FLOWNEX®
SIMULATION ENVIRONMENT

CASE STUDY

Quantifying the Effect of Condenser Tube Fouling on Power Plant Thermal Efficiency

This case study demonstrates how Flownex was used to evaluate the impact of condenser tube fouling on the thermal efficiency of a coal-fired power plant. Condenser scaling increases resistance to heat transfer and raises the main condenser backpressure. To compensate for the loss of thermal efficiency, the coal flow rate must be increased, and the associated rise in operational costs was quantified.

FOSSIL FUEL POWER GENERATION

FOSSIL FUEL POWER GENERATION

CHALLENGE:

The challenge was to quantify the impact of condenser tube fouling on thermal efficiency to accurately assess its effect on operational costs. This required a tool capable of modelling the integrated thermal and fluid behaviour of the entire plant. This analysis would enable informed maintenance decisions to minimize costs while maximizing efficiency gains.

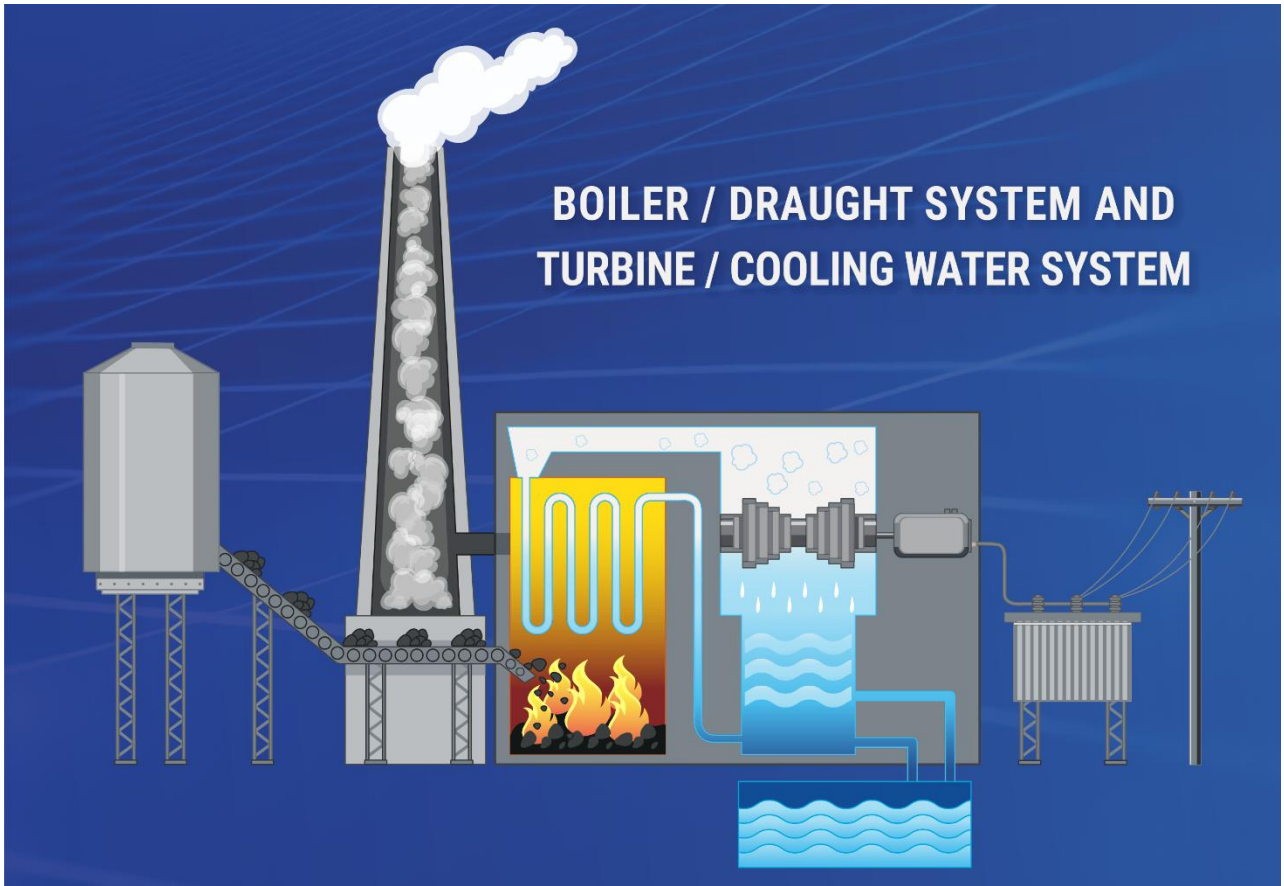
BENEFITS:

Flownex was the ideal tool as it could model the steam generating boiler/draught system along with the steam cycle's turbine/cooling water system.
By providing insight into the impact defects has on plant performance, this model enabled the project team to:

- Justify the maintenance work of defective utilities
- Proactively plan to prevent these defects from occurring

SOLUTION:

A fully integrated model of the boiler/draught system and turbine/cooling water system was developed in Flownex to represent the coal-fired power plant. Measurements of the defective plant were used to calibrate the model to align with actual plant behaviour. This ensured that the Flownex model accurately replicated the plant's performance, allowing variances to be analysed and the impact of the fouling defect quantified. When maintenance work is prioritized effectively, maximum efficiency gains can be achieved with minimal effort.



INTRODUCTION

Condenser tube fouling had an unknown impact on the overall thermal efficiency of a coal-fired power plant. To assess this, a Flownex model of the integrated system was developed. Figure 1 below presents a simplified schematic of the coal-fired power plant.

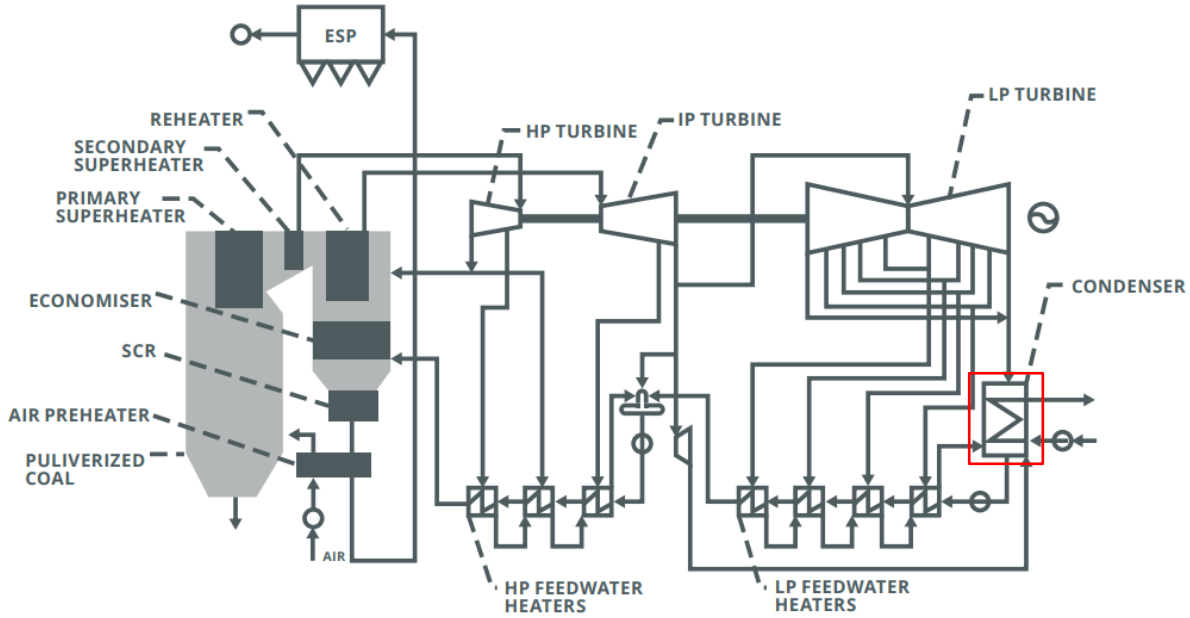


Figure 1: Process flow diagram of a coal-fired power plant

The fouling under investigation occurred in the main condenser's tubes. A red square in Figure 1 indicates where the condenser is located in respect to the whole system.

FLOWNEX MODEL

The Flownex model was developed to account for the integrated heat transfer and fluid flow behaviour of the plant. To develop the baseline, a range of datasheets were required, including original design data, acceptance test data, fan and pump curves for the fans, air heaters, boiler, gas cleaner, turbines, feedwater heaters, pumps, condensers, and cooling towers. Figure 2 below illustrates the developed Flownex model.

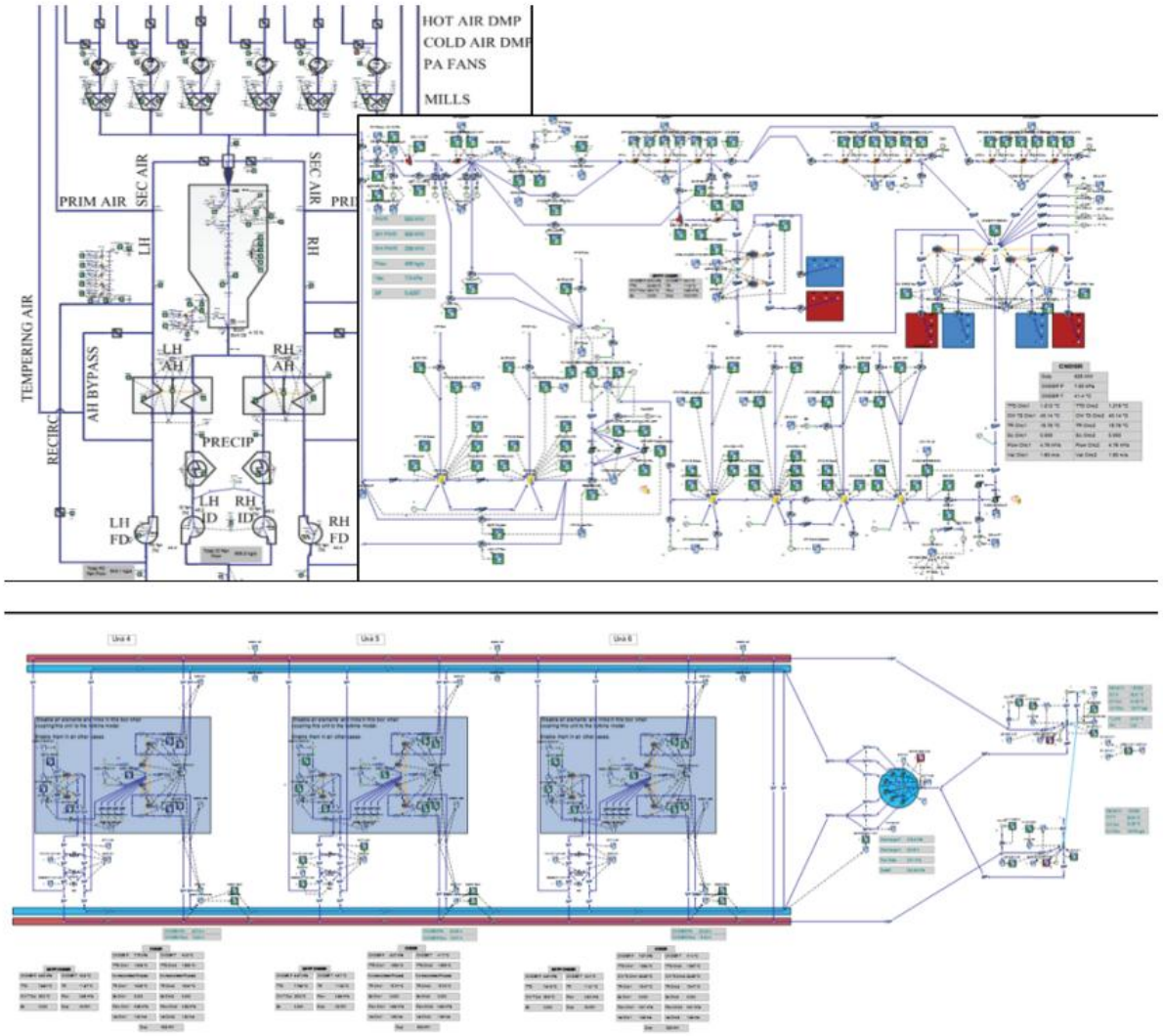


Figure 2: Flownex networks of the integrated coal-fired power station model

METHEDOLOGY

The following process was followed to quantify the effect of the fouling in condenser tubes.

1. Establish a baseline to act as a reference of comparison
2. Apply the fouling measured on plant to the Flownex model
3. Solve the Flownex model allowing control systems to stabilize
4. Record process conditions and compare to baseline

RESULTS

The Condensate System Engineer received information that scale build-up inside the main condenser tubes was measured at 437.5 µm during a weekend opportunity outage, caused by poor water quality management by the Chemical Department. Using the Flownex model, the defect was introduced, and the results in Table 1 were obtained.

Table 1: Summary of Results

	BASELINE	AFTER DEFECT	CHANGE
Tube inside scaling (µm)	0	437.5	437.5
Terminal temp. diff. (˚C)	1.2	8.9	7.7
Main condenser backpressure (kPa)	7.9	13.2	5.3
Coal flow rate (kg/s)	65.5	73.7	8.2
Turbine system efficiency (%)	43.0	41.8	1.2

The results showed that scale build-up negatively impacted the main condenser backpressure, reducing the turbine plant's effectiveness. This efficiency loss was approximately 1.2%, requiring an additional 8.2 kg/s of coal. The increased operating cost helped the System Engineer justify condenser cleaning and emphasize the importance of proper chemical treatment management for the cooling water cycle.

While this study focused on internal fouling of the main condenser tubes, it was part of a broader technical analysis that evaluated the impact of various subsystems on thermal efficiency and maximum capacity generation, including coal quality.

CONCLUSION

Using the Flownex model of the coal-fired power station, an investigation quantified the impact of condenser tube scaling on the plant's thermal performance. The additional coal flow required to compensate for this efficiency loss was determined, providing the System Engineer with data to justify main condenser cleaning during the next outage. The model also provided valuable insights for other System Engineers, enabling Engineering Management to prioritize maintenance tasks for maximum long-term cost benefits during the next plant shutdown.