



OPTIMISING COMBUSTION AND HEAT RECOVERY IN A THERMAL OXIDISER

This case study demonstrates how Flownex enabled a complete heat and mass balance for a thermal oxidiser and associated steam generator recuperator. Flownex enabled the engineering team to optimise fuel usage, ensure sufficient oxidation, and size the steam generator efficiently. The model reduced design risk and provided a reliable platform for evaluating alternative operating scenarios, making Flownex an ideal tool for complex thermal and fluid engineering problems.



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Flownex network

OIL & PETROCHEMICAL

CHALLENGE:

Designing a thermal oxidiser with an attached steam generator recuperator requires careful balancing of combustion, air supply, and heat recovery. The key problem was ensuring complete waste destruction at the required 800°C while minimising fuel consumption and optimising steam generation.

BENEFITS:

By integrating combustion, fluid flow, and heat recovery in a single model, Flownex enabled:

1. Rapid design iterations — engineers could test multiple air/fuel and heat recovery configurations in hours instead of weeks.
2. Quantified fuel savings — the optimal balance of fuel and secondary air was identified, reducing operating cost while still guaranteeing 800 °C for complete waste destruction.
3. Accurate steam generator recuperator sizing — ensuring required steam output without overdesign, saving both capital and operating costs.
4. Reduced risk in design decisions — the model gave confidence that waste would be destroyed while maximising heat recovery, avoiding expensive oversizing or performance shortfalls.

SOLUTION:

Flownex was used to build a single model capturing combustion, fluid flow, and heat transfer. Iterative scripts determined the correct fuel and air flows to achieve the destruction temperature and oxygen targets, while the recuperator section was sized to ensure efficient steam generation.

INTRODUCTION

Thermal oxidisers are widely used in the oil and gas industry to safely destroy hazardous waste streams at high temperatures. To improve efficiency, waste heat from the flue gas is often recovered in a steam generator recuperator. Accurately predicting combustion behaviour, heat transfer, and fluid flow interactions in such systems is critical to ensure complete waste destruction, stable operation, and maximum energy recovery.

SYSTEM DESCRIPTION

The system consists of three main sections:

1. Natural gas burner – provides sufficient energy to create an 800°C environment for waste destruction.
2. Thermal oxidiser chamber – where the hazardous waste stream, containing its own oxygen supply, is injected and oxidised.
3. Steam generator recuperator – recovers heat from the flue gas to produce dry saturated steam at 1,750 kPag outlet pressure.

The waste gas typically requires 3–5% O₂ in the flue gas to ensure complete oxidation. A schematic of the system is shown in Figure 1.

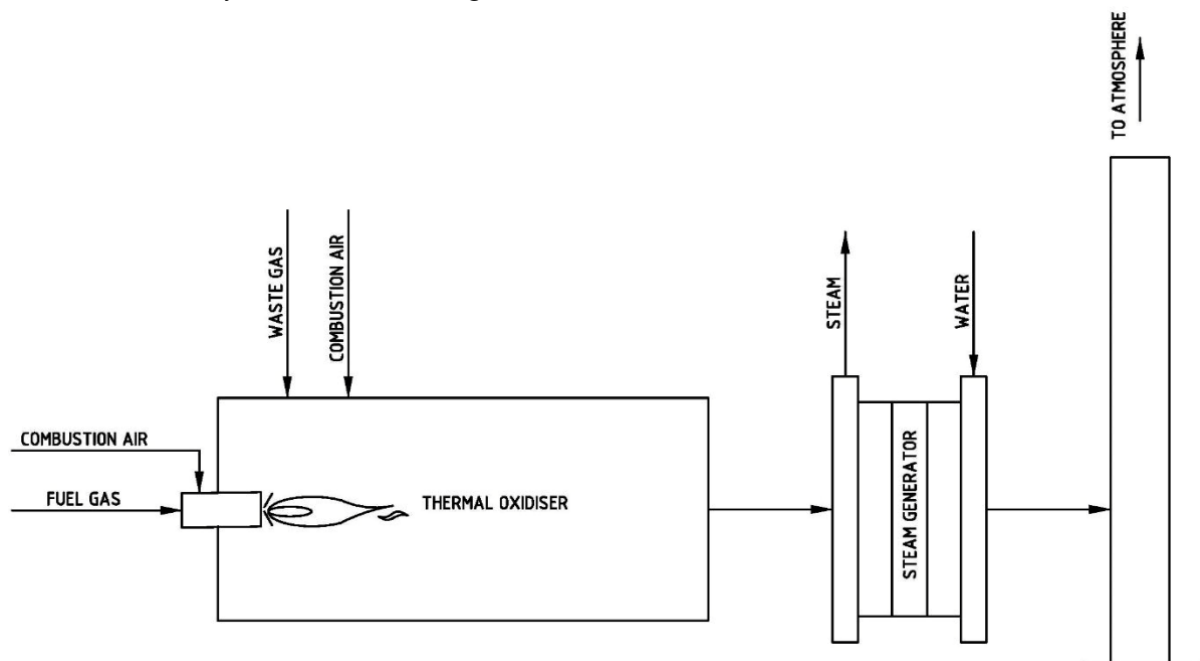


Figure 1: A schematic of a typical thermal oxidiser and steam generator recuperator

OBJECTIVE OF SIMULATION

The objective was to use Flownex to:

1. Perform a complete heat and mass balance for the thermal oxidiser and attached steam generator recuperator.
2. Determine fuel and air requirements to maintain stable combustion and achieve target O₂ levels.
3. Size the steam generator recuperator to achieve the required steam quality and flue gas outlet conditions.

FLOWNEX MODEL

A Flownex model was developed that included:

1. Standard pipe elements for chambers and flow passages.
2. Compound components for natural gas combustion, air psychrometry, and gas property specification.
3. Utility components for fuel composition conversion, flue gas analysis, and excess air control.

The network was divided into three sections: burner, oxidiser, and steam generator recuperator as seen in Figure 2 below.

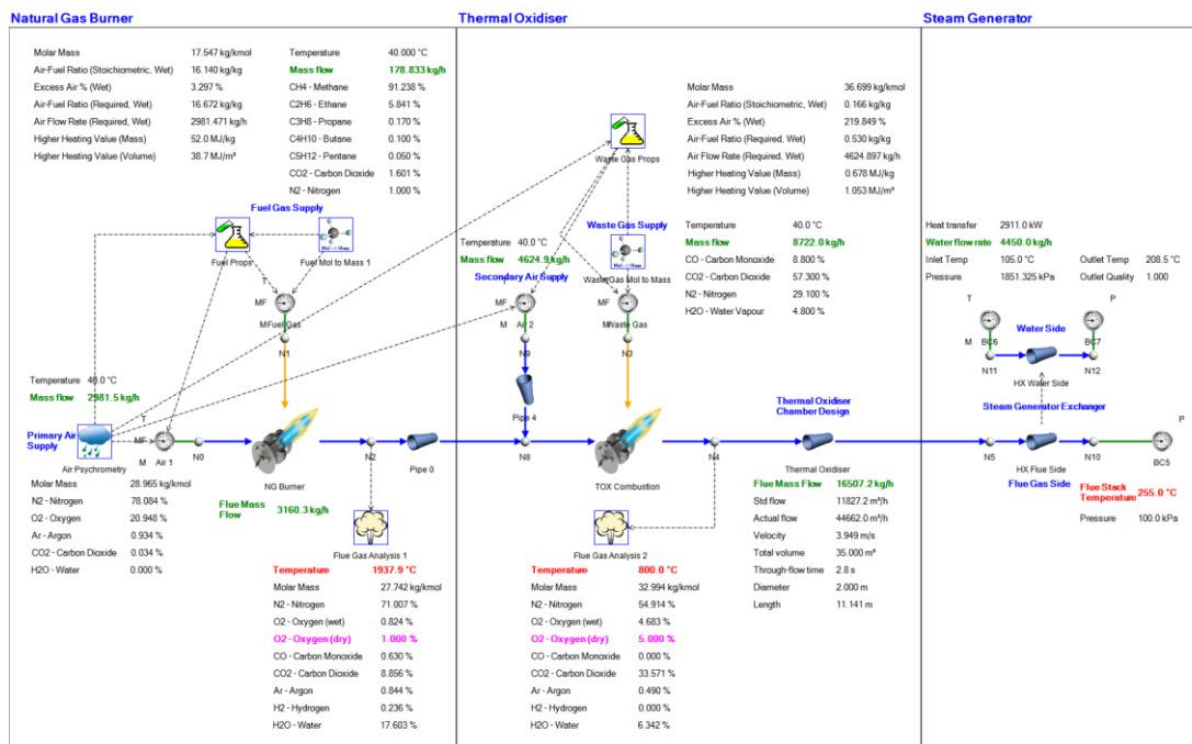


Figure 2: The thermal oxidiser and steam generator recuperator model



-Combustion of the joining air and fuel streams, creating a heated flue gas stream



- Specification of the ambient temperature, humidity and elevation



-Specification of the fuel gas composition



-Calculates the airflow required and air fuel ratio for the desired excess air- and fuel flow rate



-Provides an analysis of the flue gas composition

Data transfer links and Designer scripts were used to vary fuel, air, and flow rates until all performance targets were achieved.

DESCRIPTION OF SIMULATION

The simulation used an iterative three-step Designer procedure:

1. **Burner fuel optimisation** – adjusting burner air and fuel to achieve ~1% O₂ concentration in the burner flue gas, ensuring stable combustion and efficient fuel use.
2. **Oxidiser secondary air control** – adding secondary air in the oxidiser chamber to reach the final 3–5% O₂ in the flue gas, guaranteeing complete oxidation of the waste stream.
3. **Temperature control** – varying fuel flow in the oxidiser to maintain the target chamber temperature of 800°C.

For the steam generator recuperator, the flue gas side was modelled for a desired outlet temperature of 255°C. Heat transfer was linked to the water side, and a script adjusted water flow until saturated steam was achieved at the outlet.

RESULTS

1. Fuel and air requirements were determined for stable combustion and complete waste destruction.
2. Chamber residence time was verified to be sufficient (>1 s) for the waste gas stream.
3. Steam generator recuperator sizing ensured dry saturated steam supply at 1,750 kPag, with flue gas cooled from 800°C to 255°C.
4. The model confirmed that heat recovery targets were achievable without compromising waste destruction efficiency.

CONCLUSION

This case study shows how Flownex can integrate combustion, fluid flow, thermodynamics, and heat transfer in a single model to solve complex process problems. The simulation provided a complete heat and mass balance for the thermal oxidiser and steam generator recuperator, enabling optimisation of fuel usage, assurance of waste destruction, and efficient steam generation. The approach reduced design risk and demonstrated Flownex's value as a reliable engineering tool in the oil and gas industry.