LIFE CYCLE COST

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History – Five years to remember

1832
1927
1950
1954
1966
Today, we manufacture strategic driveline components, transmissions and axles.

Volvo has an unbeatable advantage with its own in-house developed drivetrains designed for optimal performance.
Processing of material

- The factory in Eskilstuna is one of Europe’s largest plants that performs machine processing.

- Over 400 different machines perform processing of cast and forged material. For example: turning, milling, drilling etc.

- The factory is built of separate departments called Cells where either processing or assembly takes place.

- The factory contains 32 cells.
Assembly of components

- The factory contains of 8 line assemblies
  - 4 where we manufacture axles
  - 3 where we manufacture transmissions
  - 1 where we manufacture PTO (Power Take Out)
- Line assembly contains of standard structure which provides a standard way of working
- Each line contains of different stations and a standard pace
LCC – Definitions

1. LCC is a measure of a systems or equipments total economical consequences during its entire life cycle

2. LCC is a comparative measure for a systems or equipments total economical consequences during its entire life cycle where some simplifications and omissions have been performed in order to make the calculation easier

Source: Wååk, 1992
Life cycle cost – LCC

Product price

- Education and training
- Automation
- Spare parts
- Washing fluids

- Quality
- Tools
- Rent
- Overtime cost

- Logistics
- Maintenance
- Personnel
- Programming
- Scrapping
LCC – Objective

- To enable investment options to be more effectively evaluated
- To consider the impact of all costs rather than only initial capital costs
- To assist in the effective management of completed buildings and projects
- To facilitate choice between competing alternatives

Theoretical model

Source: Hagberg and Henriksson, 2010
Theoretical model

Source: Márquez et.al., 2009
LCC procedures

1. Establish operating profile
2. Establish the utilisation factors
3. Identify all the cost elements
4. Determine the critical cost parameters
5. Calculate all costs at current prices
6. Escalate current costs at assumed inflation rates
7. Discount all costs to the base period
8. Sum discounted costs to establish the net present value (NPV)

Sources: Kaufman in Woodward, 1997
Discounting methods in investment calculations

• Payback method
• Annuity method
• Net present value
• (Internal rate of revenue)
Payback method

\[ T = \frac{C_A}{r} \]
Payback method

Example:
Machine price: 1 000 000 SEK
Capacity: 16 000 details/year
Selling price: 62,5 SEK/detail
Operator salary: 500 000 SEK
Operating costs: 150 000 SEK/year
Economic life: 5 years
Residual value: 50 000 SEK
Interest rate: 10%

\[ T = \frac{C_A}{r} \]

\[ C_A = 1 \, 000 \, 000 \, \text{SEK} \]
Rev = 16 000 x 62,5 = 1 000 000 SEK/year
Cost = 500 000 + 150 000 = 650 000 SEK
\[ r = \frac{1 \, 000 \, 000 - 650 \, 000}{650 \, 000} = 350 \, 000 \, \text{SEK/year} \]

\[ T = \frac{1 \, 000 \, 000}{350 \, 000} = 2,86 \, \text{years} \]
Even though the payback method is rather simplified, many companies use it at least as a method for a first assessment of the profitability of an investment.

Also, the payback method is a rapid method for assessment of feasibility in pre-studies.
Annuity method

\[
C = \left( C_A - \frac{S}{(1+i)^n} \right) \times \frac{i \times (1+i)^n}{(1+i)^n-1}
\]
Annuity method

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\[ C = \left( C_A - \frac{S}{(1+i)^n} \right) \times \frac{i \times (1+i)^n}{(1+i)^n-1} \]

\[ C_A = 1 000 000 \text{ SEK} \]
\[ S = 50 000 \text{ SEK} \]
\[ \text{Rev} = 16 000 \times 62,5 = 1 000 000 \text{ SEK/year} \]
\[ \text{Cost} = 500 000 + 150 000 = 650 000 \text{ SEK} \]
\[ r = 1 000 000 - 650 000 = 350 000 \text{ SEK/year} \]
\[ i = 10\% \]

\[ C = \left( 1000 - \frac{50}{(1+0,1)^5} \right) \times \frac{0,1 \times (1+ 0,1)^5}{(1+0,1)^5 - 1} = 256 < 350 \Rightarrow \text{Profit} = 94 000 \text{ SEK/year} \]
Net present value

\[ NPV = -C_A + \frac{r_1}{(1+i)} + \frac{r_2}{(1+i)^2} + \ldots + \frac{r_n}{(1+i)^n} + \frac{S}{(1+i)^n} \]

\[ NPV = -C_A + r \times \frac{(1+i)^n - 1}{i \times (1+i)^n} + \frac{S}{(1+i)^n} \]
Net present value

Example:
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NPV = - C_A + r \times \frac{(1 + i)^n - 1}{i \times (1+i)^n} + \frac{S}{(1+i)^n}

C_A = 1 000 000 SEK
S = 50 000 SEK
Rev = 16 000 \times 62,5 = 1 000 000 SEK/year
Cost = 500 000 + 150 000 = 650 000 SEK
r = 1 000 000 - 650 000 = 450 000 SEK/year
i = 10%

NPV = - 1 000 + 350 \times \frac{(1 + 0,1)^5 - 1}{0,1 \times (1+0,1)^5} + \frac{50}{(1+0,1)^5} = 357 500 SEK
LCC vision

• To develop a model that provides best balance between usability and accuracy
LCC model

Expected cost per cost allocation and year are entered into the document.

Account is taken to:

- Acquisition cost (incl project cost)
- Maintenance cost
- Operations cost
- (Down time cost)

- Project cost
- Machine/equipment
- Tools
- Spare parts
- Installation
- Renovation
- Education/training
- Maintenance
  - wages
  - external services
  - spare parts
- Rent/space
- Energy
- Media/emulsions
- Employee cost (wages)
  - operators
  - measuring technicians
  - prod. eng
LCC – testing of the model

• The test was performed with a cross-functional group, representatives from
  – Production engineering
  – Maintenance Engineering
  – Logistics
  – Production
  – (Finances & Purchasing)
LCC – testing of the model

- Makino a92
- Machining center
- Located in a production cell with 5 similar machines, all are served from a FMS and cooling system
- In order to simplify, the test have been performed as the machine was a stand alone machine
LCC – testing of the model

- In the test, the maintenance cost were extracted from the maintenance system for three similar machines and for five years, an average was then calculated and used in the model.
NPV and total cost
LCC – testing of the model

Machining center, todays production volume

- Washing fluid vs Energy
- Maintenance vs Tools
- Wages vs Machine
- Rent vs Project

MSEK – 15 year horizon
LCC – testing of the model

Machining center, projected production volume

- Wages: 37%
- Machine: 25%
- Maintenance: 8%
- Rent: 8%
- Energy: 2%
- Tools: 14%
- Washing fluid: 2%
- Project: 4%

MSEK – 15 year horizon
LCC – use of the model

Two gear hobbing machines in dire need of remanufacturing or replacement due to old control system

Flow according to blue arrow
1. Turning
2. Broaching operation
3. Gear Hobbing
4. Deburring/Shaving/Washing
5. Manually loading on hardening fixtures
LCC – use of the model

Three alternatives exists:
1. Replace the two machines with another used machine
2. Optimize process (replace as alt 1 + redesign production cell + purchase and install robot)
3. Remanufacture the two old machines

Cost for the alternative:
1. 100%
2. 300%
3. 250%
LCC – use of the model

Three alternatives exists:
LCC – use of the model
Life cycle cost – down side (only takes into consideration cost, not profit)

Life cycle cost / Life cycle profit

Sources: Hans Ahlmann LTH, Per-Erik Johansson DIS
Life cycle cost / Life cycle profit

1. Stable market, stable volumes
   - Income/cost OEE
   - Life Cycle Profit
   - Life Cycle Cost
   - Life Cycle Loss

2. Booming market, increasing volumes
   - Income/cost OEE
   - Life Cycle Profit
   - Life Cycle Cost
   - Life Cycle Loss

3. Recession, decreasing volume
   - Income/cost OEE
   - Life Cycle Profit
   - Life Cycle Cost
   - Life Cycle Loss

Source: Ahlmann, 1984
LCC in academic publications

Number of LCC/TCO case studies published in Scopus

Source: Bengtsson and Kurdve, 2016
LCC useful links

- [http://belok.se/verktyg-hjalp/lcc/](http://belok.se/verktyg-hjalp/lcc/)
References


