

## **LCCA-methodology & OEE-measurement technique contributions!**

In order to distinguish between good and correct decisions, the last one is based on a basis that contains motivation, strategy, and goals. There are several benefits the company gains when using LCCA such as, it enables engineer/manager to solve the problem properly based on cost-effective methodology, achieve the target(s), and defend the approach that has been selected when presenting the project for the management and stakeholders. Nevertheless, LCCA-methodology is one of the most powerful concepts in which contains such foundations and can almost be applied everywhere. Furthermore, I will not dig deeper into the theory, but only would like to mention the definition and the purpose. The main purpose of Life Cycle Cost Analysis methodology is to assess all costs from project inception to disposal of equipment, moreover to simplify the evaluation and comparison among different alternatives based on the data gathered to determine and select the most suitable one in accordance with company's other important aspects and criteria such as safety, environment, quality, competitiveness etc. Additionally, the applications of LCCA include both project(s) and equipment, regardless of company's size, number of employees and the amount of turnover.

This article contains a case study that was applied at (XXAB), an industrial company in Sweden.

### **Purpose**

The aim of this project is to solve the problem that XXAB faces by using LCCA-methodology and OEE-measurement technique.

### **The Company**

XXAB offers its customers turning, measurement, stamping, pressing in automatically and CNC –programmed several operations machines etc. The company hasn't any own products. However it manufactures what customers need based on their specification and order. The company works with different types of material such as bar metals and plastics and its customers include both companies and private sectors, further some of them are famous companies.

### **Empirical finding & Analysis**

By the aid of the interview with operators and managers, inspection, observation and analysis, two critical work stations could be identified. These work stations consist of two machines called X and Y and operate by one operator with only 75% of the total time. Both machines do turning and drilling. Each one has 6% rejected products, 1% external and 5% internal, due to bad quality. The first machine is 9 years old and faced about one week/year short stoppages and 10h/month due to failures. The second one is 6 years old and faced about two week/year short stoppages and 10h/month due to failures. The operator is responsible for operation, maintenance, quality control and sometimes participate in others activities. It takes about 45 min (setup time) to start both machines and to get them ready for production. Production time for the first machine is 80% of its operation time and the second one works only 50% of its operation time. Additionally, the company wants to optimize production capacity, eliminate or reduce the amount of defects, reduce the costs due to down time and achieve customer's satisfaction, within improving the current situation. Moreover, there are two available alternatives, but the management is very confused about how to select the proper and suitable one.

### Available solution alternatives

According to the interview with the CEO and based on the data gathered there are two alternatives that the company was thinking about. An “Improvement attempt of the current situation”, within maximizing the operation time up to 100%. Secondly is replacing these two old machines by getting loan from the bank and buying a new machine. However, there are other options that couldn’t be taken into account in this analysis, due to the lack of data. Additionally, the mentioned alternatives were most essential and considerable for the case company.

### An assumption

Since the company has already been in business in many years, there isn’t any investment capital that should be put when performing LCCA- cash flow. In order to conduct the calculations properly an assumption has been made regarding these two old machines. According to the data collected from the company that the remaining life length of each machine is three years. Further, the present value of these two machines is 300,000 SEK, and the salvage value for each machine after three years is 50,000 SEK. Additionally, the purpose of this assumption is to create an investment capital that could be used throughout the calculation for three years from now.

### Calculations

The calculations include OEE-measurement of the selected machines to assess their efficiencies which in return will simplify the assessment of the current situation. Furthermore LCCA-calculations will consist of three steps, the current condition, the improvement attempt of the current condition and finally when buying new machine.

### Data for machine 1(X)

$$6 * 60 = 360 \text{ min/day}$$

$$0,8 * 360 = 288 \text{ min/day (total time)}$$

$$10 * 60 / 20 = 30 \text{ min / day (unplanned down time, due to failures)}$$

$$1 * 5 * 8 * 60 = 2400 \text{ min/week}$$

$$2400 / 260 = 9.23 \text{ min /day (unplanned down time, due to stoppages)}$$

$$30 + 22.5 = 52.5 \text{ min /day (planned down time)}$$

$$5 \text{ day/week (the operator work)}$$

$$52 \text{ week/ year}$$

$$5 * 52 = 260 \text{ day/year}$$

Operator working hours	=	75 % = 6 hr	=	360 min/day
Break time	=	30 min		
Actual cycle time	=	22.5 min		
Ideal cycle time	=	7.5 min		
monthly failures	=	10 hrs	=	600 min/month
short stoppages	=	1 Week/year	=	2400 min/ year
production time	=	80 %		
No of products	=	18 pics./hr		
Rejected percentage	=	6 %		
No of working days	=	20/month		
No of working days	=	260 day/year		

total working time	=	0.8*360	=	288 min/day
unplanned downtime due to failure	=	600/20	=	30 min/day
unplanned downtime due to stoppages	=	2400/260	=	9.23 min/day
planned downtime	=	30+22.5	=	52.5 min/day

Loading time = total time – planned down time

$$\text{Loading time} = 288 - 52.5 = 235.5 \text{ min /day}$$

Operation time = loading time – unplanned down time

$$\text{Operation time} = 235.5 - (30 + 9.23) = 196.27 \text{ min / day}$$

$$\text{Availability} = \frac{\text{Loading time} - \text{Unplanned down time}}{\text{Loading time}} = \frac{196.27}{235.5} = 0,833$$

$$\text{No. of rejected pics.} = 0.06 * 18 = 1.08 \text{ pic./hr}$$

$$\text{Rate of quality} = \frac{\text{Processed amount} - \text{Defected amount}}{\text{Processed amount}} = \frac{18 - 1.08}{18} = 0.94$$

Performance efficiency =  $\frac{(\text{Processed amount}) * (\text{actual cycle time}) * (\text{ideal cycle time})}{(\text{Operation time}) * (\text{actual cycle time})}$

$$= \frac{18 * 22.5 * 7.5}{196.27 * 22.5} = 0,687$$

$$\text{OEE} = \text{Availability} * \text{Performance efficiency} * \text{Rate of quality} * 100$$

$$\text{OEE} = 0,833 * 0,687 * 0,94 * 100 = 53,79 \%$$

### Data for machine 2(Y)

$$6 * 60 = 360 \text{ min/day}$$

$$0,5 * 360 = 180 \text{ min/day (total time)}$$

$$10 * 60 / 20 = 30 \text{ min / day (unplanned down time, due to failures)}$$

$$20 * 30 = 600 \text{ min /month}$$

$$2 * 5 * 8 * 60 = 4800 \text{ min/year}$$

$$4800 / 260 = 18.46 \text{ min /day (unplanned down time, due to stoppages)}$$

$$30 + 22,5 = 52,5 \text{ min /day (planned down time)}$$

5 day/week (the operator work)

52 week/ year

$$5 * 52 = 260 \text{ day/year}$$

Operator working hours	=	75 % = 6 hr	=	360 min/day
Break time	=	30 min/day		
Actual cycle time	=	22.5 min		
Ideal cycle time	=	7.5 min		

monthly failures	=	10 hrs	=	600 min/month
short stoppages	=	2 Week/year	=	4800 min/ year
production time	=	50 %		
No of products	=	9 pics./hr		
Rejected percentage	=	6 %		
No of working days	=	20/month		
No of working days	=	260 day/year		
total working time	=	0.5 * 360	=	180 min/day
unplanned downtime due to failure	=	600/20	=	30 min/day
unplanned downtime due to stoppages	=	4800/260	=	18.46 min/day
planned downtime	=	30+22.5	=	52.5 min/day

Loading time = total time – planned down time

$$\text{Loading time} = 180 - 52.5 = 127.5 \text{ min /day}$$

Operation time = loading time – unplanned down time

$$\text{Operation time} = 127.5 - (30 + 18.46) = 79.04 \text{ min / day}$$

Availability = loading time – unplanned down time / loading time

$$\text{Availability} = 79.04 / 127.5 = 0.61$$

No. of rejected pics.= 0.06 \* 9 = 0,54 pic./hr

$$\text{Rate of quality} = \frac{\text{Processed amount} - \text{Defected amount}}{\text{Processed amount}} = \frac{9 - 0.54}{9} = 0.94$$

Performance efficiency =  $\frac{(\text{Processed amount}) * (\text{actual cycle time}) * (\text{ideal cycle time})}{(\text{Operation time}) * (\text{actual cycle time})}$

$$= \frac{9 * 22.5 * 7.5}{79.04 * 22.5} = 0.85$$

OEE = Availability\*Performance efficiency\*Rate of quality\*100

$$\text{OEE} = 0.61 * 0.85 * 0.94 * 100 = 48.74 \%$$

## Calculations for losses due to failures and short stoppages:

### Machine 1(X):

$$\begin{aligned}\text{Losses} &= \frac{\text{losses due to failures} + \text{Losses due to short stoppages}}{\text{Loading time}} \\ &= \frac{(30 \text{ min/day}) + (9.32 \text{ min/day}) * 100}{235.5 \text{ min/day}} = 16.6\%\end{aligned}$$

### Machine 2 (Y)

$$\begin{aligned}\text{Losses} &= \frac{\text{losses due to failures} + \text{Losses due to short stoppages}}{\text{Loading time}} \\ &= \frac{(30 \text{ min/day}) + (18.46 \text{ min/day}) * 100}{127.5 \text{ min/day}} = 38.0\%\end{aligned}$$

As shown above, machine 1(X) has higher OEE percentage compared with machine 2 (Y), also, both machines are in bad conditions in compliance with world class requirement.

## Following are the calculations for the different alternatives

**Observation:** The calculations are based on future value formula.

### Calculations for Alternative 1 (Assessment of the Current situation)

Given;

Present Value = 300 000 SEK

Internal rate of return = 5%

Life length of machine = 3 years

AP = Annual profit

TC = Total cost

TR = Total revenue

Total cost of finished product	=	25 SEK/pic
No of product produced by machine 1	=	18 pic./hr
No of product produced by machine 2	=	9 pic. /hr
Operator working hours	=	6 hr/day
No of working days	=	5 days/week
No. of working weeks	=	52 week/year
Revenue for each machine	=	450 SEK/ hr

From the above data

$$\text{TC} = 25 * (18+9) * 6 * 5 * 52 = 1053000 \text{ kr /year}$$

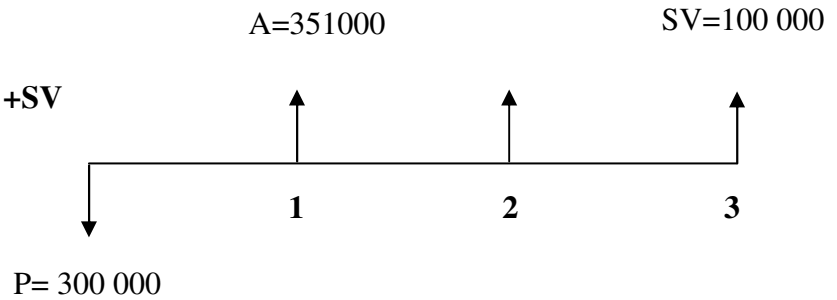
$$\text{TR} = 450 * 2 * 6 * 5 * 52 = 1404000 \text{ kr / year}$$

$$\text{AP} = \text{TR} - \text{TC} = 1404000 - 1053000 = 351000 \text{ kr}$$

### The cash flows

Future value (F) will be:

$$F = P (1 + i)^n + A \left[ \frac{(1+i)^n - 1}{i} \right] + SV$$



$$F = -300000 * (1 + 0.05)^3 + 351000 \left[ \frac{(1 + 0.05)^3 - 1}{0.05} \right] + 100\ 000$$

$$= 859240 \text{ Kr}$$

(The gain after 3 years for the current situation)

### Calculations for Alternative 2:

#### Improvement a part of the current situation

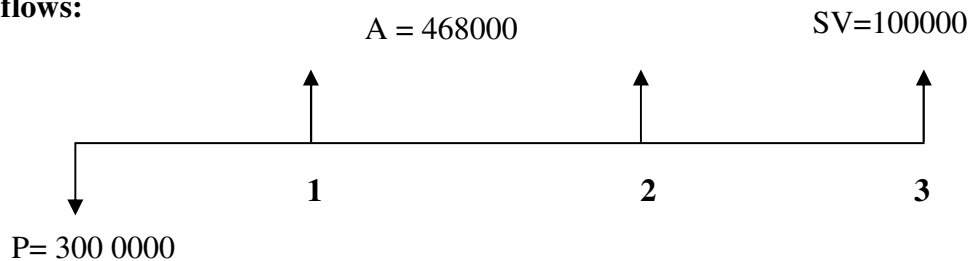
Improvement of the current situation within increasing operator's working time from 6 to 8 hours daily (Full time). The result after three years will be as follows:

$$TR = 450 * 8 * 5 * 52 * 2 = 1872000 \text{ kr}$$

$$TC = 25 * (18+9) * 8 * 5 * 52 = 1404000 \text{ kr}$$

$$AP = TR - TC = 1872000 - 1404000 = 468000 \text{ kr}$$

### The cash flows:



Future value (F) will be:

$$F = P (1 + i)^n + A \left[ \frac{(1+i)^n - 1}{i} \right] + SV$$

$$F = -300\ 000 * (1 + 0.05)^3 + 468000 * \left[ \frac{(1+0.05)^3 - 1}{0.05} \right] + 100\ 000$$

$$= 1228082.5 \text{ kr (the gain after three years if the machines operate full time)}$$

### Calculation for Alternative 3:

Buying a new machine

Actually the length life of the new machine is 10 years according to the data from the manufacturer, but in order to make a proper comparison among all alternatives the time period for the calculations is determined for three years that corresponds the remaining length life of the current machines, further to determine whether the project is worthy or not. The value of the future (F) will be:

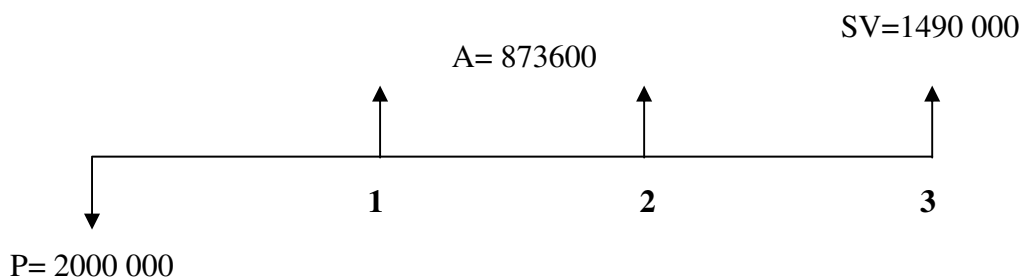
Loan from the bank	=	2,000,000 kr
Bank interest rate	=	6%
Total cost of finished product (assumption)	=	20 SEK/pic
No of product produced by new machine	=	42 pic./hr
Operator working hours	=	8 hr/day
No of working days	=	5 days/week
No. of working weeks	=	52 week/year
Revenue/piece	=	30 SEK/ hr
Salvage value after three years	=	1,490,000 kr

$$TR = 42 * 30 * 8 * 5 * 52 = 2620800 \text{ kr}$$

$$TC = 20 * 42 * 8 * 5 * 52 = 1747200 \text{ kr}$$

$$AP = TR - TC = 2620800 - 1747200 = 873600 \text{ kr}$$

### The cash flows:



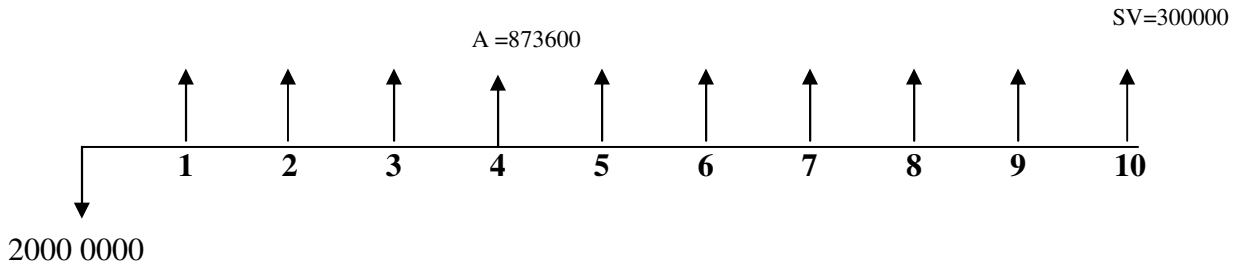
$$F = P (1 + i)^n + A \left[ \frac{(1+i)^n - 1}{i} \right] + SV$$

$$F = -2000000 * (1 + 0.06)^3 + 873600 * \left[ \frac{(1 + 0.06)^3 - 1}{0.06} \right] + 1490000$$
$$= 1889161 \text{ kr (the gain after three years for a new machine)}$$

Now, the same data that has been used in the previous calculation will be used here, but for a longer life length (10 years), moreover to see the revenue that the company will gain, in long term.

- . 300 000 kr (salvage value after 10 years)
- . 10 years (the life length of the new machine)

**The cash flows:**



$$F = P (1 + i)^n + A [ (1+i)^n - 1/i ] + SV$$

$$F = -2000000 * (1 + 0.06)^{10} + 873600 * [(1 + 0.06)^{10} - 1 / 0.06] + 300 000$$

= 8,233,047 kr (The gain after 10 years)

**Multiple Criteria Decision Making (MCDM) technique**

The MCDM- technique is another useful tool that uses to simplify and assure the selection process among these three alternatives. The different criteria were weighted according to their importance from 1 to 10 as shown in the table bellow and graded from 1 to 5 from level of how bad or good they were.

Criteria	Weight	Alternative 1		Alternative 2		Alternative 3	
		Grading	Total	Grading	Total	Grading	Total
	1-10	1-5		1-5		1-5	
Maintenance	7	3	21	3	21	4	28
Production rate	8	3	24	4	32	4	32
Quality	10	4	40	4	40	5	50
Environment	6	3	18	3	18	4	24
<b>Total</b>			<b>103</b>		<b>111</b>		<b>134</b>

**Conclusions & Recommendations**

- As shown in the calculation above the OEE for machine X and machine Y are about 54%, and 49% respectively. That’s mean both machines are not working well in accordance with the standard. Therefore, the company has to consider the current

maintenance system in order to avoid technical problems, short stoppages and failures, on the other hand to increase machines efficiencies.

- LCCA-cash flow calculations exhibit that the company gain more in both alternatives two and three compared with alternative one. Furthermore, the company recommends choosing alternative number three, because maintenance and electricity costs will be reduced, production capacity, production quality and production rate will be improved and profit margin will increase. Additionally, the investment will be profitable in long term.
- According to MCDM and based on the data gathered the company also recommends choosing alternative number three, because the total sum is higher than others

OBS: A few sections and some of the data and information of the project have been taken away, because it's not relevant in this article and also confidential.

Best regards  
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