FLOWNEX®
SIMULATION ENVIRONMENT

CASE STUDY

MAINTENANCE EFFECTIVENESS COMPARISON FOR A HALF STATION SHUTDOWN OUTAGE

This case study demonstrates how Flownex® can be used in evaluating the effectiveness of the maintenance work conducted during a half station shutdown outage by characterising a unit and comparing the performance of the unit with data before and after the outage.

FOSSIL FUEL POWER GENERATION

Challenge:

The main challenge is to determine the effectiveness of the work conducted during a half station shutdown. This is normally a difficult task, since most external factors influencing the process (fuel quality, ambient conditions and process configuration) are not the same before and after the shutdown.

Benefits:

One of the major advantages by using Flownex® is that the performance of a unit today, can be compared directly with the performance of the same unit at some point in the past even though external factors (ambient conditions, coal quality) and process configuration (e.g. number of feedwater heaters in service) may differ. This is accomplished by characterising the model according to the historic unit and then applying the current external factors and process configuration to that model. In simple terms, this equates to a previous "version" of the same unit that is placed next to the current plant and is provided with the same environmental conditions, fuel and process configuration. The differences that is then observed in the change of the fundamental loss coefficients (AH dP, condenser pressure, ID fan vane positions) between the pre- and post-characterised units, is the actual mechanical changes that occurred due to degradation or maintenance.

This method is very useful in evaluating the effectiveness of maintenance that has been performed, or to identify where actual degradation has occurred, without having the data clouded by external factors or varying process configurations

Solution:

Flownex® can be used to investigate the effectiveness of the work conducted during a half station shutdown as all of the external factors can be taken into account and therefore a direct comparison is possible.

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Introduction

During a half station shutdown outage at a power plant, maintenance and cleaning was performed on cooling towers, as well as the common Cooling Water (CW) ducting. Additional to this work, various other maintenance activities were performed on the units themselves.

As with any outage, the effectiveness of the work conducted has to be evaluated. This is always a difficult task, since most external factors influencing the process (fuel quality, ambient conditions and process configuration) is not the same right before and after the outage. It is therefore evident that no comparison can be made without having to qualify the result based on these differences that cannot be accounted for.

However, using the holistic, model based approach of Flownex®, in which all these external factors are accommodated, a direct comparison is possible. This case study describes how Flownex has been used to evaluate the performance before and after a half station shutdown outage.

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Case Study

In order to evaluate the change in performance from before to after the half station shutdown, appropriate "snap shots", that are short periods of historic data, has to be found pre- and post-shutdown. These snap shots should fulfill the following criteria:

- The unit must be stable;
- They must be operating at the highest achievable load;
- As many as possible operating conditions should be the same.

For the shutdown that took place, specific snapshots before and after the half station shutdown were found to be appropriate to be used as the basis for comparison. Some process values from these two snapshots are shown in Error! Reference source not found..

Table 1: Summary of snapshots used for comparison.

		Before outage			After outage		
		Unit A	Unit B	Unit C	Unit A	Unit B	Unit C
Unit Load	[MW]	380.0	407.0	395.9	419.9	457.8	450.0
Coal flow rate	[kg/s]	55.11	57.37	49.67	55.42	64.18	58.66
Dry bulb temperature	[°C]	31			23		
Humidity	[%]	20			56		
Wet bulb temperature	[°C]	15.3			17.8		
Calorific value	[MJ/kg]	23.26	-	23.26	22.1	-	22.1
CW inlet temperature	[°C]	34.7	34.8	34.8	32.6	32.6	32.6
CW pumps in operation	[-]	6			6		
LPT exhaust temperature	[°C]	59.7	54.2	61.2	60.1	56.4	61.0
ID fan vane position	[%]	72.6	91.0	65.8	72.8	90.1	89.0

With the appropriate snapshots identified, the Flownex® model was characterized to represent the plant's condition as it was before the outage. With this pre-outage characteristic model, a fixed plant condition can now be exposed to varying external factors (ambient conditions, fuel quality and process configuration) and the behavior of the plant due to these changes can be analyzed.

For the current comparison, the PO is exposed to the external factors as seen by the plant after shutdown (the second snapshot). Thus, when comparing the performance of the PO after shutdown with the actual plant performance on another day, the effect of external factors can be nullified and the changes observed can be attributed solely to improvement or degradations between the time of the two snapshots. Since the half station shutdown occurred in this period, the changes can safely be attributed to maintenance work performed during the shutdown period. Table 2 compares some process values from Unit C after shutdown and the PO.

Table 2: Comparison of Unit C after shutdown to the pre-outage characteristic unit.

		After outage	PO (Char.)
		Unit C	
Unit Load	[MW]	450	435
Coal flow rate	[kg/s]	58.66	57.10
Dry bulb temperature	[°C]	23	
Humidity	[%]	56	
Wet bulb temperature	[°C]	17.8	
Calorific value	[MJ/kg]	22.1	22.1
CW inlet temperature	[°C]	32.6	33.0
CW pumps in operation	[-]	6	
LPT exhaust temperature	[°C]	61.0	60.9
ID fan vane position	[%]	89.0	77.0

Results

The predictions showed that Unit C would have produced 435MW if no maintenance was done. The limiting systems would have been firstly the Low Pressure Turbine (LPT) exhaust temperature going above the limit. A 15MW performance increase can be attributed to the maintenance work. A comparison of the predicted and actual process parameters is shown in Table 4.

Table 4: Predicted performance of PO for Unit C after shutdown.

		Before Shutdown				After Shutdown			UC (Char.)
		Unit A	Unit B	Unit C		Unit A	Unit B	Unit C	
Unit Load	[MW]	380.0	407.0	395.9	0	419.9	457.8	450.0	435
Coal flow rate	[kg/s]	55.11	57.37	49.67	0	55.42	64.18	58.66	57.10
Dry bulb temperature	[°C]	31			0	23			
Humidity	[%]	20			0	56			
Wet bulb temperature	[°C]	15.3			0	17.8			
Calorific value	[MJ/kg]	23.26	-	23.26	0	22.1	-	22.1	22.1
CW inlet temperature	[°C]	34.7	34.8	34.8	0	32.6	32.6	32.6	33.0
CW pumps in operation	[-]	6			0	6			6
LPT exhaust temperature	[°C]	59.7	54.2	61.2	0	60.1	56.4	61.0	60.9

		Before Shutdown				After Shutdown			UC (Char.)
		Unit A	Unit B	Unit C		Unit A	Unit B	Unit C	
ID fan vane position	[%]	72.6	91.0	65.8	0	72.8	90.1	89.0	77.0

The analysis can be extended by quantifying how much generating capacity gain can be attributed to the different maintenance activities performed. As can be seen in Table 5, the performance of the cooling towers increases by delivering a 0.8°C lower CW inlet temperature going to the boiler, increasing the load by 8MW and 18MW respectively.

On a cold and less humid day the benefits on the ID fan vane position can also be quantified on its influencing systems. This benefits will be seen on a cold and less humid day (therefore a day with a lower wet bulb temperature) because the CW inlet temperature will decrease which will increase the condenser performance and decrease the LPT exhaust temperature below the safe operating limit. An increase in performance was seen in a lower AH pressure drop and seal leakage. The lower AH seal leakage can be due to work done on the AH seals or higher operating temperatures. The lower AH pressure drop can be due to cleaning of the packing or the fixing of holes in ducting in the back pass.

Table 5: List of improvement on process conditions.

	Fundamental mechanism	Process condition impact	Benefit	
			Unit A	Unit C
Cooling tower performance	Factor of Merit increase (0.625→0.67)	CW inlet -0.8°C	+8.0MW	+18.0MW
AH pressure drop	Decrease in loss coefficient (1.202→1.078)	Pressure drop -0.103kPa		ID Vane (-4.3%) (+3.1MW)
AH seal leakage	Decrease in representative gap size (0.479→0.465)	Leakage -1.2%		ID Vane (-1.1%) (+0.7MW)
Precipitator pressure drop	Decrease in loss coefficient (2.4→2.389)	Pressure drop -0.004kPa		ID Vane (+0.0%) (+0.0MW)
Condenser ducting cleaning	Decrease in loss coefficient (23.5→11, 19.5→16)	Total flow increase 3%	+10.0MW	-3.0MW
FD fan inlet duct	Decrease in loss coefficient (11.5→7)	FD Vane -8.0%		Vane position balanced.

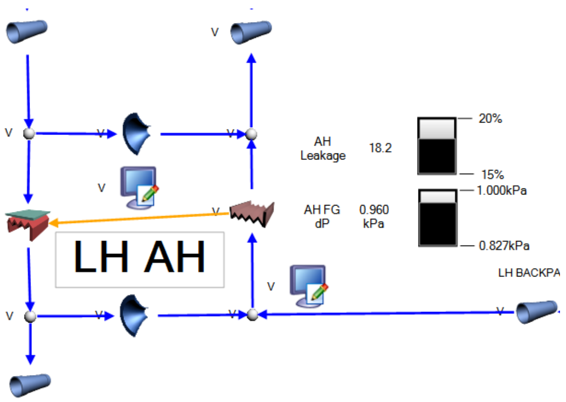

Figure 1: Part of the Flownex® network that was used for modeling the units.

Summary

In this case study it can be seen how Flownex® can be utilized to evaluate the change in performance before and after a half station power plant shut down outage.

By using Flownex®, a task that is generally difficult to perform due to varying external factors could easily be conducted and a direct comparison between the plant performance before and after shutdown could be evaluated.

The study showed that the maintenance that was performed during shut down was effective and increased the overall plant performance.