Fouling

What is the price of fouling

This presentation describes a method to calculate the losses by fouling

Fouling Performance loss software

Due to fouling the turbine will loose performance.

Fouling creates additional air flow resistance and loss of air flow through the bundles

Higher resistance and blocked fins means less air for cooling.

Less cooling air means higher back pressure at turbine exhaust, result less power from the turbine-generator.

This presentation will show the way we can quantify the performance loss Due to fouling

Looking at Back pressure at the turbine exhaust
what should it be?

The basis are the performance curves of the ACC as it is.

Not the design performance curves.

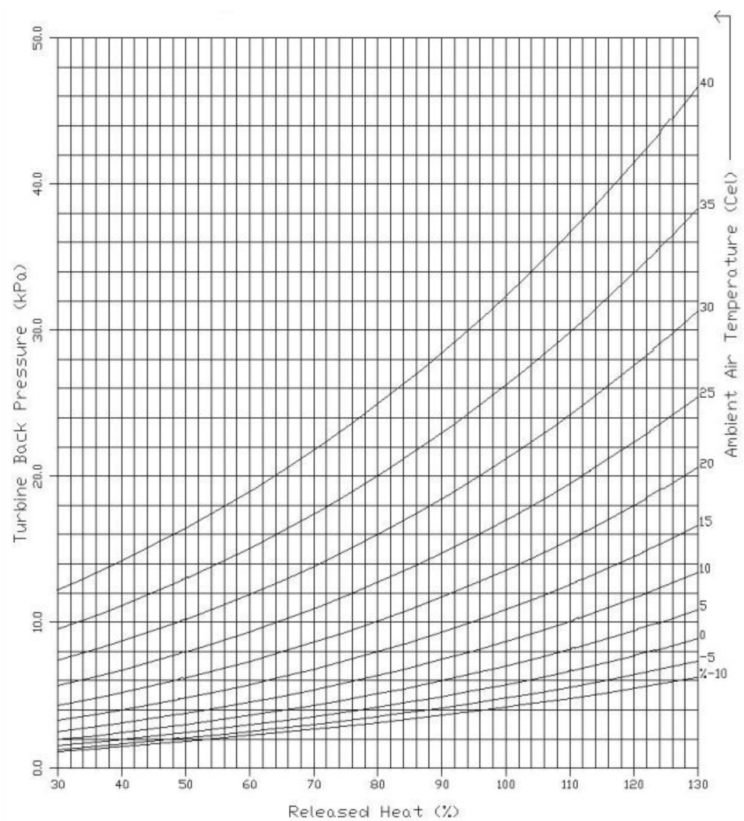
The data from the DCS is used to create the actual curves.

Also the condenser bundles should be completely clean as we want

the difference between clean and fouled.

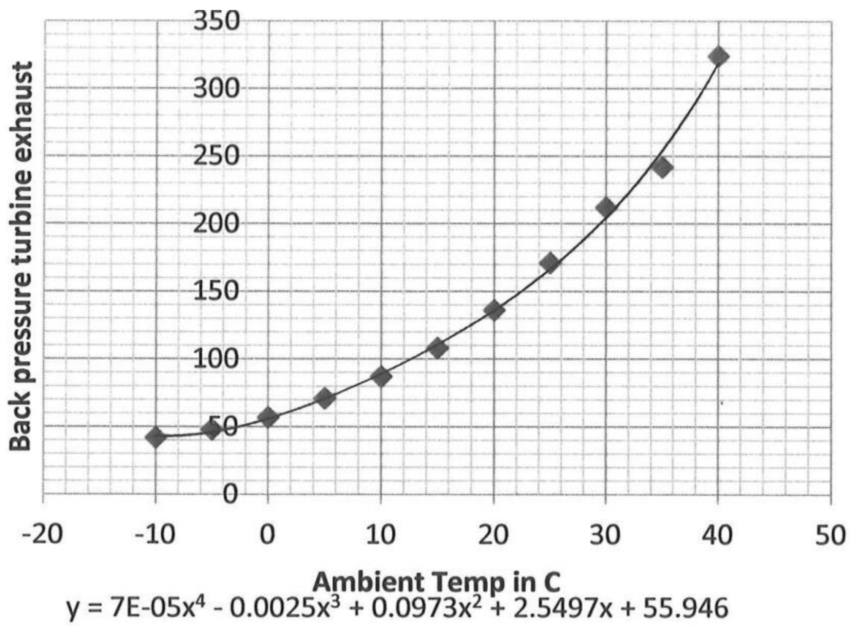
How do we calculate

The first step is to determine the Performance curves of the ACC



These are normal performance curves.
From this information the curves for each Load-case can be calculated including the formulas.

The result is a set of equations base on the different load cases



This is done for the cases 30 to 130 % duty

The curves are transferred to equations to make calculations.

Thermal calculations

With pressure and wetness the steam enthalpy at the turbine exhaust is calculated, as is really is and as it should be. With other words we calculated the expected back pressure and the measured back pressure

The result will be a difference in enthalpy between clean and fouled.

Reasons of performance loss.

There are different reasons why the performance is lower with fouling.

1. Less air for cooling
2. Lower heat transfer coefficient.
3. Less water content in steam.

If the back-pressure at the turbine exhaust increases, the enthalpy of the exhaust steam increases as well. This is done with the stem tables. With higher back pressure the water content of the exhaust steam goes down. Less water in the steam means a higher enthalpy.
The rule is, the higher the enthalpy of the steam at the turbine exhaust, the less Enthalpy is used for power generating.

Less air for cooling

This illustrates the closure of many
Air channels of the bundle, result less
air for cooling and a higher flow
resistance.

Het transfer coefficient

Part of the fouling is dust.

Dust with humidity creates a sticky material.

This can stick to the aluminium heat transfer surface, and the aluminium surface is fouled with a layer that cannot be removed by high pressure water cleaning

Steam quality at turbine exhaust

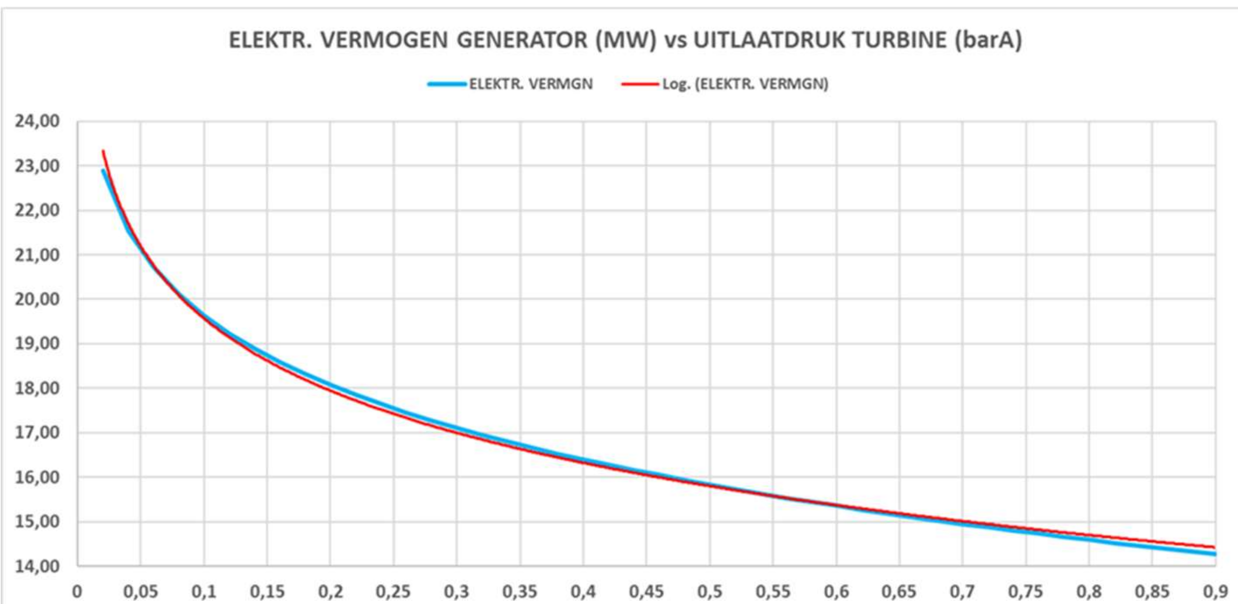
If the pressure increases at the turbine exhaust, the performance will decrease,

The temperature of the steam at the turbine exhaust will go up with higher pressures.

As a result of this the water content of the exhaust steam will go down.

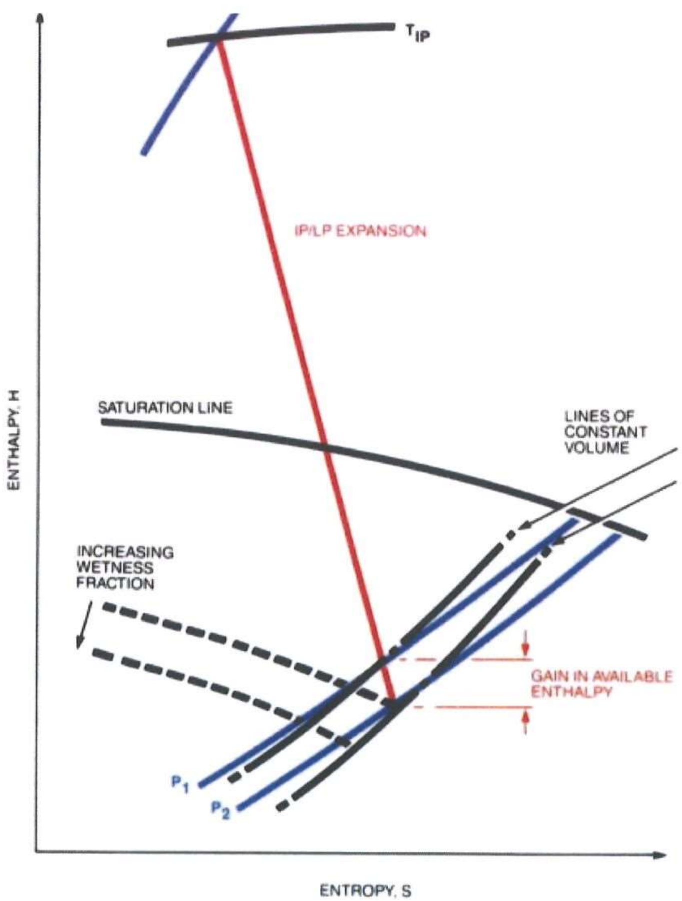
The quantity of this depends on the turbine.

A general rule says that the total power generation will drop 0.7% for every 10 mbar pressure increase at the turbine exhaust.



Sample from an Incinerator:
Between 50 and 350 mbar, performance loss = 4.3 MW = 20.5%
0.68% per 10 mbar pressure Loss (almost 0.7%

What is happening in the turbine



The pressure goes down as the expansion is higher.

This will decrease the volume, increase the wetness.

The gain of enthalpy makes the turbine works better, so less energy in the exhaust steam

The gain in available enthalpy for the turbine giving lower enthalpy for the exhaust steam

Source Science Direct Topics

The software

The software is a compilation of equations and calculations.

To make it user friendly the program has been written in en excel file.

One part is the input data, while the turbine specific data has been entered already.

The general data consist of steam tables

Input of data

input	Steam turbine nominal duty	27.75 MW	
back pressure	150 mbarA	Steam flow design	81850 kg/h design
ambient temperature	12.6 C	steam flow actual	73738.74 kg/h
duty in%	90 %	price per MWH	30 Euro
running hours a year	8400 hours	Steam turbine duty	25 MW

performance curves

are entered with equasions	backpressure should be	104.35 mbarA				
	back pressure low value	100 mbarA				
100% should meet the	back pressure top value	110 mbarA				
actual performance when clean.	wetness steam	11.45				
			steam H	water H		
Mind the wind should be not	enthalpy should be	2312.43	2584.80	191.83 kj/kg		top limit
more than 3 m/s			2588.00	199.68 kj/kg		bottom limit
			2586.19	195.24 kj/kg		average
leak rate ACC must be less	delta Enthalpy				-39.03	

Input data from DCS and operations

Results

best entry is the average over
a day or a defined period

model calculates the turbine
exhaust pressure as it should be
the enthalpy of this steam is calculated
and compared with the enthalpy
as it is, which is depending on the
turbine exhaust pressure

this difference in Enthalpy is the
energy not absorbed by the turbine
but by the ACC, decressing the
power from the turbine generator

backpressure is	150	mbarA				
back pressure low value	150	mbarA			rule of thumb, wettness decrease	
back pressure top value	160	mbarA			0.022222 per 10 mbar increase	
wetness steam	11.45	%			wetness due to higher BP	10.43889
		steam	water			
enthalpy is	2351.46	2599.2	225.97	kj/kg		
		2601.6	231.59	kj/kg		
		2599.2	225.97	kj/kg		
difference in enthalpy per kg	39.00	kj/kg				
steam flow	73738.74	kg/h				
enery loss in kj	2875810.81	kj				
energy loss in W	798.84	kW	0.7988	MW		
running hour a year	8400.00	hours				
loss in money	201,306.76	Euro/year				

The results are based on a constant operating condition.
In reality this should be done for different seasons.
This to eliminate ACC performance turndown due to low ambient temperatures