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Raman Spectroscopy

Optimization of Refinery with Process Raman

Application Note

Overview

Petroleum Refineries

Petroleum refineries convert crude oil into petroleum products for use as fuels for transportation, heating, paving roads, and generating feedstocks for making chemicals and plastics. A refinery runs 24 hours a day, 365 days a year. Most refineries focus on producing transportation fuels (85%). U.S. refineries are based upon a 42-gallon barrel of crude oil to produce 19-20 gallons of motor gasoline, 11-13 of diesel, and 3-4 gallons of jet fuel.

The optimized Crude Distillation Unit (CDU) operation requires an understanding of the nature of the crude feed. Typically, crude feeds are identified by a standard assay from the field with a TBP (True Boiling Point) curve, and not specific to any shipment. The important control parameters for the Advanced Process Control (APC) scheme are the boiling points, and the middle distillate cold properties (i.e. flash point, cloud point). These are obtained by laboratory test procedure involving a complex physical distillation apparatus. On-line measurement requires a large number of properties using discrete physical property analyzers with cycle times over 20 – 80 minutes, in contrast to the APC models delivering estimations every few minutes.

HORIBA Process Instruments Raman uses a fiber-optic based configuration with separate sample flow-cells for each process stream (side-draws), with no sample conditioning or water removal requirements, and allows for rapid multi-property, multi-stream accurate real-time product quality data for the CDU optimizer.

Refining breaks crude oil down into its various components, which are then reconfigured into new products. The volume of individual products produced varies from month to month and year to year as refineries adjust production to meet market demand and to maximize profitability.

All refineries have four basic steps:

- Distillation
- Cracking
- Reforming
- Blending

Distillation

All refineries are equipped with atmospheric distillation units, and more sophisticated facilities often include vacuum distillation units. Within these distillation units, the process of separating liquids and vapors into distinct petroleum fractions based on their boiling points takes place. The key components of a distillation unit are a series of trays strategically positioned to enable the ascent of heated vapors, which then condense at varying levels to isolate different liquids from crude oil.

The top of the column is cooler than the bottom, so liquids vaporize and rise, and then condense into their respective trays. The light fractions are on the top and the heavy fractions are on the bottom. The lightest fractions vaporize and rise to the top of the distillation unit, where they condense back to liquids. Medium weight liquids, including diesel, kerosene, and jet fuel, stay in the middle of the distillation tower. Gas oils separate lower down in the distillation unit and the heaviest fractions (highest boiling point) settle at the tower's bottom.

The HORIBA Process Instruments Raman technology is reliable, rugged, and designed to operate in all process environments. Temperature controlled redundant lasers, monochromator, and CCD camera provide stability for precise process results. The Process Instrument (PI)-200-I is a Raman Analyzer with 18 Channel Multiplex that is designed to replace multiple other process analyzer by monitoring multiple components in up to 17 process streams. The analyzer generally requires no sample conditioning and can detect and quantify trace level amounts of key components within the process streams. The analyzer can be packed in a General Purpose 19" rack or in a Purged Enclosure. PROspect process software is included to provide outputs to the plant DCS system (Modbus, 4-20mA).

Process Raman Benefits

- Predict Crude Unit cut points.
- Monitor key properties to adjust cut points based on market needs.
- Monitor product from Propane to Heavy Gas Oil
- Measurements in < 3 minutes

Practical Application: Crude Unit Control

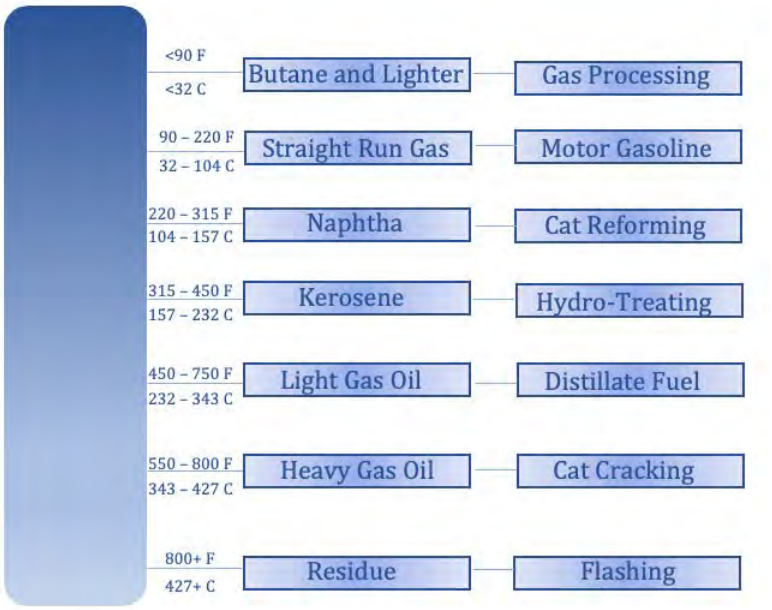
Cut point temperatures essentially define the upper and lower limits of the various distilled products. The temperature at which they start to boil is referred to as the IBP (Initial Boiling Point), incrementing in every 5-10 degrees until they reach a temperature at which they boil off completely, referred to as the FBP (Final Boiling Point). Tight control can enable the operator to get a better handle on crude unit operations, as energy requirements can change depending on the crude feed and/or quickly respond to shifts in market demand for a specific product. Below we can appreciate spectra used to train a set of calibrations based off Straight Run Diesel (SRD) product.

This application has been in service for 5 years and while multiple properties are in use the one that is closely monitored is distillation at 90% (T90). Via Raman control the operator can see how unit changes affect the distillation process, this is due to variations in the molecular composition of the observed sample. These are captured in the spectra as hydrocarbon structures such as normal-paraffins and aromatics vary in concentration.

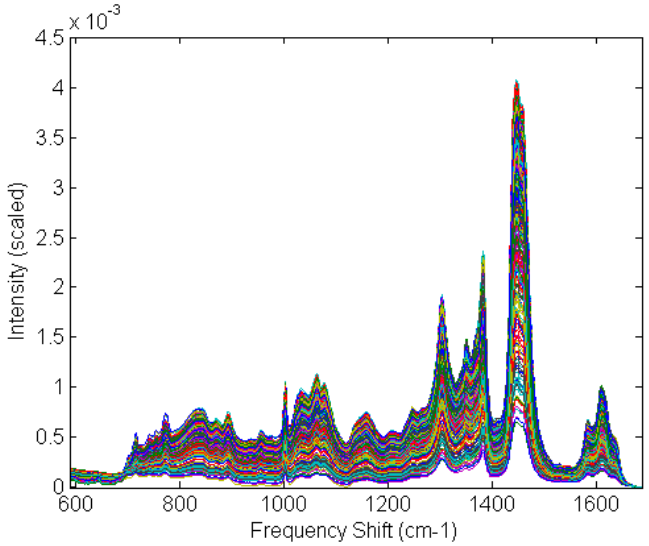
Light Gases (C1-C4)	The fuel gas consists mainly of methane through butane along with the light sulfur compounds like H2S. The sulfurs are removed, the methane and ethane will be used as Fuel Gas. The propanes and butanes are separated to be used for LPG and for gasoline blending respectively.
LSR Gasoline (C4-C6)	The Light Straight Run (LSR) gasoline is desulfurized and used in gasoline blending or processed in the isomerization unit to improve the octane number before blending.
Naphtha (C6-C8)	The Naphtha cuts are used as feed to the catalytic reformer to produce high octane reformate for gasoline blending and aromatics recovery.
Kerosene (C9-C15)	The kerosene stream is treated and then sent to the blending pool for sale as kerosene product or processed into Jet Fuel.
Light Gas Oil (C13-C20)	The LGO cut is treated and then sent to the blending pool as diesel fuel.
Heavy Gas Oil (C19-C40)	HGO are processed in a hydrocracker or catalytic cracker to produce additional gasoline, jet, and diesel fuels.
Residue (C40+)	The vacuum bottoms are processed in a Coker, Visbreaker or Deasphalting unit to produce heavy fuel oil or cracked for lube base stocks. The residues are processed further to produce road and/or roofing asphalts.

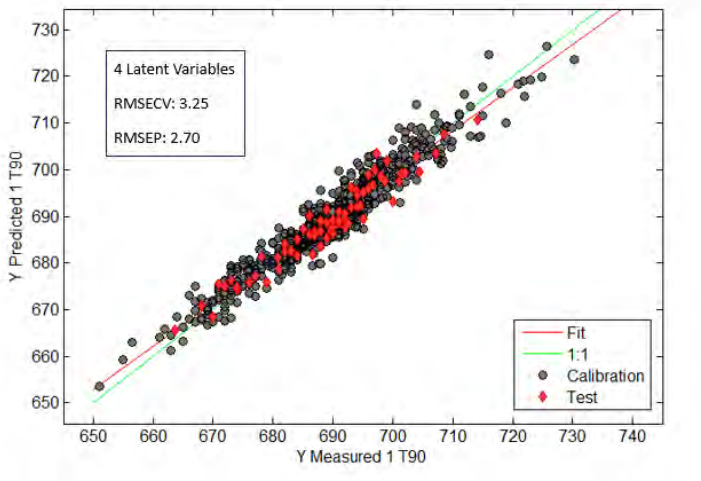
Measurements

- Distillation Points from IBP to FBP
- Flash, Freeze, Cetane, Cloud and Pour
- Aromatics and Olefins
- Octane and RVP
- Density and Viscosity



CDU	Property	Range	R^2	SECV	Samples
Kerosene	Sulfur	503 - 1224	0.93	49	133
	10% (C)	166 - 192.8	0.99	0.99	40
	50% (C)	191.8 - 208.4	0.98	1.12	40
	90% (C)	255.5 - 264.9	0.99	1.15	40
	Flash Point (C)	38 - 59	0.98	0.79	155
	Density	0.79 - 0.81	0.99	0.0004	52
	Freeze Point (C)	(-58) - (-45)	0.88	0.95	155
Naphtha	Sulfur (wt.)	83.1 - 98.7	0.99	0.48	27
	5% (C)	40.5 - 50.3	0.80	1.19	29
	50% (C)	54.1 - 93.2	0.98	1.51	29
	95% (C)	108.5 - 143.1	0.76	4.71	27
	Density	0.664 - 0.706	0.97	0.002	31
	P (%v)	71.34 - 87.23	0.97	0.84	28
	I (%v)	36.97 - 44.52	0.71	0.97	28
	O (%v)	0.01 - 0.36	0.93	0.03	24
	N (%v)	8.06 - 20.08	0.92	0.72	28
	A (%v)	2.57 - 8.58	0.98	0.34	29
Light Gas Oil	Cloud (C)	(-60.9) - (-49.8)	0.89	1.09	100
	Flash Point (C)	46.5 - 58.5	0.98	1.13	69
	IBP (C)	94.1 - 126	0.88	2.55	108
	10% (C)	145.2 - 174.7	0.97	1.24	108
	50% (C)	217.6 - 238.6	0.89	1.36	108
	90% (C)	275.2 - 297.3	0.87	1.31	108
	FBP (C)	308.5 - 344.8	0.80	3.11	108
Heavy Gas Oil	Cloud (C)	(-22) - (-11)	0.91	1.12	157
	Flash Point (C)	64 - 93.5	0.97	3.00	99
	IBP (C)	145.6 - 178.3	0.89	3.86	107
	10% (C)	236.3 - 274.8	0.94	3.58	145
	50% (C)	306.8 - 339.4	0.89	2.59	143
	90% (C)	355.5 - 380.2	0.92	1.62	144
	FBP (C)	407.9 - 450.8	0.80	3.59	143





Calibration accuracy shows a residual error (+/-) of 3 degrees F, well within the ASTM D86 test method limits of uncertainty.

- **Cracking**

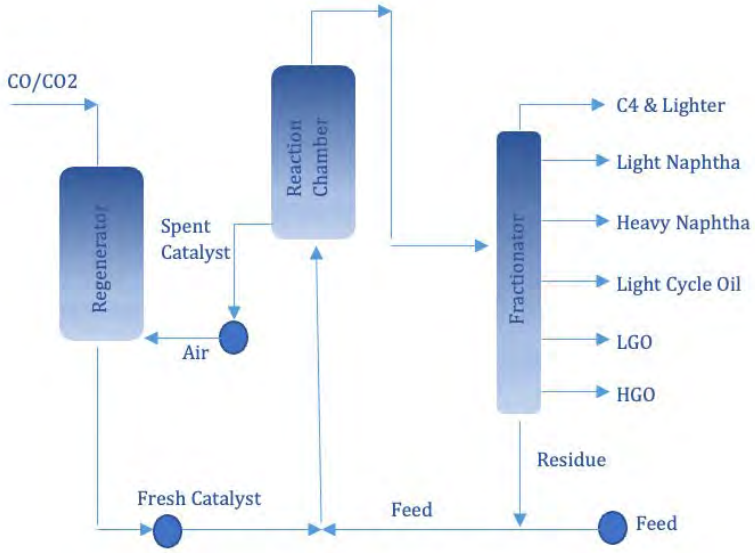
After distillation, heavier lower-value distillation fractions are processed into lighter higher-value products. The “Cracking” method uses heat, pressure, catalysts, and hydrogen to convert heavy long chain hydrocarbon molecules into smaller lighter molecules. Complex refineries may have one or more types of crackers, including fluid catalytic cracking units and hydrocracking/hydrocracker units. Cracking is not the only form of crude oil conversion.

Fluidized-Bed Catalytic Cracking (FCC)

FCC is the most important and widely used refinery process for converting low value heavy oils into more valuable products. The FCC process will convert 75% or more of the heavy oils to gasoline and lighter gases. The cracking process produces carbon (coke) which attaches to the catalyst particle, rapidly lowering its activity. To maintain the catalyst activity, it is necessary to regenerate the catalyst by burning off the coke with air. The catalyst is continuously moved from reactor to regenerator and back to reactor. The mixture of catalyst and hydrocarbon vapor travels up the riser into the reactor. The catalyst is a very fine particle, so the mixture of catalyst and vapor behaves like a fluid. In a market that favors gasoline usage over diesel, an FCC is typically more valuable than other cracking units.

Process Raman Benefits

- Monitor key feed properties.
- Monitor FCC Fractionator cuts.
- Predict PIONA properties of Light and Heavy Naphtha split.
- Monitor Naphtha/LCO cut points for changing market needs.
- Monitor Raffinate production.
- Predict Octane loss for post FCC Naphtha Hydrotreating.
- Measurements in < 2 minutes.



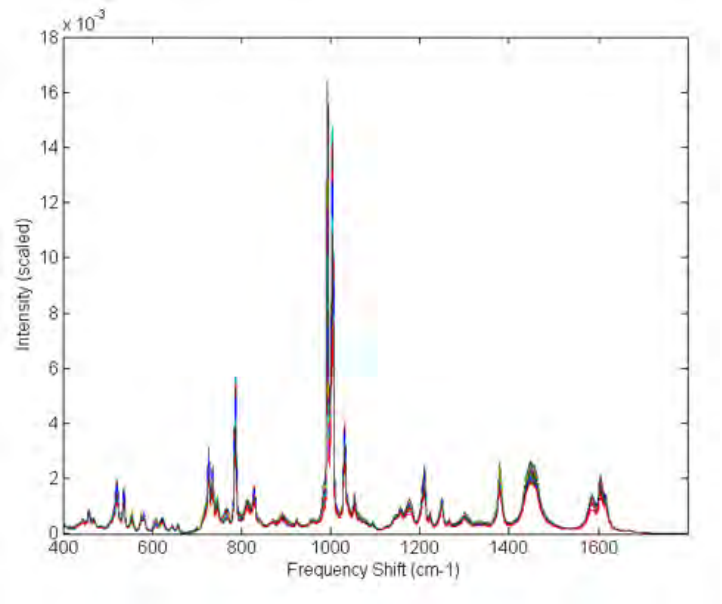
Measurements

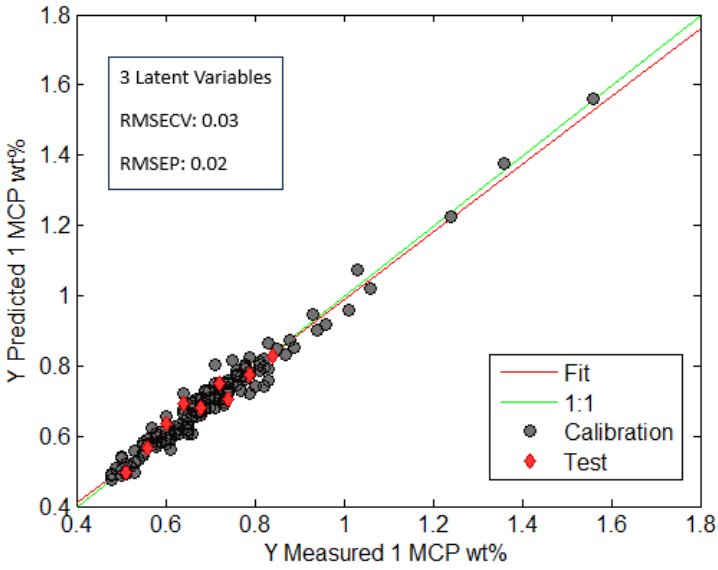
- Total Olefins, Naphthenes, and Aromatics
- Individual olefins like 1,3-butadiene, isobutylene, trans-2-butene, 1-butene, n-butene
- i-Paraffins and n-Paraffins
- Density and Boiling Points
- Octane and RVP

Practical Application: Minimize Benzene Precursors.

For most refiners, minimizing benzene content will pose a compliance challenge. Refineries need to select and execute a solution that offers optimal value, typically favoring the most cost-effective option. Benzene is a key aromatic hydrocarbon consisting of a ring of six carbon atoms. It's a fundamental building block in various chemicals, plastics and heavily regulated when blended into gasoline. The main sources of benzene into the gasoline pool are FCC Naphtha and reformate, where the naphtha serves both as a blend component and as a feed into the reforming unit. The desired reduction effect can be achieved by fractionating the generated reformate into its light and heavy components.

A different approach is to pre-fractionate the benzene precursors from the FCC naphtha by monitoring the concentrations of C6 and C5 Naphthenes like cyclohexane, methycyclopentane (MCP) and methylcyclohexne (MCH). Via Raman the operator can achieve excellent control on these key properties due to their strong spectral response, which allows monitoring at low concentrations. Added to this is the fast response of the analyzer which replaces the need to have multiple field GCs that while accurate require long term maintenance and attention. Since 2019, this customer has been using multiple calibration models to verify the concentrations of these properties in order to plan on the reformate yield and how it will ultimately impact the gasoline pool.





Calibration accuracy shows a residual error (+/-) of 0.02 wt%, well within the GC ASTM test method limits of uncertainty.

Catalytic Hydrocracker

Hydrocracking provides high yields of valuable distillates without producing low-grade byproducts and is highly selectivity between light and middle distillates. The hydrocracking process can process a wide range of feedstocks that are difficult to process in the fluidized-bed catalytic cracking. The major products from hydrocracking are jet fuel and diesel, but naphtha fractions and LPG are also produced.

The hydrocracking processing will decrease the molecular weight and boiling point of heavy oils to produce saturated hydrocarbons that form highly aromatic feedstocks and distillation residual. Hydrocracking is a catalytic cracking process that uses hydrogen to break C-C bonds.

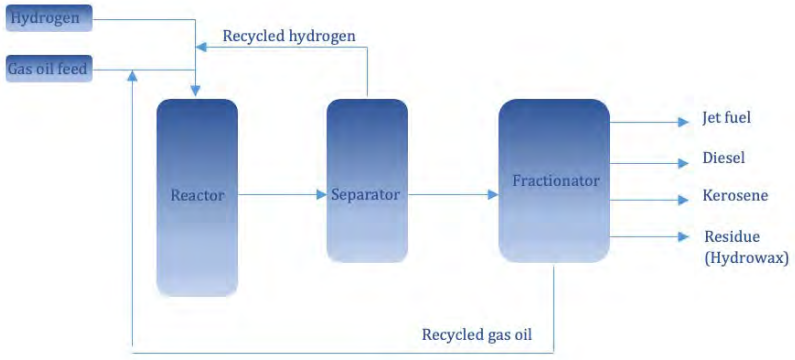
Frequently, to optimize the production of light products while maintaining a balanced output of gasoline and diesel, refineries employ both a fluid catalytic cracking (FCC) unit and a hydrocracker. In such instances, these two units operate in tandem effectively, with the FCC handling the unconverted feed from the hydrocracker, and the hydrocracker processing the heavier cracked products (such as light cycle oil or heavy cycle oil) derived from the FCC.

Process Raman Benefits

- Predict key feed boiling points.
- Monitor feed specs to better control energy needs
- Monitor Fractionator cuts.
- Monitor key product properties.
- Monitor i-Butane production.
- Monitor Hydrowax output.
- Measurements in <2 minutes

Measurements

- Boiling Point
- Flash, Smoke, Pour and Cloud Points
- i-Butane
- Octane



- **Reforming**

The reforming process raises both the quality and volume of gasoline produced by refiners. Reforming rearranges the naphtha hydrocarbons to create gasoline molecules. A series of reforming processes convert paraffins and naphthene's into aromatics and isomers with higher-octane numbers. The reforming process produces reformate which increases the octane for fuels.

The naphtha splitter fractionation tower separates light and heavy naphthas. Light naphtha contains most of the crude's C5's straight-chained paraffin and C6's cyclic aliphatic hydrocarbons having from five to six carbon atoms per molecule. Heavy naphtha is a mixture of straight-chained and cyclic aliphatic hydrocarbons having from seven to nine carbon atoms per molecule. The purpose of making such a separation is to produce a heavy naphtha which will contain the heavier naphthenes suitable for feed for a catalytic reformer.

Isomerization Unit

Isomerization transforms straight-chain hydrocarbons into branched-chain isomers by rearranging the hydrocarbons within a compound to create isomers. Typical feedstocks are composed of normal paraffins such as butanes, pentanes and hexanes, which have straight-chain structures, while the product after reforming isobutane, isopentane and isohexane.

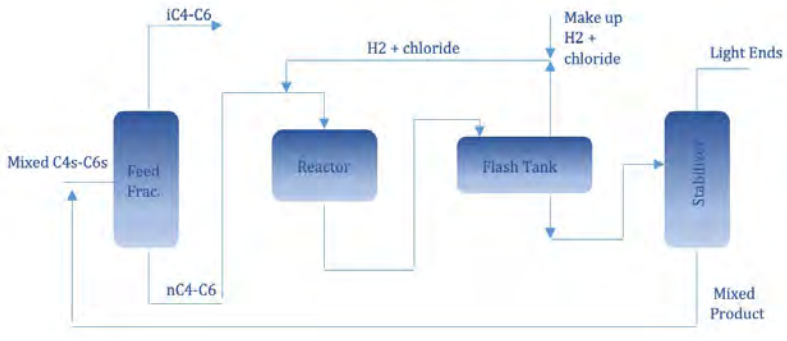
The reaction occurs under specific temperature and pressure conditions to achieve optimal isomerization without undesired side reactions. Heat and catalyst convert the C4-C6 molecules into their corresponding isomers, while the unreacted normal paraffins are recycled to increase yield. Depending on the need the product can be Isomerate used for as a high-octane quality or as a feedstock for the alkylation process (nC4 -> iC4).

Process Raman Benefits

- Predict key feed properties such as n-Butane, n-Pentane, and n-Hexane.
- Predict key product properties such as i-Butane, i-Pentane and i-Hexane.
- Monitor Isomerization process by predicting Octane, RVP.
- Monitor further light ends fractionation.
- Measurements in <2 minutes.

Measurements

- n-Butane, n-Pentane, n-Hexane
- i-Butane, i-Pentane, i-Hexane
- Light Ends (<C4)
- RVP
- Octane



Alkylation Unit

Alkylation makes gasoline components by combining some of the gaseous byproducts of cracking. Reforming uses heat, pressure, and catalysts to turn naphtha into high-octane gasoline components.

Alkylation is a chemical process that involves the combination of lightweight, gaseous hydrocarbons to create the high-octane components found in gasoline. The light hydrocarbons consist of olefins, butylene, propylene and iso-paraffins such as isobutane. These hydrocarbons are fed into a reactor, where under the presence of a catalyst bed (sulfuric-acid or hydrofluoric-acid), they react to yield a blend of high-octane hydrocarbons. The liquid fraction (alkylate) is predominantly characterized by the presence of iso-heptane and iso-octane, making it a premium gasoline blend stock due to its exceptional anti knocking properties.

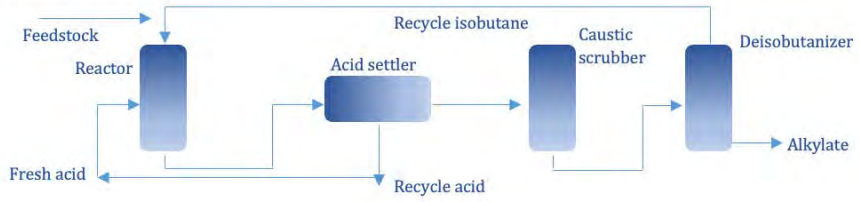
Process Raman Benefits

- Predict key Olefins to optimize Alkylation feed.
- Predict key properties such as Octane to optimize Alkylation product.
- Monitor recycled Hydrofluoric or Sulfuric Acid concentrations.
- Monitor various fractionation stages.
- Measurements in <2 minutes

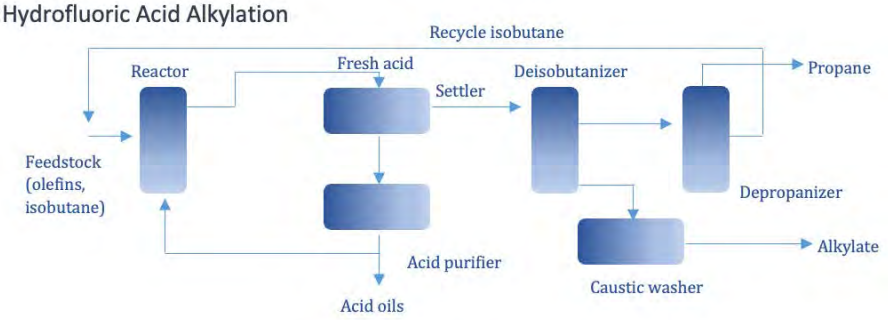
Measurements

- i-Butane
- c3-c4 olefins
- HF and H2SO4 concentration
- Propane
- Octane and RVP

Sulfuric Acid Alkylation



Hydrofluoric Acid Alkylation



Cracking	Property	Range	R^2	SECV	Samples
Alkylation	Propane	0.78 - 9.62	0.99	0.08	126
	Propylene	0.46 - 11.57	0.99	0.08	121
	I-Butane	25.76 - 44.16	0.99	0.11	124
	N-Butane	8.01 - 15.88	0.99	0.06	125
	Trans2-Butene	8.49 - 15.09	0.99	0.06	122
	1-Butene	3.53 - 11.50	0.99	0.06	125
	I-Butylene	3.86 - 1.50	0.99	0.04	126
	Cis2-Butene	4.63 - 9.18	0.99	0.04	120
	I-Pentane	1.19 - 12.32	0.99	0.10	125
	N-Pentane	0.08 - 0.94	0.99	0.03	130
	1,3 Butadiene	0 - 0.531	0.99	0.005	125
	3 Methyl-1 Butene	0.25 - 7.59	0.99	0.01	129
	Trans2-Pentene	0.19 - 1.9	0.99	0.02	129
	2 Methyl-2 Butene	0.21 - 1.76	0.99	0.02	127
	1 Pentene	0.12 - 0.57	0.99	0.01	127
	2 Methyl-1 Butene	0.22 - 1.26	0.99	0.02	130
	Cis-2 Pentene	0.11 - 0.81	0.99	0.02	126
	H2SO4	88.2 - 91.7	0.88	0.33	50

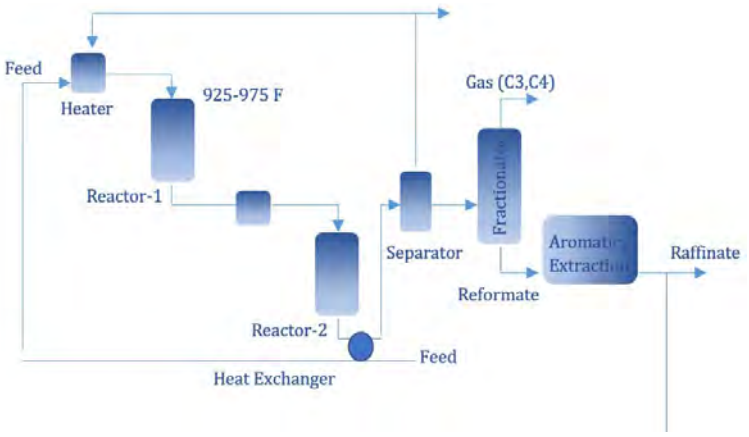
Catalytic Reformer

Catalytic reforming converts lower octane value naphtha into high octane value reformate for gasoline blending. The reformer unit is the prime supplier of hydrogen for the refinery, and it is the prime supplier of Benzene-Toluene-Xylene (BTX) for sales to chemical plants. The feedstocks to catalytic reformers are heavy straight run (HSR) gasolines (FCC) and naphthas from the crude unit. These naphthas are typically fractioned into light and heavy depending on the carbon # concentrations, C6 and lower such as Hydrogen, butanes and lighter are separated and sent off to the gas plant or Isomerization unit while the heavy naphthas are kept for reforming.

The reactors reform the "straight chain" molecules into aromatic and branched aromatic. The reformate is either sent to the gasoline blending or to the aromatics unit since the reformate contains large quantities of aromatics. Depending on the site the reforming unit might be called different names, this is typically derived from the catalytic reforming version they developed (e.g., Reniforming, Platforming, Powerforming, etc.)

Process Raman Benefits

- Predict key feed properties such as PONA, n-Hexane, n-Heptane and Cyclohexane.
- Predict key product properties such as i-Hexane, Methylcyclohexane and Benzene.
- Monitor reaction process by predicting product Octane and RVP.
- Monitor undesirable cracking reactions forming butanes and lighter gases.
- Monitor BTX feedstock production
- Measurements in <2 minutes



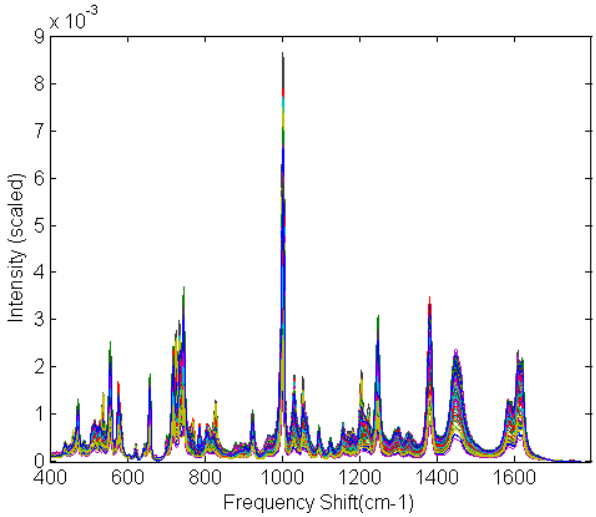
Measurements

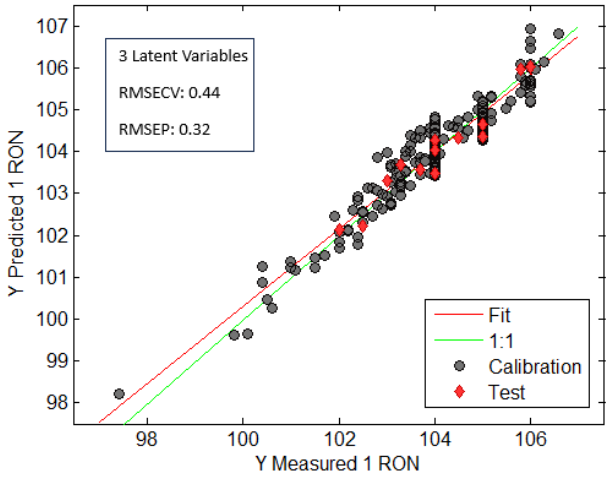
- i-Paraffins and n-Paraffins
- Naphthenes
- Propane and Butane

Reforming	Property	Range	R^2	SECV	Samples
Reformate	RON	93.5 - 99.4	0.97	0.270	163
	MON	88.7 - 96.7	0.91	0.34	180
	RVP	2.3 - 5.00	0.96	0.08	250
	API Gravity	29.9 - 34.2	0.93	0.10	91
	10% (F)	256 - 325	0.92	1.63	92
	50% (F)	304 - 338	0.98	0.89	92
	90% (F)	342 - 375	0.80	1.08	92

Practical Application: CRU octane control.

In the Catalytic Reforming Unit (CRU) the feed composed of mainly heavy naphtha and rich in n-paraffins and Naphthenes are reformed to produce a product called reformate which is high in aromatics and iso-paraffins. It's highly valuable due to its superior octane rating, which enhances the overall quality and performance of gasoline. The research octane number (RON) is defined as the volume percentage of iso-octane in a blend of iso-octane and n-heptane that causes a certain level of knocking during fuel testing. RON decreases as the molecule's carbon count increases for paraffins, iso-paraffins, and Naphthenes. Conversely for aromatics the opposite pattern is observed. Via Raman the operator can monitor the product and retroactively adjust the unit conditions to reach the desired octane which can range above 100+ ON. This is all possible due to calibration models built using Raman spectroscopy along with either field or laboratory engine test results. For this customer a calibration model was built using a small set of samples (<100) that included variations for 4-6 months' worth of reforming operations. Once online, the calibration was routinely checked and only updated when needed, by now the use of Raman at this site has been online for 6 years with much success along the way.





Calibration accuracy shows a residual error (+/-) of 0.4 ON, well within the ASTM D2699 test method limits of uncertainty for high ON values.

- **Blending**

Final product blending represents perhaps the most quality-critical aspect of refinery operation. Tight product quality characteristics are defined and must be met for product release. It is critical to be met both rapid and accurate on-line product required properties, and feedstock property measurements are necessary. Real-time feed of measured product properties are accessible to the blending optimizer. This aims to economically minimize high-cost product giveaway by utilizing the available blending feedstocks with the lowest cost.

The various grades of motor fuels are blends from different fractions such as reformate, alkylate, catalytically cracked gasoline. A refinery can produce 8 to 15 different streams of hydrocarbons that are then blended into motor fuels. Refiners might also mix in additives like octane enhancers, metal deactivators, antioxidants, anti-knock agents, rust inhibitors, or detergents.

The HORIBA range of process Raman analyzers for on-line gasoline and diesel blend optimization allows for rapid multi-stream and multi-property quality determination of the final product streams (gasoline, diesel, jet), along with their blending components. The calibration transfer of calibration databases between HORIBA laboratory and process Raman analyzers allows for rapid project startup or property expansion.

Raman analyzers accurately measuring final product qualities in real-time, will allow Advanced Blend Control blend optimizer with the required product qualities to; minimize product re-blends, reduce giveaways, and allow the use of lower-cost feedstocks while still meeting the final product quality targets.

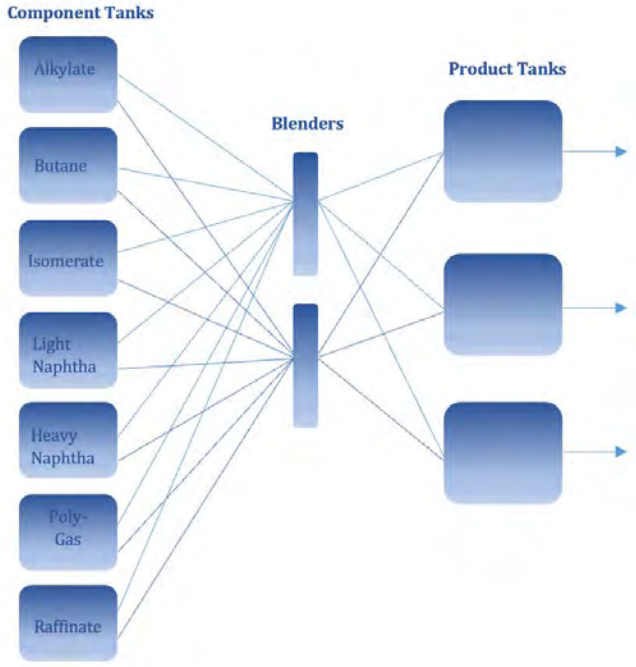
Gasoline Blender

Process Raman Benefits

- Predict key product properties such as Octane and RVP.
- Predict key regulatory properties such as Aromatics and Olefins.
- Monitor component feeds to Blender.
- Monitor Blender products with and without additives (Ethanol).
- Monitor final tanks.
- Measurement in <2 minutes.

Measurements

- Octanes and RVP
- Boiling Points
- Aromatics and Olefins



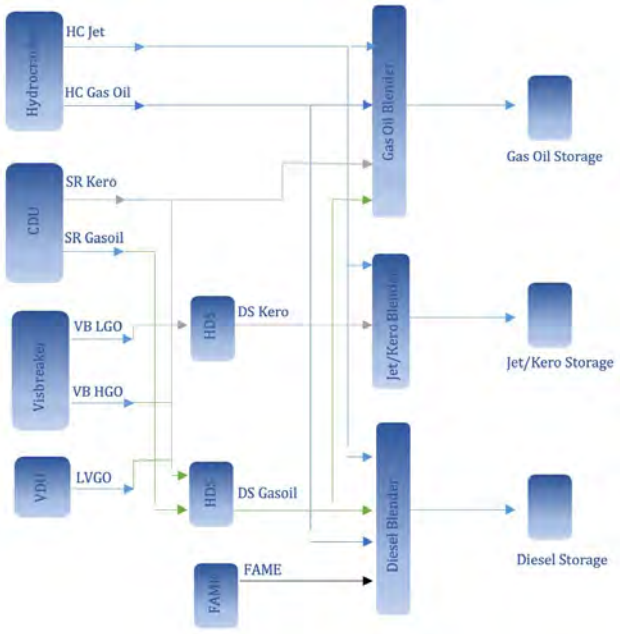
Distillate Blender

Process Raman Benefits

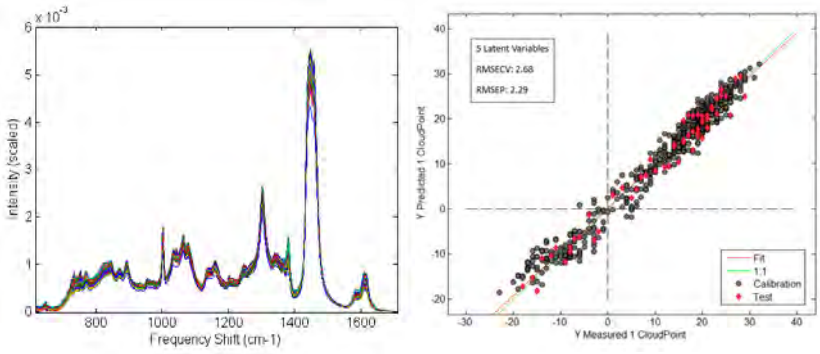
- Predict key product properties such as Cetane and Flash.
- Predict key feed properties when blending Kero into Jet or Diesel production.
- Monitor Diesel Sulfur content.
- Monitor biodiesel production.
- Monitor final tanks properties.

Measurements

- Cetane and Flash
- Boiling Points, Density and Sulfur
- Aromatics and Olefins content
- FAME additive
- C4 & C3
- Octane and RVP
- Aromatics, Naphthene and Olefins
- Flash and Cloud



Practical Application: Cold Flow property monitoring for Diesel blending.
Modifying the cold flow properties of diesel, particularly the cloud point and cold filter plugging point, poses a challenge with general hydrotreating processes. The crystallization of wax during cooling can obstruct filters and impact engine performance. Strategies to meet cold flow targets include blending lighter materials like kerosene or jet fuel and employing additives. However, these methods come with drawbacks, such as elevated costs or reduced yields. Diluting with blending stocks necessitates meeting identical specifications as the final ultra-low-sulfur diesel (ULSD), potentially requiring additional hydrotreating for the blending stock, affecting its value and imposing volume limitations within diesel's distillation and flash point specifications. This customer produces diesel that depending on the market will vary in cloud and pour point specifications, which can also be affected by the other opportunity intermediate distillates (e.g., gasoil, LCO) the refinery might have purchased to then use for blending into diesel. Since 2017 has easily monitored via Raman the effect multiple feeds can have in diesel specs prior to tankage since the spectral response will vary as the hydrocarbon's chains get longer the heavier the product gets. While other properties such as distillation points, cetane, sulfur, flash point and viscosity are important, our customer uses cloud point to monitor unit operations.



Calibration accuracy shows a residual error (+/-) of 2.6 F, well within the ASTM D2500 test method limits of uncertainty.

Blending	Property	Range	R^2	SECV	Samples
Gasoline	RON	90.4 - 98.6	0.99	0.19	167
	MON	81.5 - 87.4	0.99	0.21	163
	RVP	6.55 - 13.62	0.99	0.13	189
	IBP (F)	79 - 96	0.87	1.09	320
	10% (F)	117 - 143	0.99	0.61	316
	50% (F)	177 - 207	0.97	0.78	319
	90% (F)	289.6 - 351.5	0.98	1.43	259
	FBP (F)	397 - 429	0.98	3.02	154
	E200 (F)	24.8 - 52.3	0.99	0.54	265
	E300 (F)	78 - 91	0.99	0.30	266
	API Gravity	62.1 - 74.2	0.99	0.07	320
	Benzene	0.05 - 0.51	0.98	0.008	278
	Aromatics	1 - 18.6	0.98	0.42	251
	T(V/L)	125 - 141	0.96	0.73	316
	Drivability	966 - 1136	0.99	4.62	316
	Sulfur (ppm)	2 - 16.1	0.92	1.14	187
	Olefins	10.5 - 36.5	0.95	0.91	245
	Toluene	1.4 - 6	0.99	0.12	131
Diesel	IBP (F)	312.7 - 369	0.81	3.46	316
	10% (F)	415.7 - 456.4	0.94	2.22	316
	50% (F)	486.6 - 534.1	0.99	1.23	335
	90% (F)	567.7 - 604.8	0.95	1.68	331
	FBP (F)	610.2 - 641.7	0.87	2.30	331
	Flash Point (F)	135 - 156	0.81	1.80	340
	Sulfur (ppm)	1.6 - 14.2	0.70	1.23	590
	Cetane	39 - 54	0.98	0.47	286
	API Gravity	34.1 - 38.2	0.99	0.084	354
	FAME (vol%)	0 - 5	0.99	0.05	25
	Cloud Point (C)	-13 - -8	0.80	0.69	105
	Pour Point (F)	-15 - 10	0.83	1.05	340
	CFPP Low	-38 - -14	0.90	1.94	88
	CFPP High	-16 - -2	0.70	3.93	48
	Density	828 - 853.8	0.99	0.57	109
Jet	Smoke	15.9 - 24.5	0.99	0.16	157
	Sulfur	0.001 - 0.129	0.99	0.01	99
	Aromatics	9.0 - 23.0	0.91	0.88	100
	Olefins	0.8 - 2.5	0.36	0.32	99
	Saturates	74.5 - 84.9	0.88	0.96	100
	Naphthalene	0.2 - 2.46	0.98	0.97	99
	RSH	0.228 - 3.32	0.84	0.50	98
	IBP (C)	147.4 - 167.5	0.99	1.66	107
	10% (C)	164.8 - 185.2	0.99	1.00	145
	50% (C)	205.5 - 221.4	0.99	0.70	143
	90% (C)	255.5 - 264.9	0.99	0.95	144
	FBP (C)	278.4 - 294.4	0.66	1.26	143
	Flash Point (C)	108 - 126	0.97	1.05	180
	API Gravity	39.8 - 43.3	0.99	0.05	160
	Density	818 - 833	0.99	0.36	109
	Viscosity	5.002 - 6.004	0.99	0.02	98
	Freeze Point (C)	(-52.8) - (-38.4)	0.95	1.27	181

Summary:

HORIBA's Process Raman analyzer is tailored specifically for refining applications where process control and monitoring are required. The PI-200-I Raman Analyzer, equipped with an 18-Channel Multiplex, is designed to replace several process analyzers by actively monitoring and reporting on a diverse number of components in up to 17 process streams. With over 165 field installations overseeing more than 465 process streams globally, this analyzer does not require complex sample conditioning setups, therefore reducing capital planning and operational costs. It excels at detecting and quantifying trace amounts of critical components within the process streams. HORIBA specializes in providing solutions to streamline and optimize production, leveraging our Raman and analytical expertise to guarantee long term results.

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