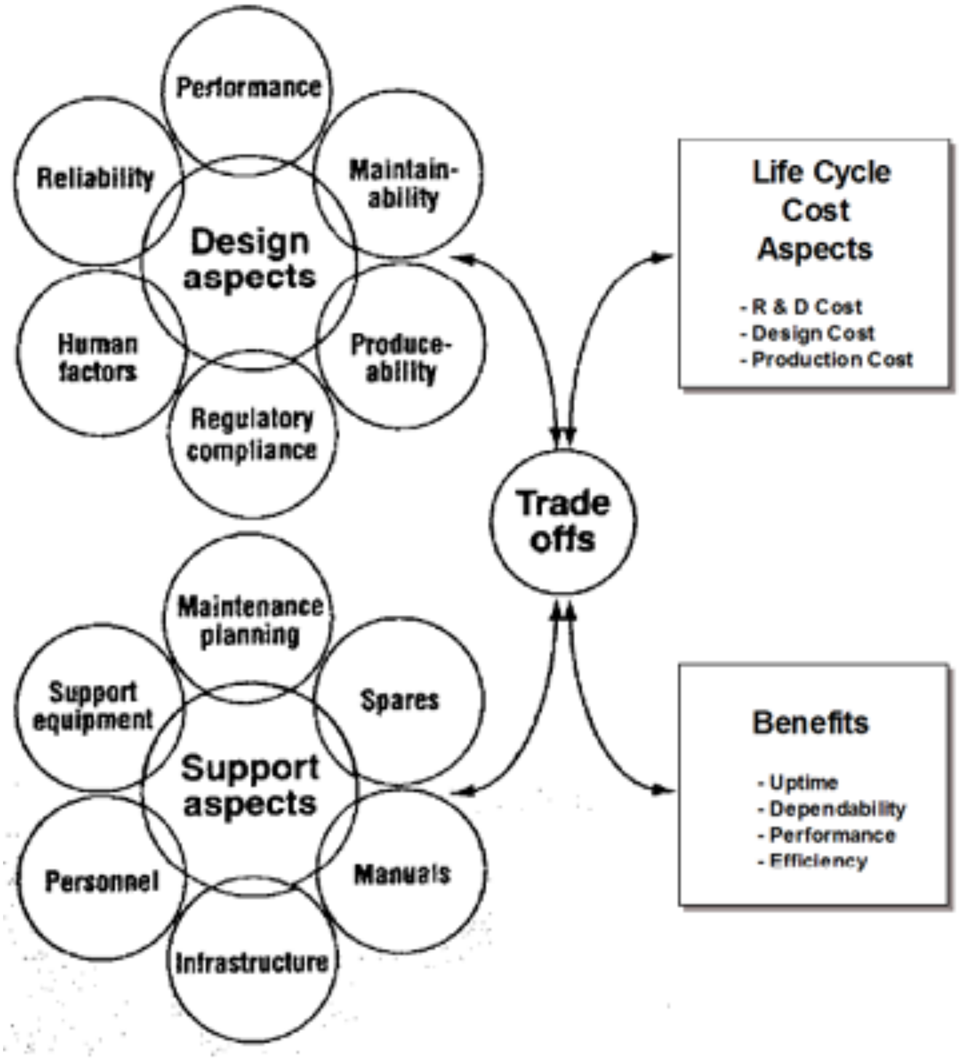

Figure 1. LCC trade-offs.

Table 1. LCC steps.

STEP 1: Define the problem.
STEP 2: Identify feasible alternatives. Engineering must produce preliminary designs of multiple configurations. This stage eliminates unworkable solutions. The concern here is with meeting performance parameters.
STEP 3: Consider alternatives and the system requirements. This is the first look at operations and maintenance. Identify and categorize the life cycle activities. If nothing else, this activity raises awareness that reliability is a parameter in the design process.
STEP 4: Analyze the total lifetime of events for the physical asset. Include in these events all applicable future activities associated with research, development, production, construction, installation, commissioning, operation, maintenance and disposal. In the analysis, identify all resources required during the lifetime of the asset. Group the identified events, activities and resources into major LCC elements, and then break them down into sub-elements. This activity has been refined into what is known as the cost-breakdown-structure (CBS)[1].
STEP 5: Set up a model to define the cost factors and estimating relationships. These factors and relationships include items such as: hourly labor rates, profit margins, and fuel-consumption rates.
STEP 6: Work up the cost of each of the life cycle elements. The previously determined cost estimating factors and relationships are applied to cost models for each of the elements.
STEP 7: Account for inflation and learning curves. Set the accuracy required in the calculated life-cycle cost. Inflation will have strong effects on the life-cycle cost of today's physical assets.
STEP 8: Discount all the estimated costs to a base period. Discounting yields a common basis for financial comparison, by removing the effects of time differences. The process is based on finance mathematics and uses the concepts of sinking fund, present value and capital recovery.
STEP 9: Identify the high-cost contributors. There are facilities in which one or two costs overwhelm all the others. It is a shortcut to concentrate on such items, because they promise the highest payoff.
STEP 10: Calculate the final LCC, using an appropriate cost model. In many cases, this is likely to entail a straight summation of the cost breakdown elements.

In most cases, the model should include a sensitivity analysis. Sensitivity analysis consists of evaluating the results displayed by a model (mathematical or other) upon changing one or more input variables.

STEP 11: Perform a risk analysis. The LCC technique can be useful when applied to situations that consider alternative decisions on a cost basis. These are basically tradeoffs. A few typical situations are:

- Balancing the relative levels of reliability and maintainability for a given piece of machinery or asset against a desired level of availability
- Deciding on the most cost-effective maintenance policy for sub-elements of a given asset. The usual choice is: predictive, preventive, or run to failure.
- Deciding which asset to procure when faced with two or more that will satisfy all specified requirements

STEP 12: Recommend a solution. LCC can be applied to assist in logical management of an asset, even without looking at alternatives. Examples of this approach are:

- Identifying the exact subsystems where design simplification and cost control will produce major cost reduction and longer life cycles
- Establishing a more accurate budget for the actual project
- Understanding the inner workings of a machine or asset. This sets up a more-effective management organization, and better control procedures

The following is a simple example for an LCC tool used in sensitivity analysis (Table 1, point 10): Frequently it is not obvious what repairs on process equipment really cost. Consider a population of centrifugal pumps which are important elements in pipeline and petrochemical plant operations. Long-term records show that the MTBR[1] of these pumps is 25 months. We want to find the equivalent capital cost of the repairs. The life of a pump is 15 years. This calculation discounts annual repair costs (C_Y) back to the date of purchase.

Other data from the operation are:

MTTR = 5 d; C_G = $7,500; i = 6.5%; C_Y can be calculated by:

$$C_Y = \frac{8{,}760 \times C_G}{[(MTBR \times 30.4 \times 24) + (MTTR \times 24)]}$$

$$C_Y = \frac{8{,}760 \times 7{,}500}{[(25 \times 30.4 \times 24) + (5 \times 24)]} = 3{,}578$$

C_{PV} = PV (rate, years, C_Y)[2]

C_{PV} = PV(0.065, 15, 3578) = $33,643

Our sensitivity analysis now has a basis. Look for the benefits that could be derived from attempting to reduce repair costs. Evaluations will compare purchasing a more-expensive and hence – hopefully – more-reliable pump or by making repairs more efficient and hence less costly.

Finally, many reliability professionals are talking about Life Cycle Costing.

[1] Look for abbreviations in Table 2.

[2] Excel PV function

Frequently, this is where this subject remains - in the talking phase. A few basic and simple administrative procedures can help to familiarize plant personnel with LCC concepts. However, to implement LCC practices, a company policy must be established.

Table 2. SYMBOLS

C_G = Average repair cost, $
C_{PV} = Present value of costs, $
C_Y = Annual repair costs, $
i = Current interest rate, dimensionless (decimal form)
MR&O = Maintenance, Repair & Overhaul
MTBR = Mean time between repairs, mo
MTTR = Mean time to repair, d

References

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