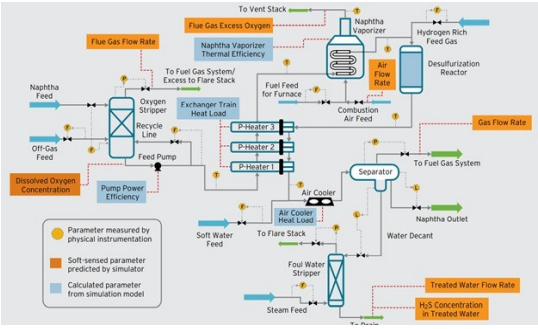
Case Study: Dynamic Simulator-Based Soft Sensing at a Hydrocarbon Purification Plant

The Opportunity



A section of a naphtha (lighter than petrol hydrocarbon fluid) sweetening plant demonstrates the efficacy of dynamic soft sensing. The process involves purifying naphtha of sulfur that is naturally present in the mixture, by decomposing the complex sulfur compounds present in the mixture in a hydrogen rich environment into H2 S (hydrogen sulfide), followed by stripping off H2 S to generate sweetened naphtha.

The Approach

Our first step was to generate a high fidelity dynamic simulation model of the process plant on a commercial dynamic simulator platform, which was validated against the actual process plant data. Next, the model was tuned to match actual plant operating conditions at steady state. The model was then linked with process instrumentation and distributed control-system feed using a compatible software interface. The dynamic simulator then began predicting all the process parameters which were not physically measured in the plant, along with the equipment operating efficiency indicators.

The above Figure illustrates how some of the soft-sensed process parameters, along with estimated equipment performance indicators, are computed by the simulation model. The important parameters soft sensed by the model, and their relevance in the plant operations, include:

- **Dissolved oxygen concentration in naphtha liquid exit oxygen stripper:** A higher value than 5 ppm indicates fouling threat for the downstream P-heater exchanger train.

- **Oxygen stripper overheads gas flow rate:** A higher rate indicates more gas being fed to the fuel gas system, leading to the possibility of flaring of excess gas that is not utilized as fuel in the process.

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- **Oxygen content in flue gas exit naphtha vaporizer:** A higher value indicates more flow of combustion air in the furnace, which will reduce the thermal efficiency of the process.

- **Hydrogen sulfide concentration in treated effluent exit foul water stripper:** A higher value indicates increased pollutant concentration in effluent water discharged from the plant.

Similarly, the equipment performance indicators estimated by the simulator that cannot be directly measured in the plant are:

- **Exchanger fouling in P-heater train:** A higher value indicates reduced exchanger heat transfer efficiency, leading to higher fuel consumption in the naphtha vaporizer and extra cooling load on the air cooler fans.

- **Naphtha vaporizer firebox thermal efficiency:** The ratio of heat pickup by the feed stream against the total heat released in the firebox. A lower number will indicate heat loss, and increased fuel consumption.

- **Pump power efficiency:** A lower value will indicate increased power consumption in the system, leading to poor energy efficiency in the process.

- **Reactor catalyst activity:** This indicates the effectiveness of the catalyst in the reactor. A low activity would require increasing reactor temperature, leading to increased fuel consumption and loss of catalyst working life.

The Benefits

- Reduced Off Gas Feed Flow to the Oxygen Stripper

- Auto-Tuning the Simulation Model to Ensure Soft-Sensed Parameter Fidelity

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