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Simulation of Pumps by Aspen Plus

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Abstract*— Simulation of pumps in an Ammonia synthesis unit (Production of ammonia) process is gaining importance and so the process needs to be studied and better ideas suggested such that the production cost is reduced. With the advent of computers and simulating software's like "ASPEN PLUS" it is possible to design and optimize a particular process. Proper design can significantly reduce production cost as well as provide to make the process safe and reduce environment hazards. The material, unit operation and processes involved are been identified. Steady state simulation is done. Each unit is taken into consideration and the variables are been optimized. The units are sequentially optimized. Use of newer equipment's in the process is been going to be suggested. The distillation column will be optimized and number of trays will be seen for smooth production and to attain high efficiency in product.

***Index Terms*— Simulation, Design, Pumps, Steady State, Dynamic.**

I. INTRODUCTION

The purpose of analysis/simulation is to model and predict the performance of a process. It involves the decomposition of the process into its constituent elements (e.g. units) for individual study of performance. The process characteristics (e.g. flow rates, compositions, temperatures, pressures, properties, equipment sizes, etc.) are predicted using analysis techniques. These techniques include mathematical models, empirical correlations and computer-aided process simulation tools (e.g. **ASPEN Plus**). In addition, process analysis may involve the use of experimental means to predict and validate performance. Therefore, in process simulation, we are given the process inputs and flow sheet and are required to predict process outputs. The lab will focus on ASPEN Plus. It is a computer-aided software which uses the underlying physical relationships (e.g. material and energy balances, thermodynamic equilibrium, rate equations) to predict process performance (e.g. stream properties, operating conditions, and equipment sizes).

a) Simulation Modes:

There are two modes of simulation-

1) Steady state mode
2) Dynamic mode.

b) Steady State Mode and Dynamic Mode :-

Initially process simulation was used to simulate steady state processes. Steady state models perform a mass and energy balance of a stationary process (a process in an equilibrium state) it does not depend on time.

Dynamic simulation is an extension of steady-state process simulation whereby time-dependence is built into the models via derivative terms i.e. accumulation of mass and energy. The advent of dynamic simulation means that the time-dependent description, prediction and control of real processes in real time has become possible. This includes the description of starting up and shutting down a plant, changes of conditions during a reaction, holdups thermal changes and more.

Dynamic simulations require increased calculation time and are mathematically more complex than a steady state simulation. It can be seen as a multiply repeated steady state simulation (based on a fixed time step) with constantly changing parameters.

Dynamic simulation can be used in both online and offline fashion. The online case being model predictive control, where the real-time simulation results are used to predict the changes that would occur for a control input change and the control parameters are optimized based on the results.

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c) Various Process Simulators:-

- Aspen Plus.
- Aspen Hysys.
- Aspen Custom Modeller by Aspen Technology.
- CHEMASIM.
- CHEMCAD.

d) Introduction To Aspen Plus

Aspen PLUS is a market leading process modeling tool for conceptual design, optimization, business planning, asset management and performance monitoring for oil and gas processing, petroleum refining, and air separation industries. Aspen PLUS is a core element of Aspen Tech's aspen ONE Engineering applications. Aspen PLUS has established itself as a very intuitive and easy to use process simulator in oil and gas refining industry. Users with little prior knowledge of Aspen PLUS can pick up and train themselves in its modeling capabilities. Some of the very intuitive capabilities include a highly interactive process flow diagram for building and navigating through large simulations. The program also provides a very flexible and easy to use distillation column modeling environment. Additionally the interactive nature of PLUS enables users to build and use their models quickly and effectively. Aspen PLUS offers a comprehensive thermodynamics foundation for accurate calculation of physical properties, transport properties, and phase behavior for the oil & gas and refining industries. Comprehensive library of unit operation models including distillation, reactors, heat transfer operation, rotating equipment's, controllers and logical operations in both the steady state and dynamic environments.

1. Description

Before Starting with simulation we have to select the available simulation templates as shown in fig.1. There are numerous options and the highlighted one is generally the solution to all and or can solve as seen by the no of available templates.

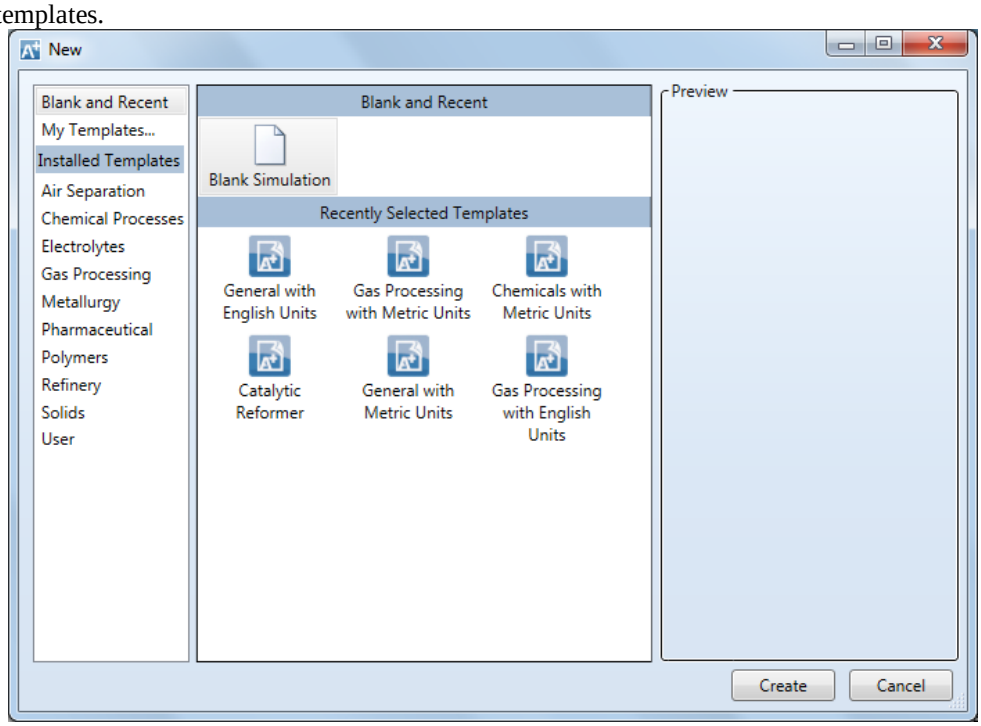

Fig 1: Available Simulation Templates

Aspen has a huge database of commonly used (and some not so commonly used) components and their physical properties. It also has an option where a user can define components that are not included in the database. Under

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the Specifications option we will input our components in the Selection tab. While making the PFD material streams are specified and entered. This is the only option where we will need to input data under the Components tab as shown in figure 2.

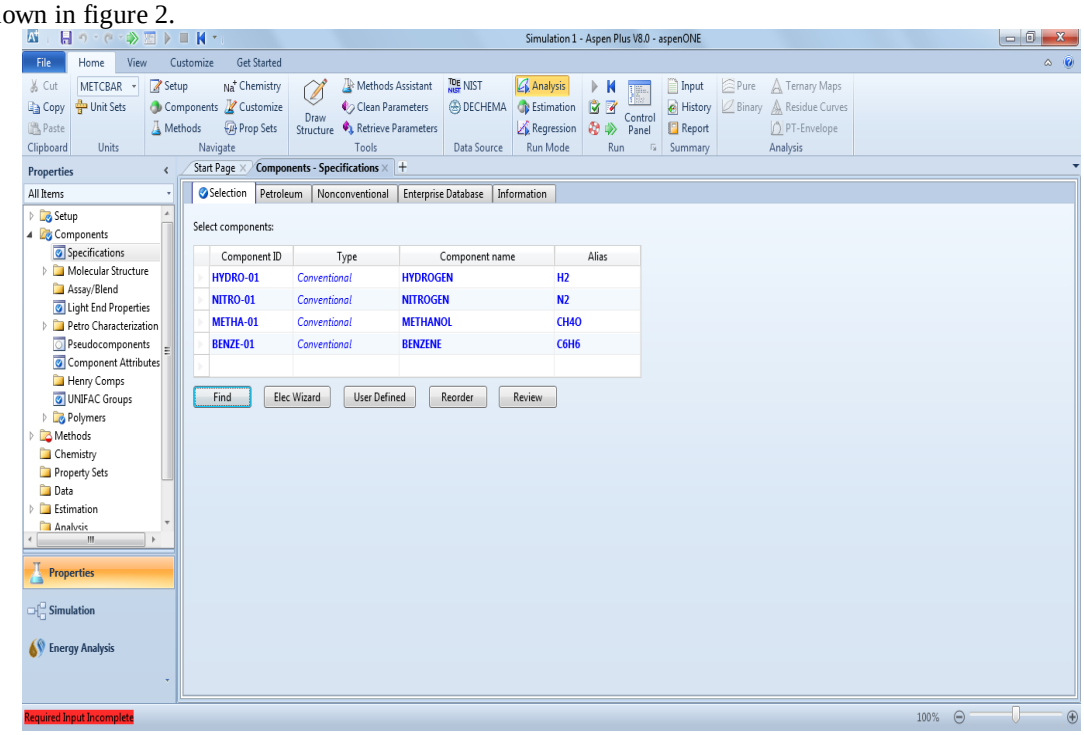

Fig 2: Component Selection

By knowing all the required data, process inputs we simulate the flowsheet. By knowing the specific volume with the help of equation of state we can determine the size and thus cost of the plant. Fig.3 represents the Aspen Plus screen where one will be able to draw the flowsheet and also simulate it by adding numerous inputs and also can check the energy analysis.

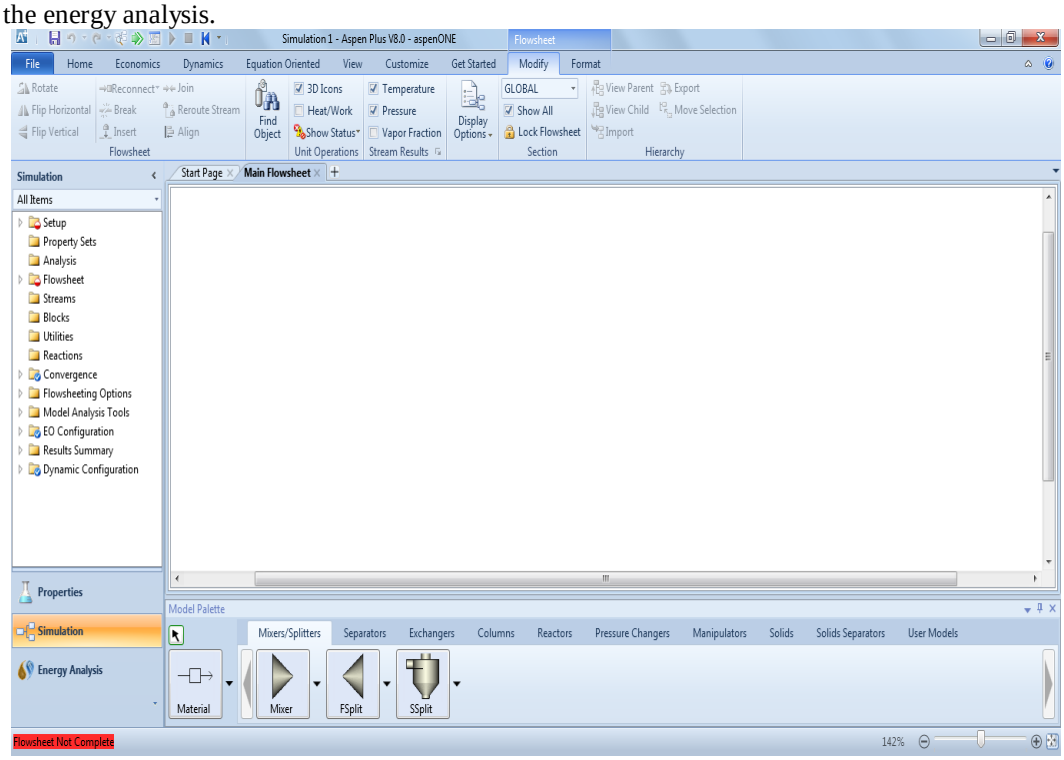

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Fig 3: Aspen Plus Screen

II. WORKING WITH PUMPS

A. Pumps

A pump is a device used to transport liquids, gases, and slurries. However, the term pump is usually used to refer to liquid handling equipment (this is true with Aspen Plus). The purpose of the pump is to provide a certain pressure at certain flow rate of a process stream. The pressure requirement is dictated by the process and piping involved, while the flow rate is controlled by the required capacity in the Downstream units. There are several types of pumps used for liquid handling. However, these can be divided into two general forms: positive displacement pumps (including reciprocating piston pump and the rotary gear pump), and centrifugal pumps.

B. Pump efficiency

Pump efficiency is defined as the ratio of the power imparted on the fluid by the pump in relation to the power supplied to drive the pump. Its value is not fixed for a given pump, efficiency is a function of the discharge and therefore also operating head. For centrifugal pumps, the efficiency tends to increase with flow rate up to a point midway through the operating range (peak efficiency) and then declines as flow rates rise further. Pump performance data such as this is usually supplied by the manufacturer before pump selection. Pump efficiencies tend to decline over time due to wear (e.g. increasing clearances as impellers reduce in size).

C. Working with Pumps

In general, a pump is a device used to transport liquids, gases, and slurries. However, the term pump is usually used to refer to liquid handling equipment (this is true with Aspen Plus).The purpose of the pump is to provide a certain pressure at certain flow rate of a process stream. The pressure requirement is dictated by the process and piping involved, while the flow rate is controlled by the required capacity in the downstream units. There are several types of pumps used for liquid handling. However, these can be divided into two general forms: positive displacement pumps (including reciprocating piston pump and the rotary gear pump), and centrifugal pumps. The selection of the pump type depends on many factor including the flow rate, the pressure, the nature of the liquid, power supply, and operating type (continuous or intermittent). Centrifugal pumps are by far the most widely used type in the chemical process industry, with other types employed for special process specifications (e.g. high pressures).

D. Pumps in Aspen Plus

- A pump takes one or more input streams and one product stream. It can also take a work stream.

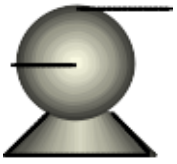

Fig 4:- Pump in Aspen Plus

- The pump specification is given through the Setup windows (accessed by double clicking on the pump).
- There are three different ways to define the pump performance: pressure, power, or performance curves. The first two options can be input directly, while the third is done in a separate window (Performance Curve window).
- The minimum input needed for a pump is one of the direct specifications (either pressure related or power). With this input, Aspen Plus will calculate many of the pump parameters including:
    - Fluid horsepower (FHP): this is the weight of fluid being pumped multiplied by the head across the pump.
    - Brake horsepower (BHP): is the actual power required by the pump and is equal to FHP divided by the pump efficiency.

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- Electricity: electric power needed to drive the pump, and is equal to BHP divided by the drive efficiency.
- NPSH available.
- NPSH required: in order to calculate this value, you have to supply some information about the specific speed (roughly, the rpm of the impeller multiplied by the flow rate and divided by the head) and the suction specific speed (which is an index used for centrifugal pumps with values ranging from 6,000 to 12,000, where 8,500 is a typical value). These can be input in the Setup | Calculation Options tab.

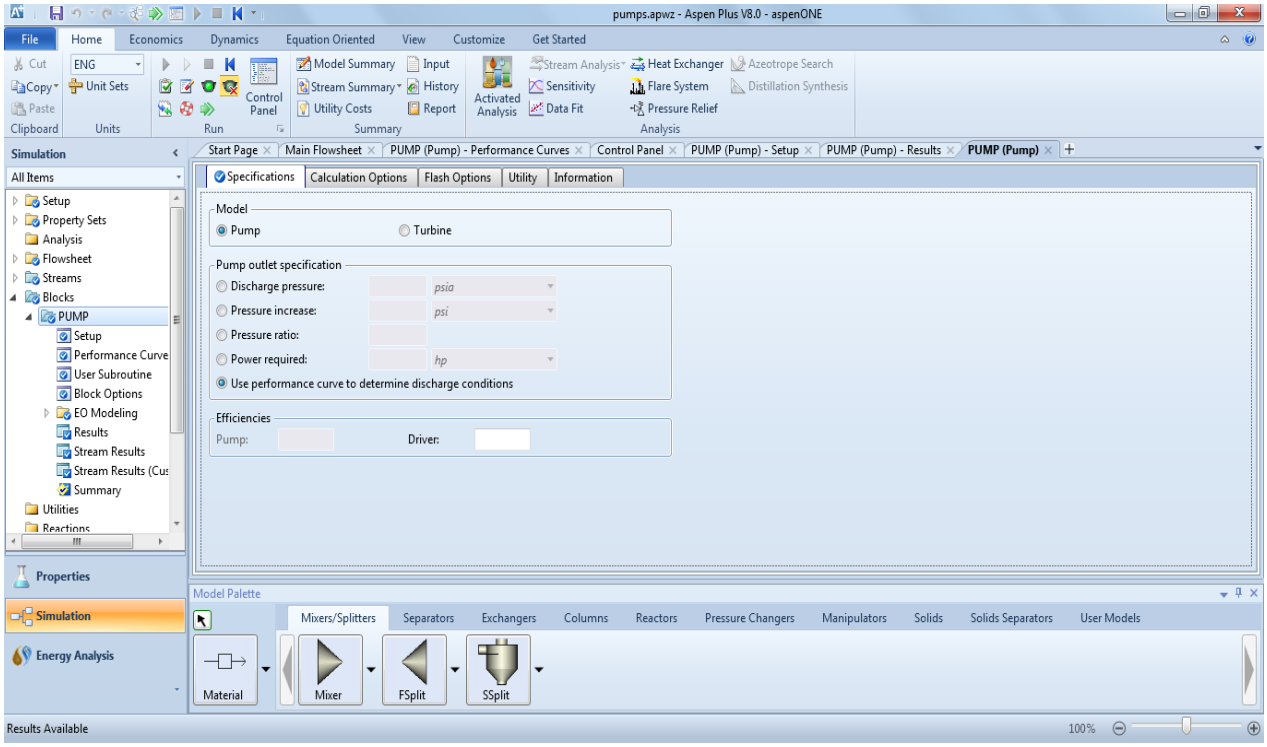

Fig 5:- Selection of Pump

E. Simulation of Pumps in Aspen plus

The fig below represents the schematic diagram of a pump in a aspen plus . H_2O-IN is the suction inlet to the pump and keyword H_2O-OUT is the discharge outlet.

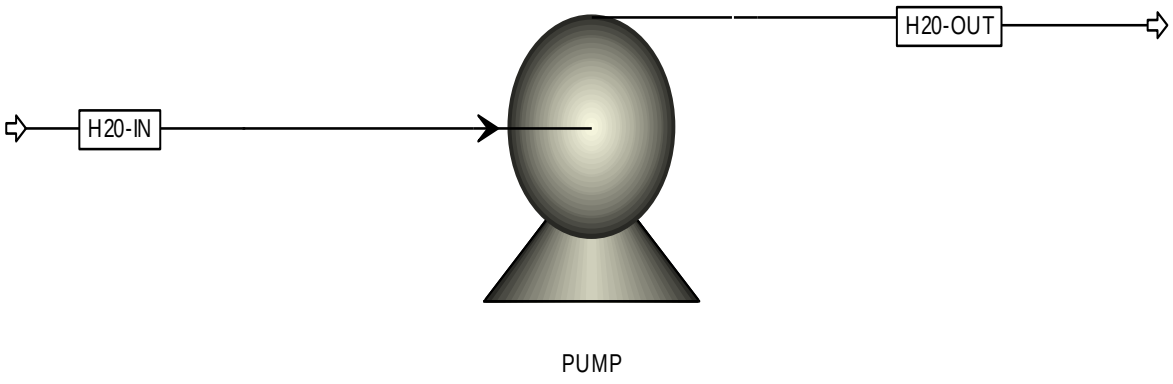

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Fig 6:- Simulation of Pump

The inlet conditions are specified wherever required.
The inlet conditions are:-

Inlet Conditions	
	H20-IN
Temperature F	100
Pressure psia	80
Vapor Frac	0
Mole Flow lbmol/hr	1223.752
Mass Flow lb/hr	22046.23
Volume Flow cuft/hr	355.516
Enthalpy MMBtu/hr	-149.867
Mole Flow lbmol/hr	
WATER	1223.752

Table 1:- H_2O-IN

H_2O-OUT is as follows:-

Outlet	
	H20-OUT
Temperature F	100.8
Pressure psia	431.97
Vapor Frac	0
Mole Flow lbmol/hr	1223.752
Mass Flow lb/hr	22046.23
Volume Flow cuft/hr	355.193
Enthalpy MMBtu/hr	-149.83
Mole Flow lbmol/hr	
WATER	1223.752

Table 2:- H_2O-OUT

The following are the results of the pump which concludes all the necessary requirements which are needed as shown in Table 2.

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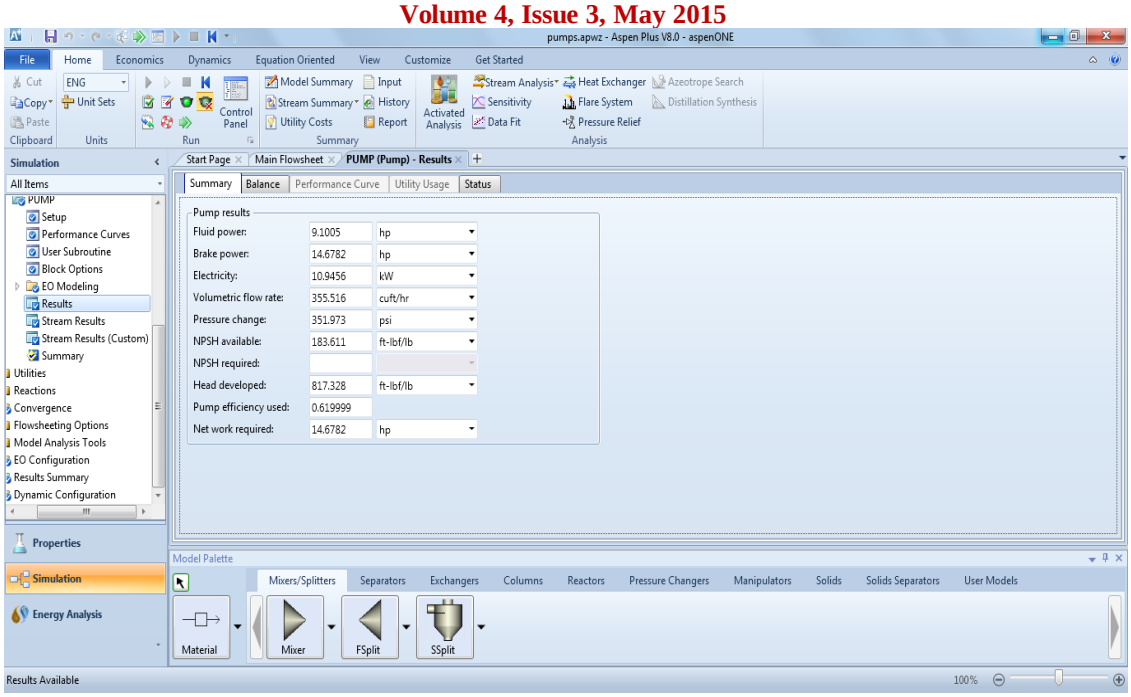

Fig 7:- Results

III. CONCLUSION

The goal of Plus is to provide a capability to design an entire process completely and accurately.

3.1 Advantages of Aspen Plus:

1. Aspen Plus provides an extremely powerful approach to steady state modeling.
2. Aspen Plus approach to modeling maximizes return on simulation time through increased process understanding.
3. Aspen Plus offers a comprehensive thermodynamics foundation for accurate calculation of physical properties, transport properties, and phase behaviour and newer versions of Plus have almost doubled in its capabilities on physical properties.
4. Aspen Plus introduced the novel approach of steady state and dynamic simulations in the same platform. It has became the defacto standard in industry, and today enjoys universal acceptance.
5. Aspen Plus let process engineers estimate the Green House Gas Emissions associated with a process.
6. Refinery Reactor Technology which includes Fluidized Catalytic, Hydro cracking and Hydro treating, Reforming and Isomerisation enables Aspen Plus to perform single unit, multi unit as well as refinery wide simulations.

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