Predictive maintenance in refinery pre-heat trains: driving operational excellence and energy efficiency through digital technology

hexxcell REPSOL

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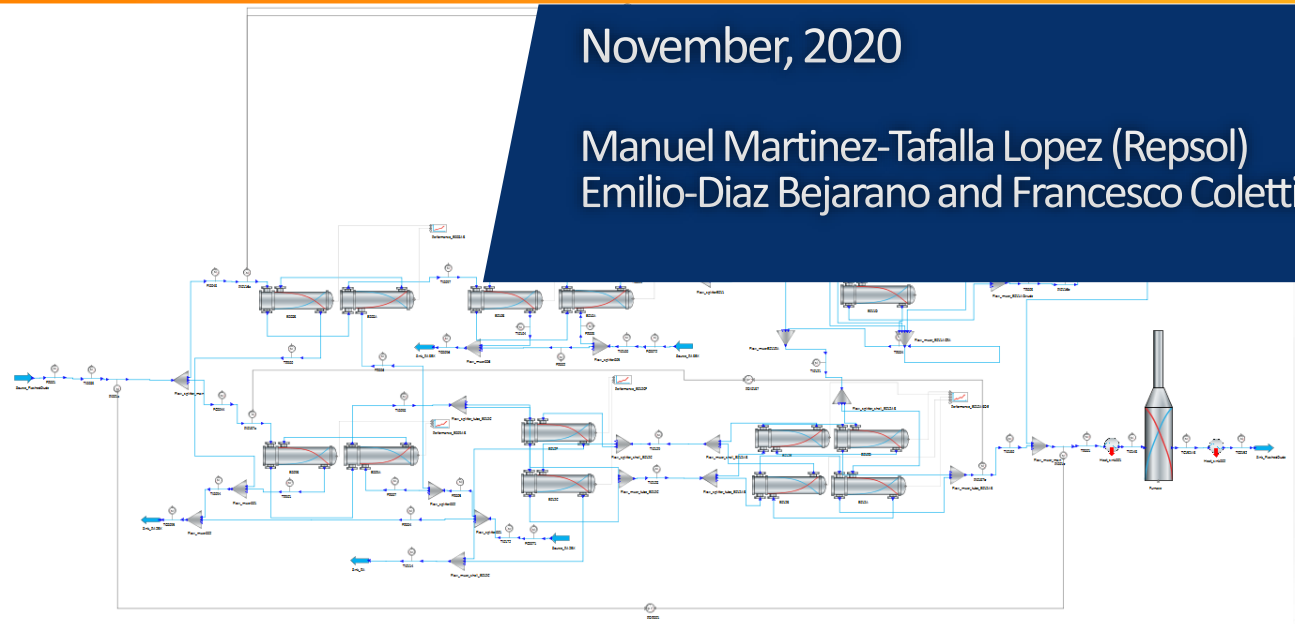


Importance of digital in improving maintenance

Areas where digital is having the most positive impact for refiners:

56%

Maintenance and reliability

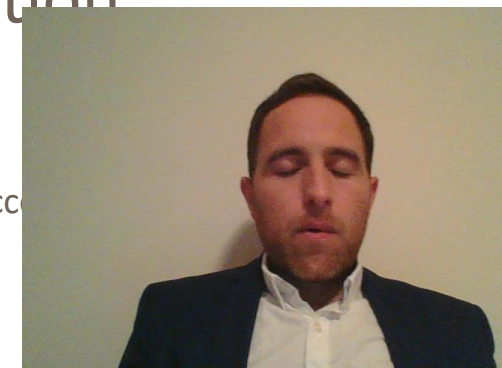
50%

Production planning and scheduling

47%

Production execution

Source: Acc



Why Focus on Fouling in Refinery Pre-heat Trains?

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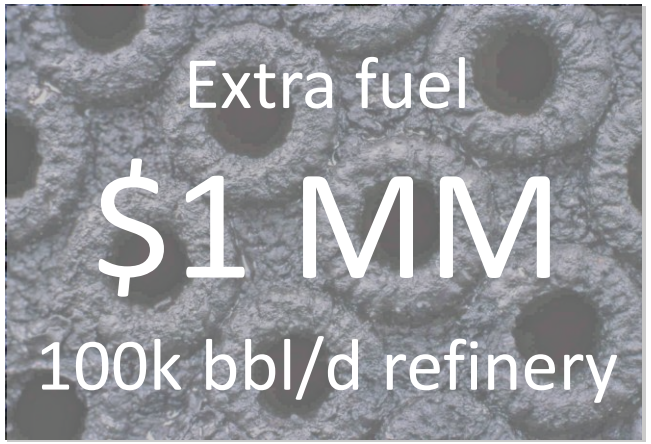
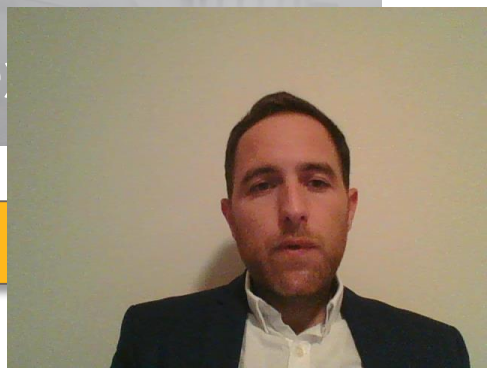
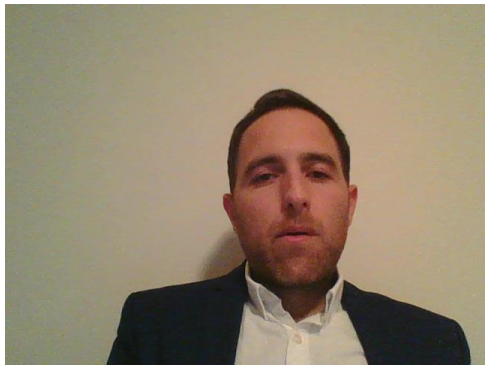


Significant opportunity to realise benefits using digital



Monitoring of heat exchangers - industry standard

- Use of fouling resistance to monitor past performance -> Simple indicator (sometimes misleading), limited information on actual performance, costs and cause of fouling etc.
- No indication on hydraulic performance (related to throughput)
- No prediction of future behaviour
- No effects of crude composition on fouling behaviour
- Decisions which/when to clean a HEX -> Typically based on simple heuristics/experience, not driven by economic decisions

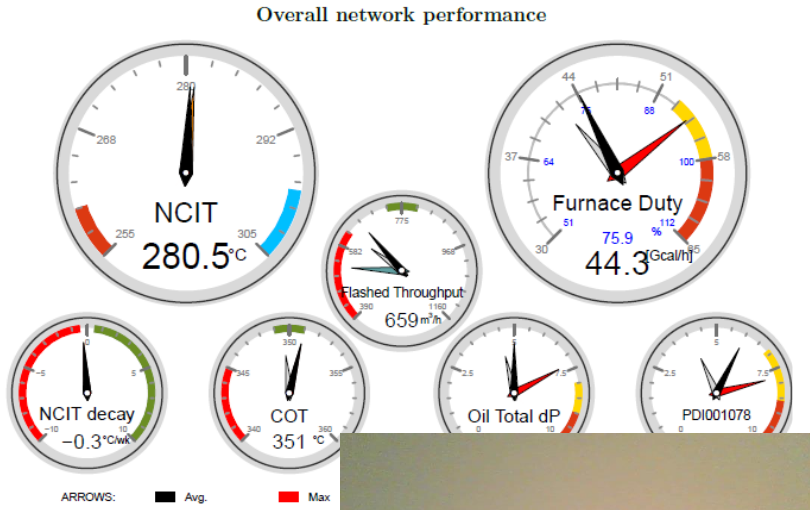


What if?

What if we were able to predict how refinery heat exchanger train perform as a function of crude composition and operating conditions?

We would be able to:

1. Maximise energy recovery and reduce CO_2 emissions
2. Maximise uptime and optimise maintenance to avoid production losses
3. Plan and react to unexpected events during turnarounds
4. Early detect and react to operational issues
5. Make oil blending decisions that minimise fouling

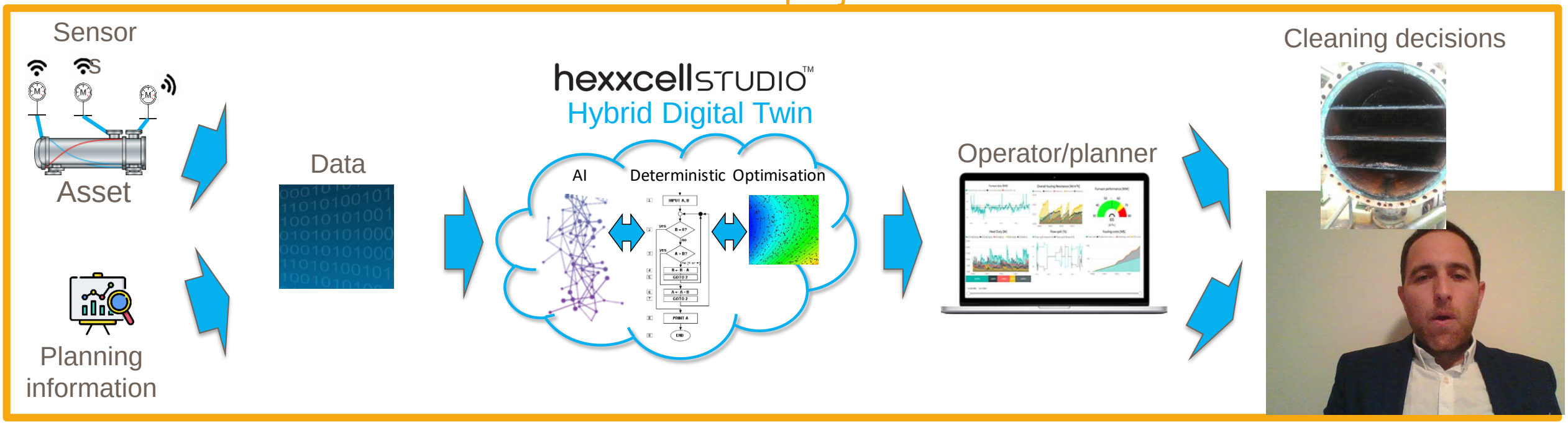


Heat-X project

Repsol implemented Hexxcell's Hybrid Digital Twin technology for accurate monitoring and predictive maintenance of crude pre-heat trains

The tool has been scaled up to all Repsol refineries enabling them with a new real-time decision making capability

Heat-X project



Project Partners

Multi-energy company leading the energy transition by being the first company in the energy sector to set the goal or reaching net zero emissions by 2050.

We employ over 25,000 people, operate across 34 countries, and sell our products to 10 million customers in more than 90 countries. Also, our portfolio includes low-emissions electricity generation assets, and we are developing various renewable solar and wind energy projects.

We have launched more than 190 digital initiatives to improve efficiency and safety and optimize resources

www.repsol.com

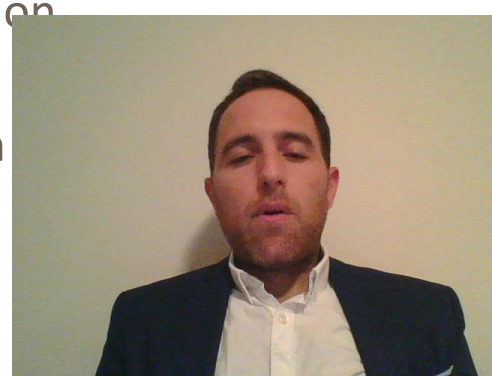
London based High-Tech company

Digital innovation for advanced monitoring, predictive analytics and prescriptive maintenance

Serving global refining and petrochemical customers since 2013

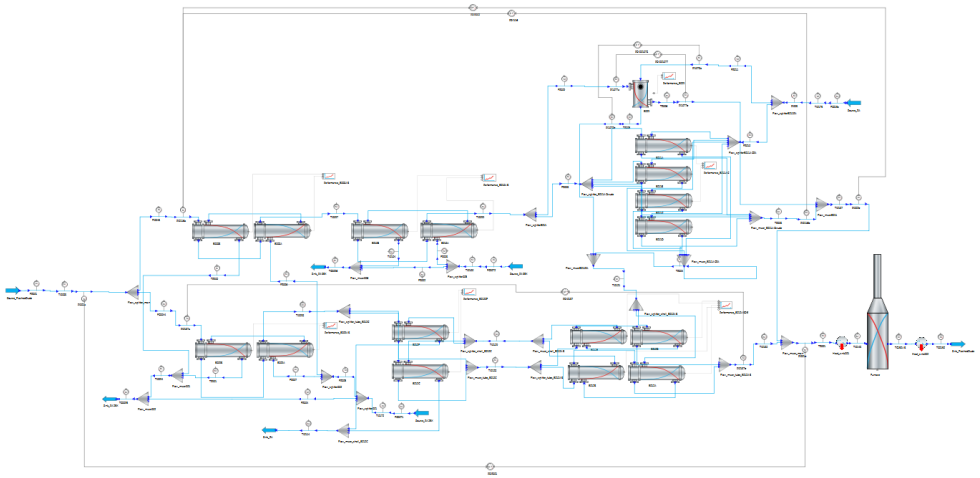
Deep domain knowledge in industrial heat transfer (particularly fouling of heat exchangers), data science, software development and digital innovation

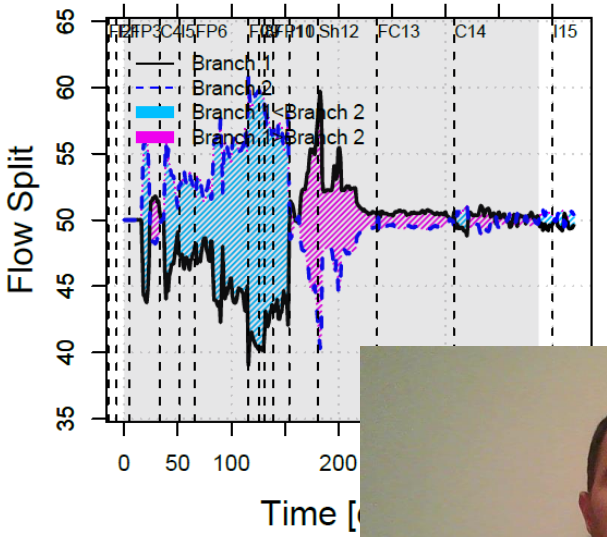
www.hexxcell.com



1. Maximise Energy Recovery and Reduce CO2 Emissions

- Optimal flow split to maximize energy recovery provided to the operator
- Predictive capabilities used to minimise impact of fouling, ensuring long-term benefits
- Zero-cost option to increase energy efficiency and reduce emissions

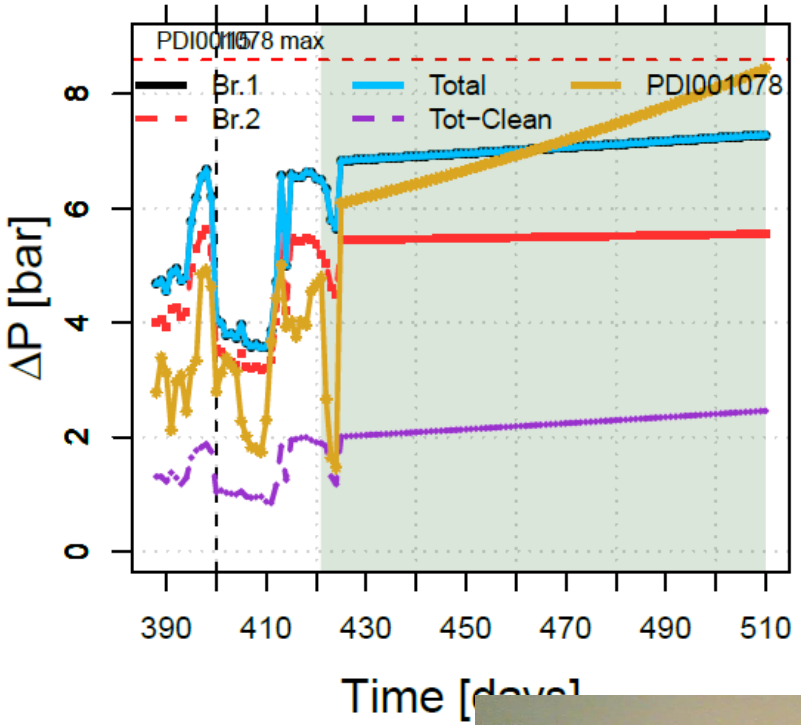




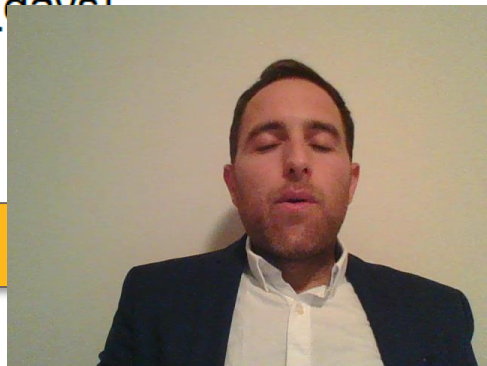
Benefits: increase in CIT of ca. 1.5-2°C and 8% reduction in CO_2 emissions due to

2. Maximise Uptime and Optimise Maintenance to Avoid Production Losses

- Thermo-hydraulic predictions warned several months in advance of possible *hydraulic limit* due to fouling build up in a key HEX in the network.
- High pressure drops could result in *loss of production*, leading to severe economic penalties.
- Early warning allowed keeping the unit onstream, recovering energy for as long as possible and cleaning it at the optimal time before any loss of production occurred



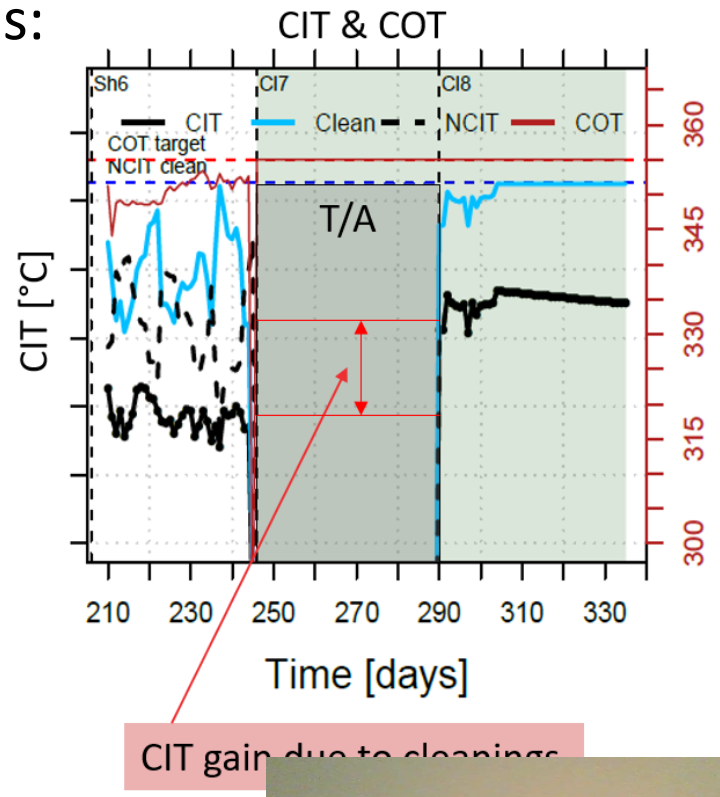
Benefits: cleaning action saved ca. 3% of total production



3. Plan and React to Unexpected Events in Turnarounds

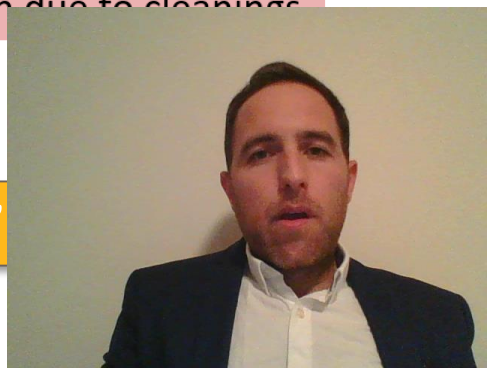
Predictive analytics answer questions before (or during) T/A such as:

- What will the performance be after T/A, including planned cleanings?
- Can we start up w/o a key exchanger or several exchangers?
- What would the performance be if we need to plug tubes?
- What if cleanings are ineffective?



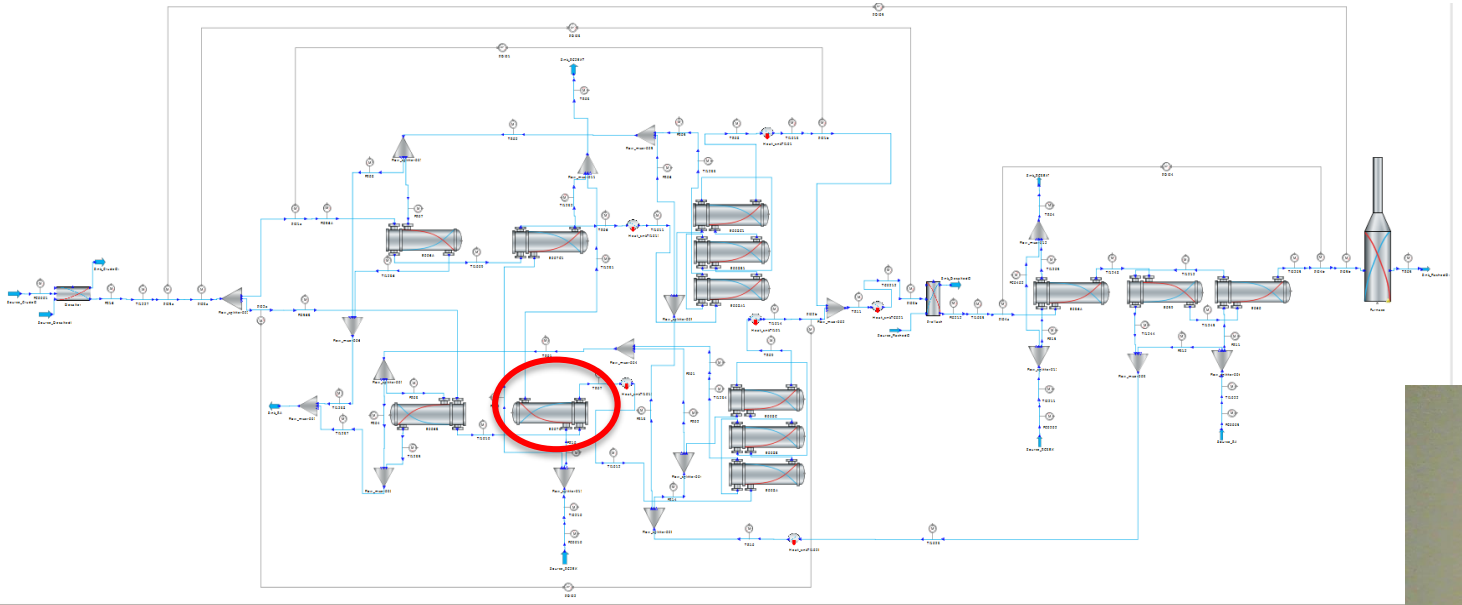
	CASE 1A Without key exchanger	CASE 1B Without hot end (3 hx)	CASE 1C Without hot end (3 hx) + inefficient cleaning
Furnace limit reached {max. % furnace capacity}	No {67%}	No {79%}	No {86%}
CIT loss [°C] while exchangers offline	2	23	32
Design T - Maximum hot fluid T[°C] E59	-19	-	-
Design T - Maximum hot fluid T[°C] E-8	+60	+15	+15
Design T - Maximum hot fluid T[°C] E-6	>+35	>+35	+5

Predictive analytics provides expected performance after T/A for various “what if”

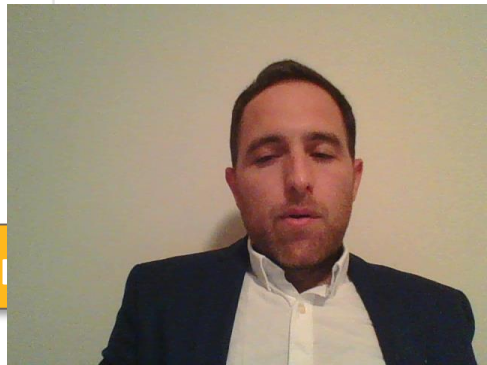


4. Early detect and react to operational issues

- Unexpected behaviour **flagged** 7 days after a T/A → Investigation open by operators
- **Issue fixed** 7 days after being flagged → bypass valve stuck in open position: intermediate HEX was being bypassed unintentionally



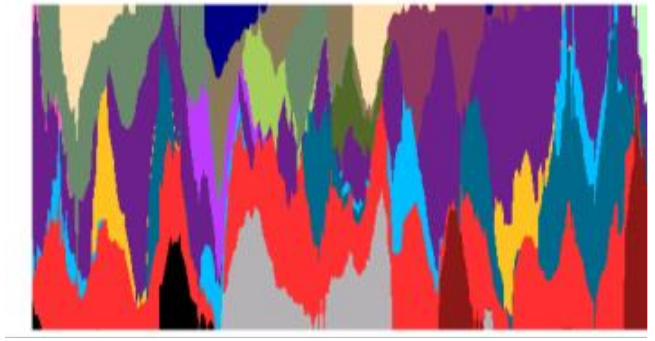
Benefits: increase in CIT of ca. 5°C and savings of >300 ton CO_2 per month after

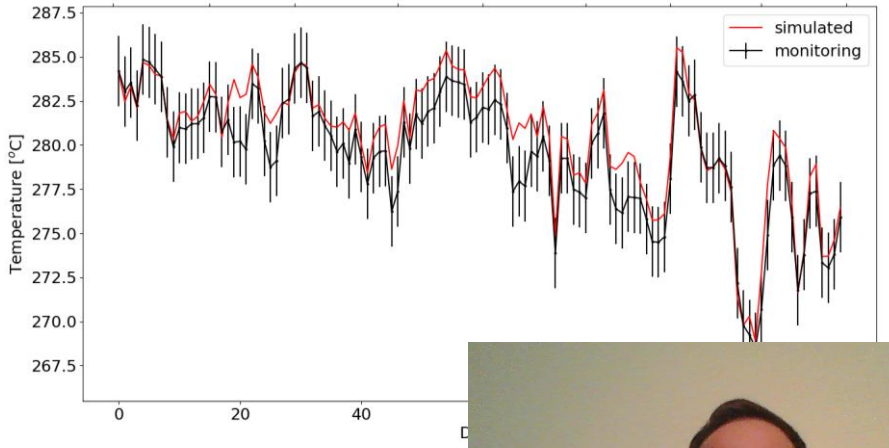


5. Make Oil Blending Decisions that Minimise Fouling

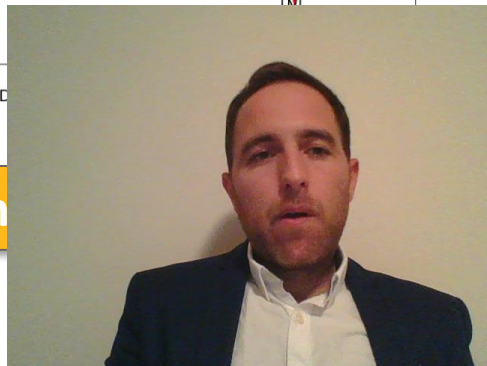
- Objective: account for energy costs and CO_2 emissions when making blending decisions.
- Allows including key trade-offs that would be missed when oil prices and yields are considered alone.
- Cheap opportunity oil could be economically advantageous on paper, but lead to very high fouling and energy losses and operational problems when processed.

Oil blending decisions





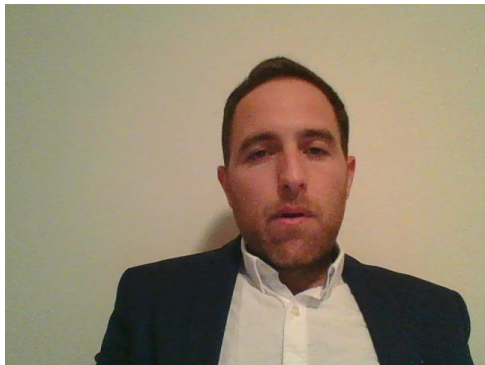
CIT predictions within <1% (±2 °C): tool can be trusted for blending decision-m



Conclusions

Heat-X project, in partnership with Hexxcell, enabled Repsol refineries to gain new advanced digital capabilities, ultimately leading to:

- Better real-time decision making avoiding fouling
- Early detection and reaction to issues before they manifest themselves
- Maximise production and optimise energy recovery
- Safer operations



Thank you

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