Case study: Enhancing diesel hydrotreater capacity and reducing CO_2 emissions

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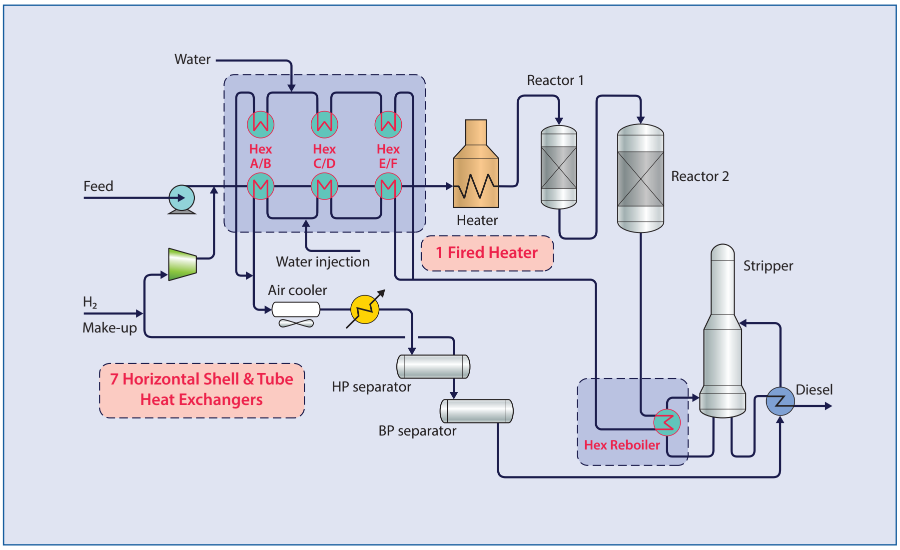
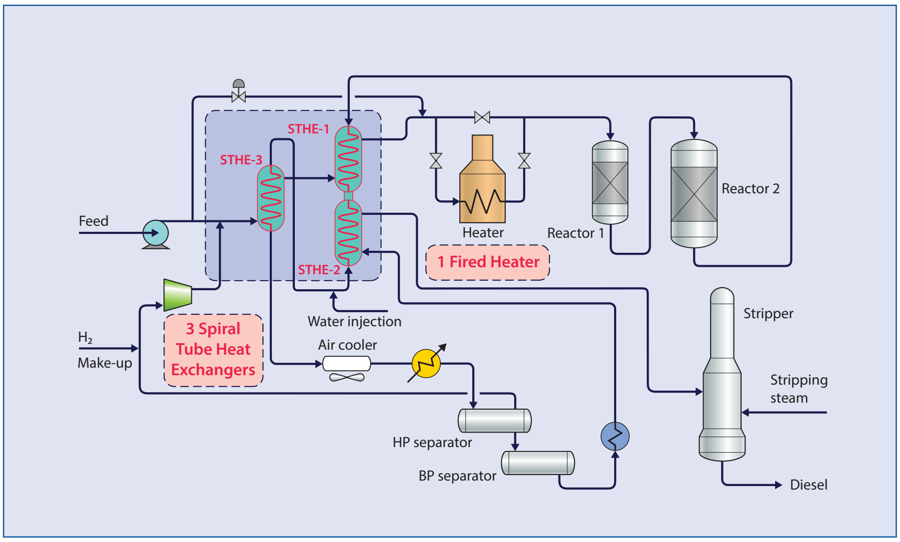
Introduction

In the pursuit of emission reductions and sustainable growth, the Axens Group, through its business lines Heurtey Petrochem Solutions and Nectis (a joint venture between ZPJE and Axens), offers a flow scheme with advanced technology equipment. For process unit heat integration, traditional shell-and-tube exchangers are replaced by high-efficiency spiral tube heat exchangers (STHE) distributed by Nectis. This reduces heat consumption in fired heaters and decreases energy use in compressors and pumps thanks to its low-pressure drop. Additionally, in facilities with access to an electrical source, replacing process fired heaters with electric tubular radiant heaters from Heurtey Petrochem Solutions enables zero carbon emissions at unit level.

The diesel hydrotreater (DHT) revamp project is an excellent example of how this advanced technology scheme can be applied to achieve both operational and environmental improvements. The goal of the project was to increase the DHT unit's capacity from 30,000 to 40,000 BPSD while reducing CO_2 emissions. The project faced several constraints, including a fired heater operating at maximum capacity, a hot approach temperature (HAT) of 81°F (45°C) in the heat exchangers, and limited space for new equipment. Despite these challenges, two solutions were identified and evaluated.



Existing flow scheme



Advanced technology equipment flow scheme: Option 1

Project Objective and Constraints

The key objectives were increasing capacity and reducing CO_2 emissions. The main constraints included:

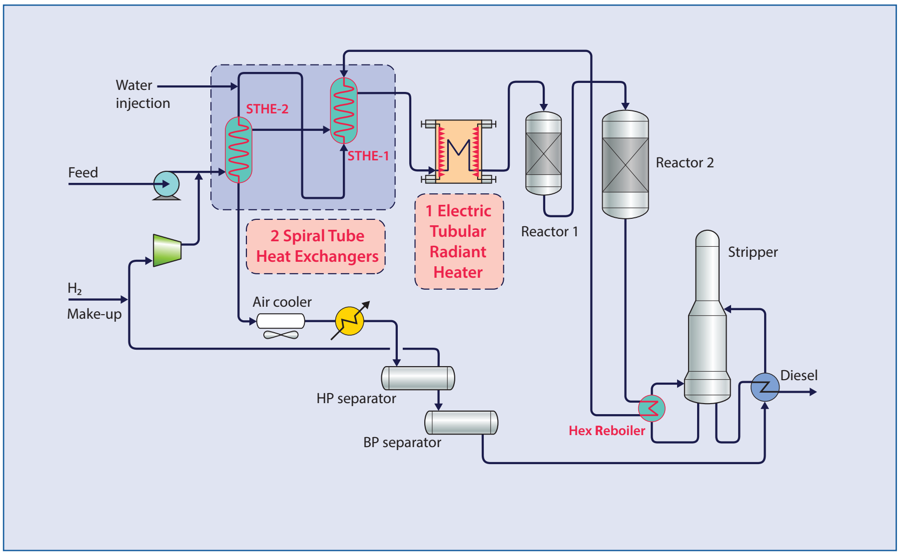
- **Fired heater operating at maximum capacity:** Limited thermal energy available for increased processing.
- **HAT of 81°F (45°C):** Poor heat transfer efficiency.
- **Limited plot plan:** Restricted space for new equipment.

Given these constraints, two identified solutions were evaluated and are outlined below as Option 1 and Option 2.

Option 1: Stripper reboiler and heat exchanger modification

Option 1 proposed replacing seven traditional shell-and-tube heat exchangers with three STHEs. These exchangers could recover all available heat, enabling the unit to operate without the fired heater during normal operations. The fired heater would only be needed for start-up and transient operation, reducing CO_2 emissions and achieving a net-zero emissions solution during normal operation. The proposal for Option 1 also included the following modifications::

- **Simplified system:** Fewer exchangers reduced complexity.



Advanced Technology equipment flow scheme: Option 2

	Existing flow scheme	Advanced technology equipment flow scheme – Option 2
No of exchangers:	6	2
Hot approach	81 °F (45°C)	18 °F (10°C)
Heaters duty	51.6 MMBTU/h (15.1 MW)	16.3 MMBTU/h **(e-heater)** (4.8 MW)
Electricity cost(1):	–	-2.4 MM USD/year
Fuel savings(2):	–	3.1 MM USD/year
Emission savings(3):	–	1.8 MM USD/year
Total savings	–	**2.5 MM USD/year**

(1) Considering an electricity cost of 17.7 USD/MMBTU
(2) Considering a fuel cost of USD/MMBTU
(3) Considering CO_2 emission cost of 70 USD/ton

CO_2 savings ≈ 25,000 tons/year
Zero emissions at Process Unit

- **Reduced flanges and piping:** Led to cost savings and easier installation.
- **Increased complexity:** Additional equipment in the low-pressure section of the unit made the implementation more difficult.
- **Reactor #1 inlet control:** A bypass of the heat exchangers was proposed forTemperature control during normal operation.

Additionally, a bypass of the fired heater would optimise the reaction section loop overall differential pressure in normal operations, allowing a lower recycle gas compressor utility consumption.

Although Option 1 offered numerous advantages, it was ultimately not selected due to its impact on the stripper reboiler caused by the introduction of stripping steam, which would result in:

- **Higher capital and operational costs:** The addition of a vacuum dryer system and utilities would significantly increase both capital and operational expenditures.
- **Increased complexity:** The inclusion of additional equipment in the low-pressure section of the unit would make implementation more challenging.

Option 2: Optimised heat exchanger and heater solution

Option 2 was chosen for its simpler design and greater cost-effectiveness:

- **Heat exchanger replacement:** Six conventional heat exchangers were replaced by two STHEs, reducing the HAT from 81°F (45°C) to 18°F (10°C) and reducing heater duty by 68%.
- **Fired heater replacement:** The fired heater was replaced with an electrical tubular radiant heater, supplied by Heurtey Petrochem Solutions. This is presently the only proven electrical technology available on the market for hydrocarbon processing, enabling the achievement of net zero emissions at the unit level.
- **Simplified design:** Fewer exchangers and piping led to reduced costs and easier implementation and maintenance.
- **Operational similarity:** The design maintained process continuity, allowing for seamless integration into the existing operation.

Cost Considerations

In both options, the heat exchangers' costs were similar, but Option 2 offered lower overall costs due to its simpler design. By eliminating the vacuum dryer and related equipment, Option 2 avoided significant capital expenditure. The electrical radiant heater further reduced fuel consumption and CO_2 emissions, making it the more cost-effective solution.

Conclusion

Axens Group's offering for the DHT revamp project positions it to successfully increase capacity to 40,000 BPSD while targeting CO_2 emissions reduction. Although Option 1 offers net zero emissions, its complexity and high costs make it less viable. Option 2 involves replacing traditional heat exchangers with STHEs distributed by Nectis and transitioning the heating source from a fired heater to a unique electric tubular radiant heater designed by Heurtey Petrochem Solutions. This option provides an efficient, cost-effective solution that aligns with both operational and environmental goals. This case study demonstrates the value of integrating advanced technology with careful cost considerations to enhance refinery performance and sustainability.

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