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Optimization in Oil & Gas:

Maximizing Efficiency and Sustainability in Oil and Gas Operations for Enhanced Production and Reduced Environmental Footprint.

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Executive Summary

The global economy is significantly impacted by the Oil-and-Gas sector as it produces numerous forms of fuel as well as a variety of vital chemicals that play a very dominant role in the Global Economy.

The refining of petroleum involves a variety of methods. These, for instance, include:

- Chemical sweetening, hydrotreating, and hydrodesulfurization
- Conversion procedures like polymerization, cracking, and alkylation
- Management of feedstock and products.

The Oil-and-Gas industry is quickly transitioning to a new generation and a vision of using the latest & greatest from analytics & data science. The expansion of Oil-and-Gas units' capacity and the enhancement of its chemical production process may result in considerable economic gains for the sector – and it's all about maximizing the production of key products by controlling the wastage and reducing the production of undesirable components.

This white paper aims to outline the most common optimization methods and the associated challenges of adaptation and how the envisaged approach can solve some of these on-ground challenges.

Problem Statement: Challenges to Optimization of Hydrocarbon Production

Optimizing hydrocarbon production in oil and gas fields is frequently limited by various factors such as reservoir conditions, pipeline network deliverability, facility fluid handling capacity, safety considerations, and downstream constraints including supply chain or economic considerations from the commodity as well as paper trading or a combination of all these considerations. The ask from field & plant operators is to devise optimal operating strategies to achieve certain operational goals, which can vary from field to field and over spread and timeline. Typically, one may wish to maximize daily production rates or minimize production costs.

Optimizations

Margin Optimization:

Profit refers to the total income earned by the enterprise during a specified period, while profitability refers to the operating efficiency of the enterprise. Profitability is an indicator of the company's ability to generate earnings. Margin is calculated by subtracting the costs at completion (feedstock + time and expenses lodged + time resourced and future expenses) from the revenue at completion (invoiced already + forecast to be invoiced).

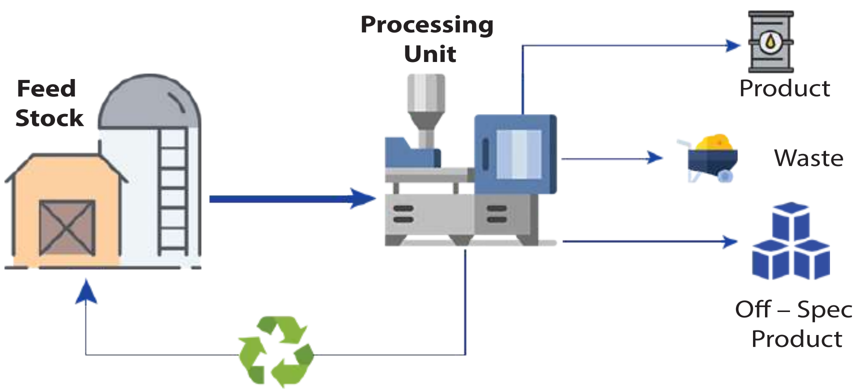
Following are the possible ways to optimize the margin:

- Producing a sizable volume of high-cost goods from low-cost raw materials while using fewer resources and energy
- Optimizing yield without changing the quality and quantity of feedstock, or the energy consumption.
- limiting waste, or minimizing the loss of feedstock or finished products during production
- Reducing energy consumption by opting for different energy sources such as changing steam turbine drivers to motors (power source from renewable energy)
- Limiting manual intervention using automation

Yield Optimization:

Yield is directly proportional to margin but inversely proportional to energy consumption.

Yield is a metric that results from dividing the amount of finished product by the amount of feedstock, used as input material.



As per above picture Yield = Product / Feedstock.

Following are the possible approaches towards Yield optimization:

Optimizing Yield by Increasing the feedstock– Increasing feedstock, thereby increasing the final product, is one of the simplest ways to boost yield. However, in operational plants, there are restrictions on increasing feedstock limitlessly. Since there are equipment design restrictions, limiting the processing capabilities of very large quantities of feedstock, the operating units can't hold or process the feedstock beyond their design capacity.

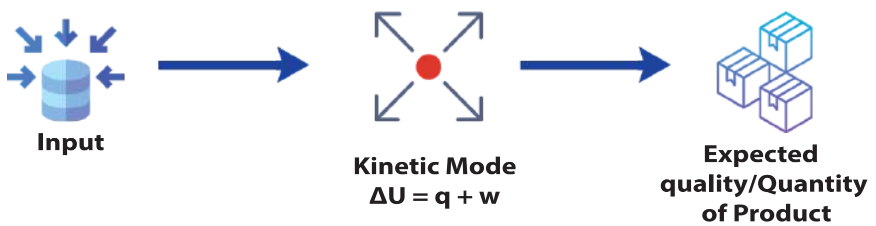
Optimizing yield by using higher-quality feedstock – In some cases, using premium feedstock results in the overall usage of lower energy while producing higher yields. The production of waste is likewise decreased by using premium feedstock. Due to the high price of premium or high-quality feedstock, profitability can occasionally be constrained if the premium-quality feedstock is used.

Optimizing yield without changing feedstock or energy consumption – This is the most challenging objective amidst all the considerations since the degree of freedom is very low for altering the processing parameters of an operating plant. There could be a few marginal values for most operating equipment, and those might have been set during the design phase itself thereby, leaving very little room for further optimization.

Let's take a deeper dive into the various methods, outlined below, which can help in optimizing the yield and achieve the various objectives as outlined above:

Using Kinetic Model or Simulator– IKinetic models use rigorous thermodynamic equations to predict yields. This is proprietary information from technology suppliers. Most of the time, it is not publicly available.

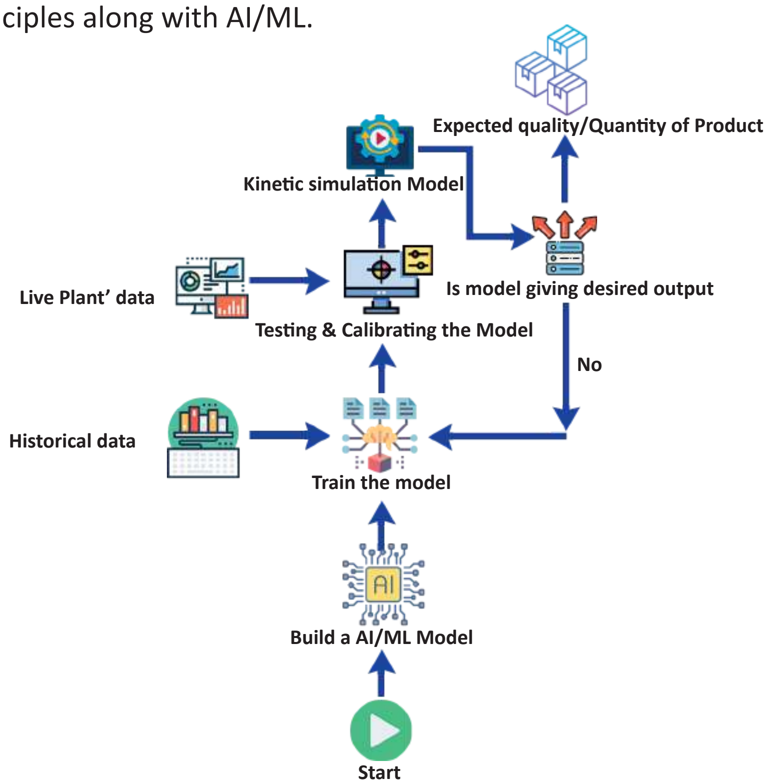
The objective of chemical process simulation is to depict a chemical or physical transformation process using a mathematical model that incorporates calculations of mass and energy balances along with phase equilibrium and chemical kinetics equations. Process simulators are commonly available to facilitate the design, monitoring, and troubleshooting of a process unit.



Hybrid Model for Yield Optimization – A hybrid model is a technique for fusing domain knowledge with Data Science, using first principles based process simulation models, and AI/ML techniques. A hybrid model uses AI/ML techniques to analyze, project, and predict the output, while a simulator uses the predicted analyses from the AI/ML technique as an input and further processes to achieve the desired yield.

Analysis of the plant data to calculate the product loss with the help of the AI/ML method and thermodynamics to detect the root cause of issues certainly helps in increasing yield.

By using simulation and AI/ML models to optimize throughput of each individual unit and tweaking design parameters will roll up to the entire plant's throughput without changing feedstock or energy, thus increasing the yield. This model is particularly suitable for plants where flow meters and/or sensors are not installed everywhere, and helps optimization using combination of thermodynamics first principles along with AI/ML.



By Using AI/ML – This approach bolsters the hybrid models with fast processing and minimal manual intervention for executing and running the model in run time, since AI/ML models are created and trained using available historical data. Once the model has been trained to the highest level of accuracy, it runs on a large amount of data using a variety of operational parameter combinations and runs the models repeatedly until they produce the best predictions. Various model accuracy testing mechanisms exist to ascertain the desired level of accuracy. In most cases, this is not either or but a combined approach classically referred to as 'Hybrid Model', which uses the best of both worlds to arrive at a more compelling value proposition.

Conclusion

We have envisaged providing a high level outline of the optimizing processes used in the Oil-and-Gas industry and the associated constraints and challenges for each approach. Our focus was to provide an overview of margin optimization considering the most common technical and design limitations.

Monitoring the plant remotely and taking proactive measures on some KPIs can reduce material losses at a significant level, and it also helps to implement proper planning before critical situations arise and thus avoid them. There are several digital monitoring systems that are available as tools for assisting with the monitoring challenges. Whereas, Kinetics models, hybrid models, and AI/ML models or techniques are available as methodologies to predict & optimize the desired goals and yield/margin or on an overall basis, the 'YETQ' i.e. Yield/Energy/Throughput/Quality values.

While doing so, our experience says that the kinetic model goes through numerous number of steps of rigorous thermodynamic calculations, and hence, prediction through this process is quite time-consuming, but helps significantly for designing a plant wherein the plant is yet to be operational or does not have sufficient operating data.

Hybrid models overcome this challenge by merging the thermodynamics with AI/ML, and the combined approach's turnaround time is faster than that of a kinetic model. AI/ML-driven driven yield optimization & prediction approach is the demand of the day as this approach is stringent and has the capability to achieve greater (or similar) accuracy to the Kinetic models with the ability to cater & factor in the unforeseen challenges with the least turnaround time & manual intervention.

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