

*On-Line Process Analyzers:
Potential Uses and Applications*

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INTRODUCTION

The purpose of this report is to provide ideas for application of Precision Scientific process analyzers in petroleum refineries. The information is arranged by refining process.

Included in this synopsis are applications which we believe will be economically feasible in many refineries. Special conditions may exist in any specific refinery which justify an "unusual" use of Precision Scientific instruments. For example, most refiners would be more likely to use a flash point analyzer on a crude unit, fluid catalytic cracking unit or hydrocracking unit than on a coker. (The volumes of naphtha and distillate streams from the coker are substantially smaller than the corresponding materials from the crude, catalytic cracking or hydrocracking units, and thus there is relatively less economic incentive to optimize yields of coker naphtha and coker distillate). However, a specific refiner could have some problem with the configuration of his coking unit which would provide more than the normal incentive. This special situation is not reflected in the applications that we have included in this report.

The primary advantage to using on-line process analyzers in refining operations is the ability to control the product streams closer to specifications. Periodic analysis of the product streams leaving a particular unit can be used for both quality control and for control of the unit operation, in order to maximize the yield of high-value products. A dedicated process analyzer would be able to provide measurement results quicker and with better repeatability than laboratory analysis. This would allow for better control of heater loads, reflux, and the tracking of transients. Improved control would allow for greater yields of high-value products by reducing the give-away needed to assure that all products meet specifications.

CRUDE DISTILLATION

Almost all refineries have a crude distillation unit. This is the initial processing unit used in refining crude oil into finished products. It normally produces unfinished product streams, which are then sent to downstream processing units for upgrading into finished products or components for further blending. A typical crude distillation unit is shown in Fig. 1. Most refineries have both atmospheric and vacuum distillation. However, some small topping refineries have only atmospheric distillation.

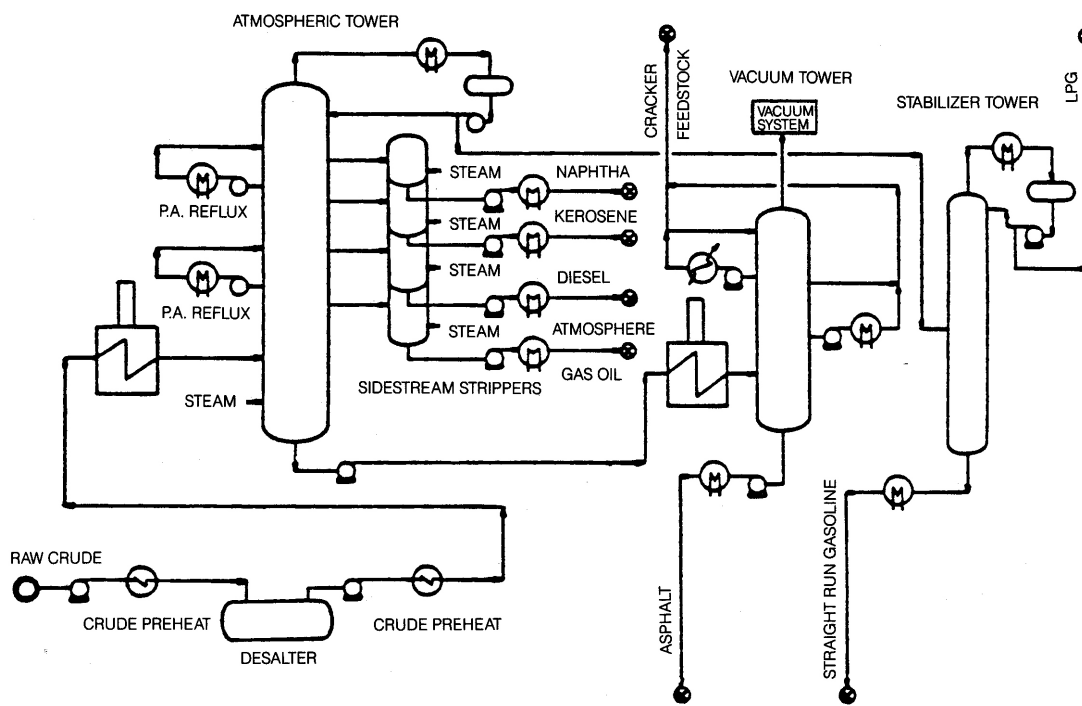


Figure 1 – Crude Distillation Unit

Crude Distillation, continued...

Some possible applications of various Precision Scientific analytical instruments in the crude distillation unit are as follows:

Boiling Point Analyzers

A Boiling Point or Distillation Analyzer would typically be used to control the 5% or 95% evaporated temperatures of the atmospheric tower side cut products. Examples are the 5% evaporated and the 95% evaporated temperatures in the naphtha stream, the 95% evaporated temperature of the kerosene stream, and the 95% evaporated temperature of the diesel fraction. Depending on the individual refiner's circumstance, boiling point analyzers might be profitably employed to monitor or control appropriate percent evaporated temperature for other streams in the crude distillation unit.

Vacuum Distillation Analyzer

This analyzer could be used to control appropriate percent evaporated temperatures on gas oil streams from the vacuum tower. Refiners will be more inclined to use this unit in refineries which have a hydrocracker or a lube oil manufacturing facility.

Flash Point Analyzer

This analyzer would most commonly be used to monitor or control the flash point of the kerosene products. In some instances, it might be installed on the naphtha or diesel stream.

Cloud Point Analyzer

This instrument would normally be used to monitor or control the diesel product from the crude distillation unit. Closer control of the cloud point would allow the refiners to reduce the amount of kerosene which must be used to product specification heating oil during the winter.

Freeze Point Analyzer

This instrument could monitor or control the freeze point of the naphtha or kerosene streams in refineries which produce jet fuel, thereby maximizing yields of these normally high-priced products.

Pour Point Analyzer

This analyzer would normally be used to monitor or control the pour point of the diesel stream from the crude distillation unit. This will decrease the amount of kerosene which must be added to produce specification product during the wintertime, and permit the kerosene to be added to the normally higher-priced jet fuel feeds.

Color Analyzer

Some refiners employ crude oil to cool and condense the crude tower overhead vapor stream. If a leak develops in this heat exchanger, crude oil can leak into the naphtha or light straight—run product. This could have a serious effect on catalyst in down-streaming processing units. A Color Analyzer installed on these streams can warn of leakage of crude oil into the light straight—run or naphtha streams. A similar application could be made on the crude / pump-around reflux or crude/product exchangers. A Color Analyzer could also be installed on the atmospheric gas oil stream to warn unit operators if residual material is being entrained into this stream. A similar application could be made on the gas oil stream from the vacuum tower.

Crude Distillation, continued...

Density Analyzer

This instrument might be used on the crude unit charge or on product streams to improve weight balance accounting.

Viscosity Analyzer

This instrument could monitor or control the viscosity of the light and heavy gas oil streams as well as the vacuum tower bottoms stream.

Salt-In-Crude Monitor

This analyzer could be used to alert operators to changes in the salt content of the incoming crude oil stream so that they could make appropriate changes in the desalter operation. It could also monitor the salt content of the desalter outlet stream to alert operators to any malfunction of this equipment. High salt concentrations in the crude after the desalter could cause costly corrosion in the equipment and/or high fuel usage due to the fouling of the heat exchangers used to preheat the crude before the furnace.

CATALYTIC REFORMING

This unit processes the naphtha stream from the crude unit into higher octane reformate for use in gasoline blending. Most refineries have a catalytic reforming unit. The most likely applications of Precision Scientific analyzers in the catalytic reformer are as follows:

Boiling Point Analyzers

Processing excessively heavy hydrocarbons can result in dramatic increases in coke formation on reforming catalyst. This may lead to reduced yields of reformate and more frequent catalyst regeneration. A refiner might consider use of a boiling point analyzer on the naphtha charge stream to warn of excessively high end points.

Moisture Analyzer

The moisture content of the hydrogen recycle stream should be kept extremely low and a moisture analyzer could be used on this stream.

Density Analyzer

The density of the hydrogen recycle stream in a catalytic reformer is very critical to reformer operation and this stream could be monitored continuously.

Vapor Pressure Analyzer

Depending on the particular refinery configuration, it may be advantageous to control the amount of butane which is included in the reformate stream from the reformer. In this case, a vapor pressure analyzer could be installed on the stabilizer bottoms stream and be used to monitor or control the fractionating tower conditions to adjust the amount of butane left in the reformate.

FLUID CATALYTIC CRACKING

Catalytic cracking units are found in most refineries in the United States. These facilities convert heavy gas oil into light gasoline and distillate blending stocks. A simplified flow diagram of a fluid catalytic cracking unit is shown in FIG. 2.

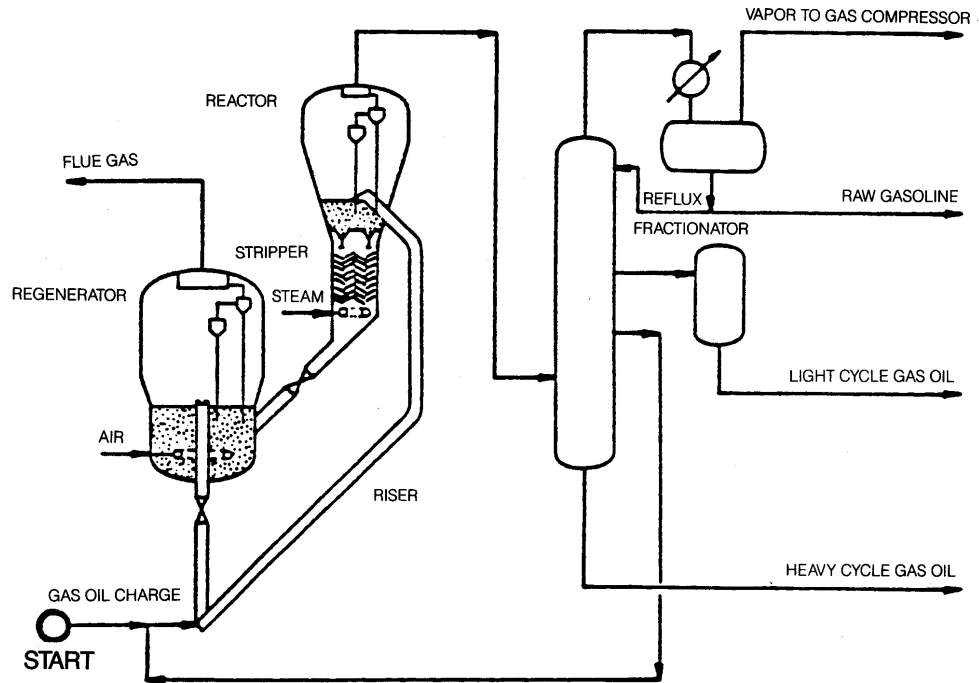


Figure 2 – Fluid Catalytic Cracking Unit

The following instruments could be used in a catalytic cracking unit:

Boiling Point Analyzers

We previously analyzed the use of a boiling point analyzer on a fluid catalytic cracking unit main fractionator.

Flash Point Analyzer

This instrument could be used to monitor or control the performance of the light cycle oil stripping column.

Cloud Point Analyzer

This analyzer could monitor or control the cloud point of the light cycle gas oil product.

Pour Point Analyzer

This instrument could be used to monitor or control the pour point of the light cycle gas oil product.

Fluid Catalytic Cracking, continued...

Viscosity Analyzer

This analyzer could monitor or control the viscosity of the heavy cycle gas oil material product in the FCC unit.

HYDROCRACKING

Hydrocracking is similar to catalytic cracking in that gas oil is converted into lighter gasoline and distillate blending stocks. However, the hydrocracking process uses high pressure and a hydrogen—rich atmosphere so that the reaction products are predominately saturated hydrocarbons, rather than the unsaturated (or olefin) products from catalytic cracking. Many refiners add a hydrocracker as part of a refinery expansion project to operate in parallel with an existing catalytic cracking unit. This allows the refiner to direct various feedstocks to each unit to achieve optimum performance.

The following Precision Scientific analyzers may find application in a typical hydrocracking facility:

Boiling Point Analyzers

These units could be used to monitor or control the cut points between various products in the same way they would be used on a crude distillation unit. For example, most hydrocrackers have a fractionating tower similar to an atmospheric distillation tower which produces light straight run, light naphtha and a distillate stream. Boiling point analyzers could be used to control the 5% evaporated temperatures and the 95% evaporated temperature of these streams.

Flash Point Analyzer

A flash point analyzer could be used to monitor the flash point of the distillate stream from the hydrocracker. It might also be used to monitor the flash point of the naphtha product.

Freeze Point Analyzer

The freeze point of the naphtha stream or the distillate stream could be monitored if this material is going to be used for jet fuel blending.

ALKYLATION

Most refineries which have a catalytic cracking unit, also have an alkylation unit to convert propylene and butylenes formed in the catalytic cracking process into high octane gasoline by reacting these compounds with isobutane. Alkylation units use either sulfuric acid or hydrofluoric acid as a reaction catalyst.

Boiling Point Analyzer

In facilities in which a rerun column is used to produce light alkylate for aviation gasoline blending, a boiling point analyzer could be used to monitor the 95% evaporated point of the light alkylate stream.

Trace Moisture Analyzer

Alkylation units are very sensitive to water. A trace moisture analyzer could alert operators to any problems which might occur in feedstock drying facilities.

Alkylation, continued...

Density Analyzer

This apparatus could monitor the density or specific gravity of the acid utilized as catalyst in the alkylation process. This would alert the unit operators to process changes that should be made in the event of changes in acid strength which can be detected by measuring the density of the acid solution.

DIMERSOL (CATALYTIC POLYMERIZATION)

This unit is used to react propylene formed in the catalytic cracking process to form a higher boiling molecule which can be used in gasoline.

Trace Moisture Analyzer

High water content in the feed can have an adverse effect on the catalyst used in this unit. A trace moisture analyzer could be used to monitor the operation of feed drying equipment.

VISBREAKING

Visbreakers have not been employed to any extent in United States refineries over the past twenty years. However, the process has recently been improved and some refiners have decided to install visbreaking capacity. A visbreaker unit mildly thermally cracks a vacuum tower bottoms stream to reduce its viscosity, thereby reducing the amount of light cutter stock which must be blended with the vacuum tower bottoms material in order to achieve the viscosity specification for finished residual fuel oil.

Boiling Point Analyzers

These instruments could monitor or control the 5% evaporated temperature and the 95% evaporated temperature of the Visbreaker naphtha.

Viscosity Analyzer

This instrument could be used to monitor or control the viscosity of the visbreaker product stream. Unit operations would then be adjusted for changes in feed quality, etc.

THERMAL CRACKING

Thermal cracking facilities are generally not used in modern U.S. refineries because catalytic cracking or hydrocracking processes are more efficient. However, there are a few operational units in the older refineries which could require analyzers similar to the Visbreaker.

COKING

Many refineries employ coking of residual streams to form petroleum coke and lighter petroleum products. The Precision Scientific analyzers which might be used on a coking unit include:

Boiling Point Analyzers

These could be used to control the 5% evaporated temperature and the 95% evaporated temperature of coker naphtha, the 5% evaporated and the 95% evaporated temperatures of coker distillate and the 95% evaporated temperature of coker gas oil. Depending on the specific circumstances of an individual refiner, the boiling point analyzer might be used to monitor or control other points on the distillation curves of these products streams.

HYDROTREATING

The hydrotreating process is used to react hydrogen with various sulfur compounds in the hydrocarbon feeds to form H₂S which can be removed from the liquid hydrocarbon stream by stripping. Normally, very little chemical change occurs in the hydrocarbon product and we are not aware of any significant application of process analyzers for monitoring or control of these units.

LUBE OIL

Many refineries do not have lube oil processing facilities. However, these units could be very attractive candidates for use of Precision Scientific instruments. The exact process configuration is quite complex in these facilities, and the Pour Point Analyzer, Viscosity Analyzer, and Viscosity Index Analyzer should be seriously considered by refiners to maximize the yields of all lube blend stocks.

BLENDING OPERATIONS

Many refineries store intermediate compounds in run-down tankage and use these components to blend up finished specification products. Precision Scientific instruments should be very useful in several areas of the refinery.

- **GASOLINE**

A Process Spectrometer could be used to predict the research octane number, motor octane number, aromatic content, and olefin content of the blended gasoline or the blending components. Similarly, a Reid Vapor Pressure Analyzer could be used to verify compliance with gasoline specifications. A Process Spectrometer could also predict distillation points, or a separate Boiling Point Analyzer could also be used in this area of the refinery.

- **JET FUEL**

Analyzers which could be used in this area of the refinery include the Boiling Point Analyzer, Freeze Point Analyzer and the Vapor Pressure Analyzer (for military jet fuel). A Process Spectrometer could also be used to predict the aromatic content, heat of combustion, or smoke point of the blended fuel.

- **DIESEL FUEL**

A Process Spectrometer could be used to predict the cetane number and index, and aromatic content of the blended fuel. A Boiling Point Analyzer and Cloud Point Analyzer could be used for control during summer blending, and Pour Point Analyzer could be used for winter blending.

- **DISTILLATE**

The Cloud Point Analyzer and the Pour Point Analyzer could be utilized effectively in this area of the refinery. In addition, the Flash Point Analyzer and the Color Analyzer could be used to warn of off-specification products.

- **CONDENSATE**

Analyzers which could be used in this area of the refinery include the Boiling Point Analyzer, Freeze Point Analyzer and the Vapor Pressure Analyzer.

Blending Operations, continued...

- **RESIDUAL FUEL**

A Pour Point Analyzer, Viscosity Analyzer, and Flash Point Analyzer could be used in residual fuel blending.

- **ASPHALT**

A Viscosity Analyzer or Viscosity Index Analyzer could effectively monitor the blending of various grades of asphalt and road oils.

PIPELINES, PUMPING STATIONS, AND TERMINALS

Dedicated pipelines are used to transport not only the crude oil coming into the refinery, but also for moving finished products to customers, tanker terminals, and tank farms. The ability to detect contamination, and to detect product interface, is important in controlling the destination of each product.

Salt-In-Crude Analyzer

This analyzer could be used to detect high salt concentrations entering a pipeline or leaving a gathering station that would lead to excessive corrosion. A measurement of base salt concentration could also be used to detect contamination by seawater.

Color Analyzer

Several different types of color measurements could be used. A Color Analyzer measuring dye concentration could be used to identify interfaces in a products pipeline. Similarly, a refractive index measurement could be used to identify products independent of density. Measurement of product haze could identify contamination by water.

Density Analyzer

Density measurement could be used to identify products transported to a terminal.

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