FT-NIR PROCESS SPECTROMETER

MATRIX-F II

Keeping an eye on your process

Innovation with Integrity

Check important process parameters immediately for reaction monitoring and control

Optical spectroscopy is today a highly important technology for online process monitoring and optimization. Fiber-coupled probes allow a direct look into the process without time delay.

The MATRIX-F II FT-NIR spectrometer allows direct measurements in process reactors and pipelines, leading to a better understanding and control of the process. Its innovative technology provides consistent high quality results, less downtime and direct method transfer. All Bruker process spectrometers are characterized by robustness, long-term stability, and low maintenance costs.

Thousands of installations in the chemical, petrochemical and polymer industry as well as in pharmaceutical production processes and in the field of food and feed manufacturing prove our experience.

FT-NIR Process Monitoring

Today many manufacturers are striving not only to produce the highest quality final product but also to improve manufacturing efficiency by shifting the final quality analysis from the laboratory to the production plants.

By gaining tighter control over the manufacturing process, it is possible to optimize the use of materials and reduce or eliminate the production of off-specification batches, thus saving reprocessing or disposal costs.

The key advantages of using the MATRIX-F II FT-NIR spectrometers online are:

- Accurate in-line results in seconds
- Non-destructive, multi-component analysis
- Optional built-in 6-port multiplexer
- Direct method transfer
- Rugged, low maintenance design
- 10 years warranty on moving parts of the interferometer and solid state laser
- Available for Ex hazardous areas
- Ethernet connectivity and industry standard communication protocols

Fiber Optics Advantage

The advantages of real time, on-line FT-NIR analysis have been well established. However, conventional spectrometers can only be installed close to the process that they are monitoring, which often means exposing the analyzer to a hostile environment. This can include drastic temperature changes, high humidity and exposure to dust and dirt. Furthermore, the point of measurement is sometimes positioned in hard-to-access and often Ex hazardous areas.

By utilizing fiber optic technology, the MATRIX-F II can be placed several hundred meters away from the actual measurement point, e.g. in an air conditioned room if the local conditions require. This will further optimize the performance of the spectrometer, since extreme temperature changes are eliminated. Moreover, the MATRIX-F II is protected from excessive dirt and dust.

Bruker offers complete solutions for various online analysis tasks depending on the customer needs.

The MATRIX-F II FT-NIR spectrometer can adapt up to 6 fiber optic probes or contactless sensor heads

MATRIX-F II Series

One Spectrometer - Multiple Options

The MATRIX-F II is the only FT-NIR spectrometer which can measure material in contact as well as contactless with just one instrument. Different measurement accessories are available:

- Fiber Optic Probes:
  Classic diffuse reflectance, transflectance or transmission immersion probes with various path lengths can be adapted as well as process flow cells or pilot plant assemblies. Various probe materials are available, like stainless steel or Hastelloy. Moreover, the probe can be customized to different lengths and flange geometries.
- Sensor Heads for Contactless Measurements:
  The fiber optic NIR illumination and detection head contains tungsten sources which illuminate the sample. The scattered light is collected and guided via a fiber optic cable to the spectrometer. This way, a contactless measurement can be performed remotely, opening a whole array of new applications.

The standard version of the MATRIX-F II can adapt a variety of different fiber optic probes and is widely used for the online process monitoring inside reactors, pipes or bypasses. It offers fiber optic connections for the adaption of up to six flow cells or probes for the measurement of liquids and solids in contact.

For contactless measurements, Bruker designed the MATRIX-F II emission. It utilizes the fiber-coupled sensor head for measuring solid samples e.g. over a conveyor belt or through a viewing glass inside a process.

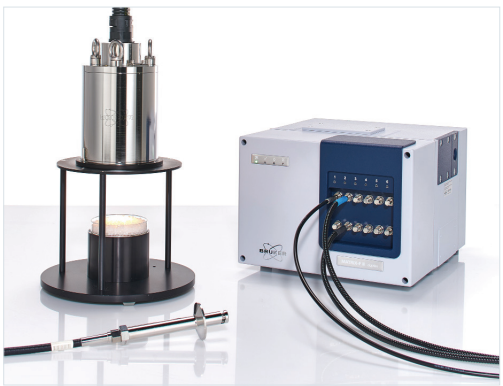
The MATRIX-F II duplex is a combination of the MATRIX-F II and the MATRIX-F II emission. The light path can be switched between an internal or external NIR source which provides the customer with full flexibility. With these two options the MATRIX-F II duplex is the only NIR spectrometer on the market offering the possibility to measure in contact and contactless with only one device.

Smart Analyzer ready for Industry 4.0

With the optional integrated PC and built-in communication modules the MATRIX-F II comes as a smart analyzer, reducing installation efforts and enabling a robust and modern 24/7 process monitoring. Together with the CMET software solution, the MATRIX-F II can provide many additional device parameters for condition monitoring, via its IoT (Internet of Things) interface.

MATRIX-F II: classical FT-NIR spectrometer with fiber optic coupling for the use of flow cells and immersion probes (for solids and liquids)

MATRIX-F II emission: special version of the MATRIX-F II spectrometer for the use of fiber-coupled sensor heads for the contactless measurements only



MATRIX-F II duplex: extension of the classical MATRIX-F II FT-NIR spectrometer for the simultaneous use of fiber optic probes and fiber-coupled sensor heads

Accessories

Immersion Probes

Immersion probes are most widely used for FT-NIR measurements in process control. Bruker will assist to select the appropriate probe with the best materials matching the process conditions. In many cases the plant or reactor will already be equipped standard connection ports for immersion probes.

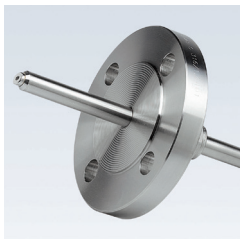
Immersion probes can be divided into three groups based on the measuring principle:

- Transmission probes for clear liquids
- Reflection probes for solid materials
- Transflection probes for suspensions or emulsions

Different types of fiber optic cables are available. Standard transmission probes use mono fibers, whereas transflectance and reflectance probes usually utilize fiber bundles to guide the light from and to the spectrometer.

Fiber optic probes are produced with the highest accuracy in terms of reproducible light transfer and exact path length. Calibration models built on a certain type of probe can be transferred without any manipulation of the data to systems using the same type of probes.

Transmission probes with optional flange adaption for measuring transparent liquids (photo: Hellma Analytics)



Diffuse reflectance probe for measuring solids, slurries and opaque liquids in diffuse reflection (photo: Solvias AG)

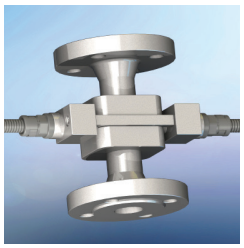
Flow Cells

Besides immersion probes, flow cells are widely used in process control. They can be implemented directly into a pipe or a bypass, allowing the sample to flow through the cell. The cells vary in size and can be applied to different pipe diameters. Flow cells are merely available for transmission measurements: a fiber optic cable transfers the light beam from the source to the sample. The light penetrates the sample, is collected a collimator and finally guided back to the detector via an opposite fiber optical cable.

The fiber optic cables are normally kept in a fixed position using brackets. Therefore, it is possible to remount the cell with high precision, after exchanging or cleaning optical components, allowing the calibration transfer from one measurement point to another.

Bruker offers a variety of flow cells specified to the customer needs.

Transflection probe for the measurement of scattering liquids, e.g. reactions in fermenters, measurement of slurries or emulsions, e.g. all variations of milk and cream

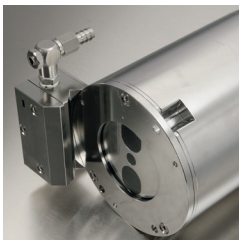


Flow cell for the implementation in a pipe system or bypass (photo: Solvias AG)

Sensor head is placed on the laboratory mount for offline measurements

Connecting the sensor head to a viewing window of a reactor

Flexible connection of the sensor head with rubber gaiter and viewing window installed, to keep the measurement area clean from dust and dirt



An optional air blower prevents fouling of the measurement window, e.g. by the electrostatic attraction of dust

Sensor Heads for non-contact Analysis

The NIR sensor head was designed by Bruker for contactless measurements of moving solid materials in diffuse reflection mode. Compared to conventional reflection probes the Sensor Head offers some unique advantages:

- Two NIR light sources illuminate a sampling spot of approx. 10 mm in diameter - over 10 times more than a conventional diffuse reflection probe.
- For enhanced process safety, the sensor head can be operated in single source mode. In case of source failure, the second source is automatically activated for continuous process measurement.
- Monofibers are used to transmit the light back to the spectrometer, compared to cost-expensive fiber bundles for conventional reflectance probes.
- A reference standard is integrated for automatic background measurements without the need to demount the sensor during the process, in contrast to most solid probes.

The large sampling area reduces the effect of variable particles sizes making it ideal for the measurement of heterogeneous materials like food and feed constituents, polymer pellets or slurries.

The sensor head can simply be placed in front of pre-existing viewing windows in pipelines or reactors or can be attached directly via a number of specifically designed weld-in adapter flanges. It can also be mounted over conveyor belts to measure moving materials.

With the internal optical multiplexer of the MATRIX-F II, up to 6 sensor heads can be controlled by a single spectrometer. This is reducing the investment per measurement position drastically, allowing the precision of FT-NIR spectroscopy while costs are in the range of less advanced grating or filter technology.

Maximum Utility

Bruker developed various accessories, to facilitate an installation of the sensor heads in most demanding environments.

- A vortex cooling device is available for those areas, where elevated temperatures up to 75°C can occur.
- For dust-prone areas, an optional air jet assembly prevents fouling of the measurement window.
- A flexible connection, using a rubber gaiter allows the installation to vibrating machinery, like sifters.

Moreover, customizable adaptions to viewing windows or pipelines are available on request.

Process Analyzer Cabinets

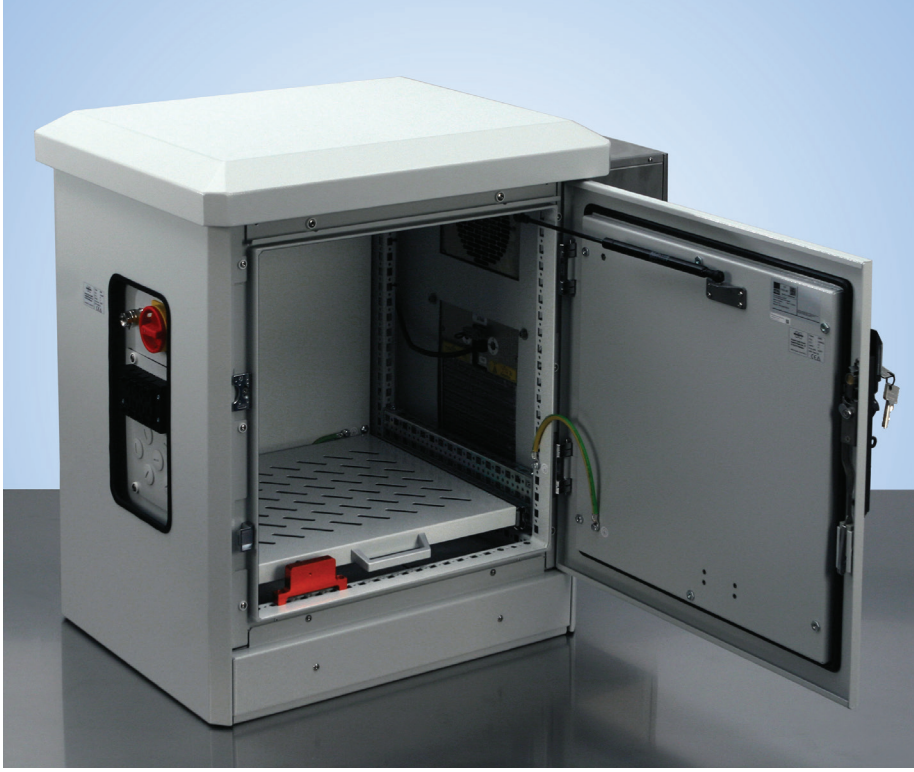
The MATRIX-F II and its peripherals like the industrial PC are designed to fit easily into standard 19" rack, making it ideal for the use in process analyzer cabinets.

These cabinets are recommended for the following situations:

- Occurrence of temperature fluctuations
- Access to the spectrometer needs to be restricted
- Environment with high humidity

Air conditioned cabinets maintain a constant temperature and humidity inside hence guaranteeing a stable measurement even if the outside conditions are fluctuating.

Bruker offers cabinets in two different sizes. The large cabinet provides enough room for the MATRIX-F II as well as for the external 6-port multiplexer and an industrial PC with TFT-display. The smaller size is designed for confined spaces and houses a single MATRIX-F II.



Small version of the 19" Process Analyzer Cabinet for the MATRIX-F II spectrometer

Multiplexer

The MATRIX-F II spectrometers are available with 1- or 6-channel internal multiplexer. With only one spectrometer a maximum of 6 measurement points can be monitored thereby reducing the investment costs. The fiber optic probes are connected to the spectrometer using standard SMA connectors.

Internal 6-port muiltiplexer: the operating measurement channel is indicated with a blue LED

Large 19" Process Analyzer Cabinet equipped with an air conditioning system on top and an industrial PC including TFT-display

Solutions for Ex Zones

The MATRIX-F II is certified to guide light into in hazardous areas:

- Ex II(1) G [Ex op is IIC T4 Ga]
- Ex II(1) D [Ex op is IIC Da]

Depending which part of the entire system has to be placed in the hazardous location, the retrofitting can include the following changes:

- Data transfer via optical conduits in hazardous locations
- Internal compartments of the spectrometers are purged and pressurized with dry air or N_2
- All surface materials (light fibers, power cable etc.) have to comply with the Ex requirements regarding electrostatic discharges

MATRIX-F EX

The MATRIX-F is also available as an ex-proof, ATEX certified version, complying to the following standard:

- II 2(1) G Ex pxb [op is T4 Ga] IIC T6 Gb

MATRIX-F EX with pressurized housing for direct placement in Ex zones

Sensor head for non-contact analysis in Ex zones

In combination with a MATRIX-F II, the sensor head is also available as an ex-proof version (ATEX/IECEx and AEx). It complies with the following standards:

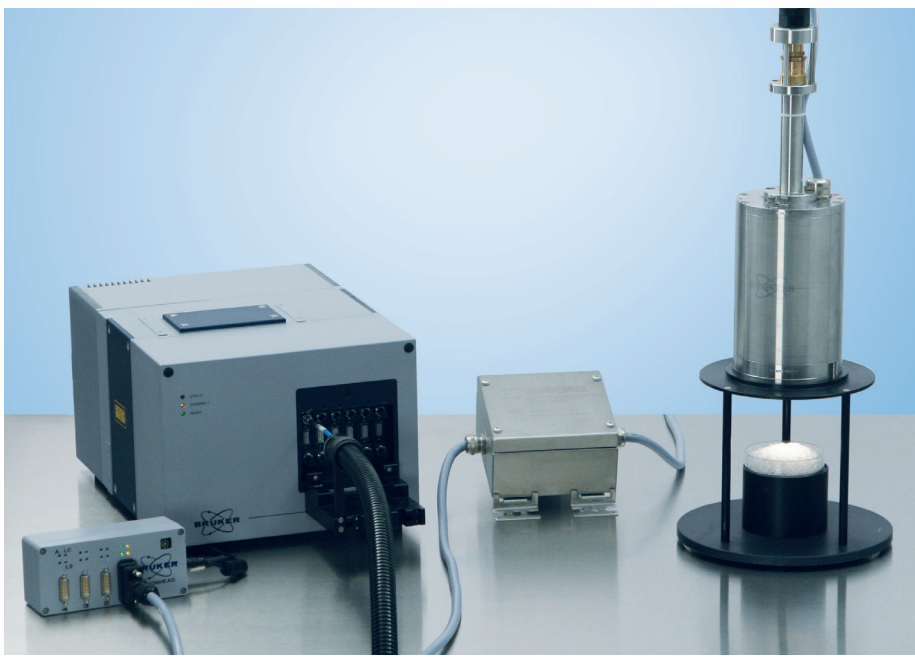
ATEX:

- II 2(1) G Ex d [op is T6 Ga] IIC T6 Gb
- II 2(1) D Ex tb [op is T85°C Da] IIC T85°C Db

UL certification:

- Class I, Zone 1, AEx d [op is T6] IIC T6
- Zone 21, AEx tb [op is T85°C] IIIC T85°C

With our Ex certified systems, Bruker offers a customer-tailored solution for your specific needs in hazardous environments.



Ex-proof sensor head connected to a standard MATRIX-F spectrometer

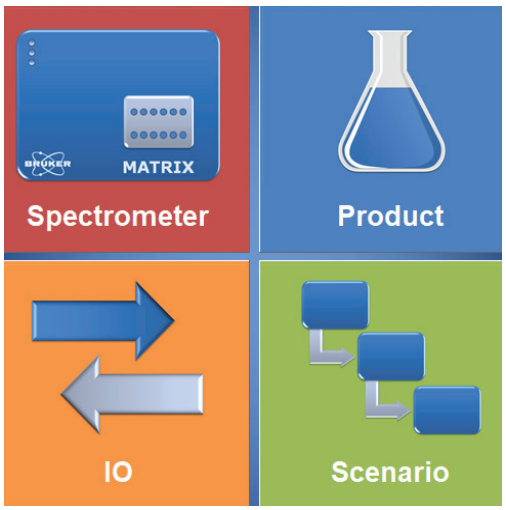
CMET Process Software

The CMET Process Software is the link between Bruker's outstanding FT-NIR process analyzer and the customers Distributed Control System (DCS). Commands given by the DCS are transferred to CMET which in return starts a specific measurement and transmits the data back to the DCS for visualization and archiving.

The increasing demand of automation requires not only a state-of-the-art hardware but also an equivalent software. CMET consists of a configuration interface and a runtime environment, which can also be installed on separate PC's.

Key Features

- Easy-to-use Modular Concept
- Standalone Configurator and Runtime Environment
- Watchdog Signal
- Automatic Start as Application or Service
- Supports the most common communication protocols
- OPC Client and Server Functionality
- Different Trigger Modes
- Customizable Logfiles
- Webserver based Trendcharts
- Online BIAS and Slope/Offset correction



CMET Configurator – setup options divided into four groups

CMET Configurator

The interface with its modular concept incorporates all the necessary functionalities to setup a scenario for different applications like simple continuous measurements up to very complex batch processes with permanently changing products (recipes). By using external triggers the DCS has full control over the instrument.

- **Spectrometer Setup**

Define general measurement points and their measurement parameters

- **Product Setup**

Create Products, adjust specific measurement parameters and add calibration models. Customize storing options and define additional product input variables (e.g. Batch IDs).

- **I/O Setup**

Setup the different communication protocols (simultaneous usage of different protocols possible).

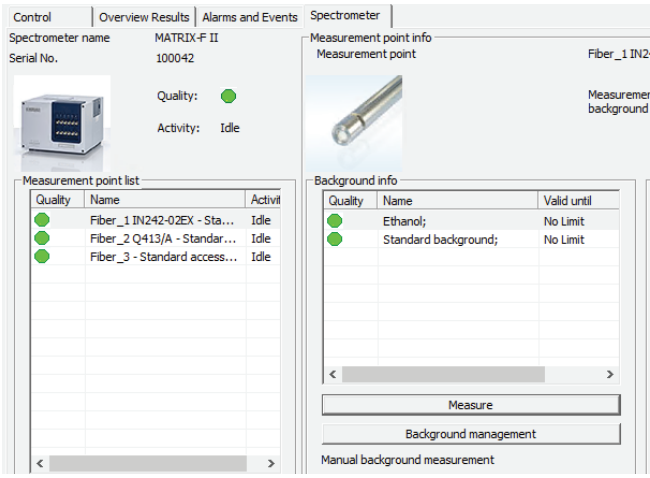
- **Scenario Setup**

Assign a product to a specific measurement point and define start triggers and output signals.

CMET Runtime

The Runtime environment is used for two major tasks:

- Background measurement & management
- Continuous measurement and process monitoring



CMET Runtime – user interface for easy management of complex scenarios

Runtime can be easily configured to load and automatically start a specific scenario which comes in handy during a power failure. CMET provides besides the quantitative and qualitative results a series of signals, e. g. which measurement is currently running, chemometric alarm or the actual light intensity at the measuring point.

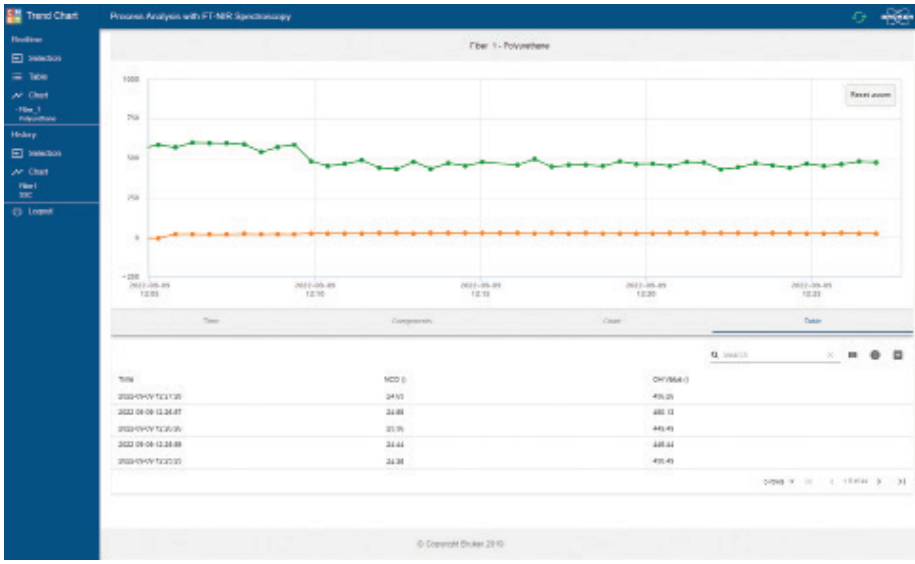
Runtime Service

In addition to the auto start, CMET Runtime can be started as Windows Service to ensure full functionality without a user login. This is especially helpful for server installations, where a login is not intended.

CMET Trend Chart

To monitor the most recent data, CMET Runtime is equipped with a web based (including network access) trend chart.

- **Real Time Section**
  Monitor the current measurement results using self-updating trend charts for each product.
- **History Section**
  Brows your database stored result history.



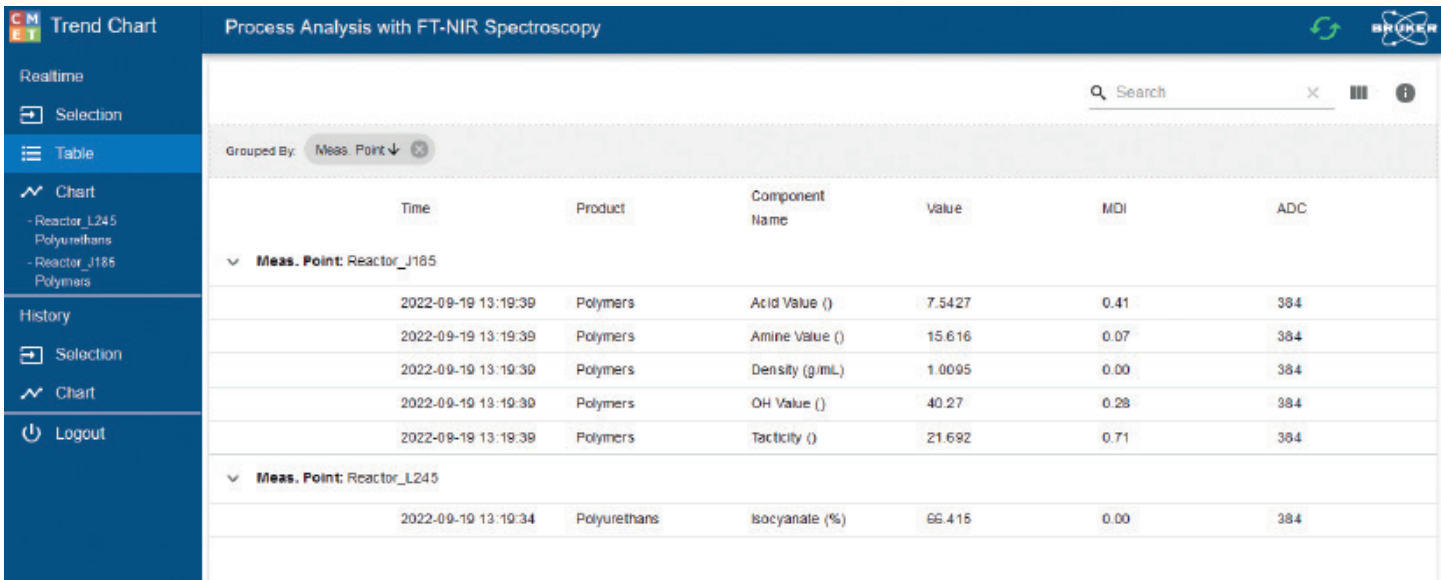
CMET Trend Chart – monitor measurement results in a trend or table view

Communication Protocols

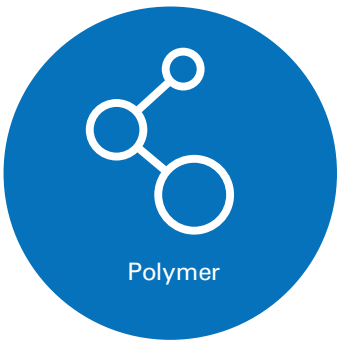
CMET supports various communication protocols, the following are offered by Bruker:

- **OPC DA**
  - Client and Server functionality
- **Analog Communication (4 – 20 mA)**
  - ADAM Units
  - Analog Cards (PCI slot required)
- **Fieldbus (PCIe Cards)**
  - Profibus DP (Connection: RS485)
- **Fieldbus (Software Solution)**
  - Ethernet TCP/IP (e.g. Modbus TCP, Allen-Bradley, Siements Industrial Ethernet)
- **Fieldbus (External Modules)**
  - Modbus RTU or TCP (Connection: RS485, RS232 or RJ45)
  - Profibus (Connection: RS485)
  - ProfiNET (Connection: RJ45)
- **Fieldbus (On-Board Solution, MATRIX-F II only)**
  - Modbus (Connection: RS485, RS232, Ethernet TCP/IP)

CMET Trend Chart – display of the Real Time Table showing the latest results of all measuring points



Applications: Chemical, Polymer & Pharma



Process analytical technology (PAT) aims at controlling the manufacturing process to ensure a reliable quality of the final product. The need for shifting the quality control from the end product to the production has been recognized by the chemical, petrochemical and pharmaceutical industry alike. This is achieved by real-time analysis of raw materials, intermediates and final products by FT-NIR spectroscopy.

Example: Chemical Industry

FT-NIR technology is widely used in a variety of chemical industries. The high information content in NIR spectra, measured in only a few seconds, allows the simultaneous analysis of many different components and system parameters with high precision.

Typical examples are monitoring the synthesis of basic chemicals, distillation and rectification processes as well as the end-point determination of chemical reactions.

Example: Semiconductor Production

In today's challenging environment and high demand of semiconductors, optimizing the production process and keeping out of spec production at a minimum is imperative to stay competitive.

NIR in combination with multivariate analysis is a perfect inline tool for various production steps of semiconductors to reach this goal. Typical semiconductor production steps where FT-NIR can be used are cleaning, etching, photoresist development as well as photoresist stripping.

Example: Polymer Industry

Typical parameters measured during the production process of polymers are density, Melt Flow Index, OH-number or free monomer content. FT-NIR spectroscopy can monitor the production of polymers such as polyethylene at the crucial processing steps.

The current status of the polymerization can be determined as well as the product quality before and after the extrusion. Another typical example is the online analysis of rubber for vinyl- and styrene content.

Example: Petroleum Refining Processes

Refining gasoline from petroleum is another complex process where FT-NIR can be applied to optimize and control the different processing steps. The first key stage is the fractional distillation of the crude oil yielding the raw products light and heavy naphtha and diesel which are analyzed by FT-NIR.

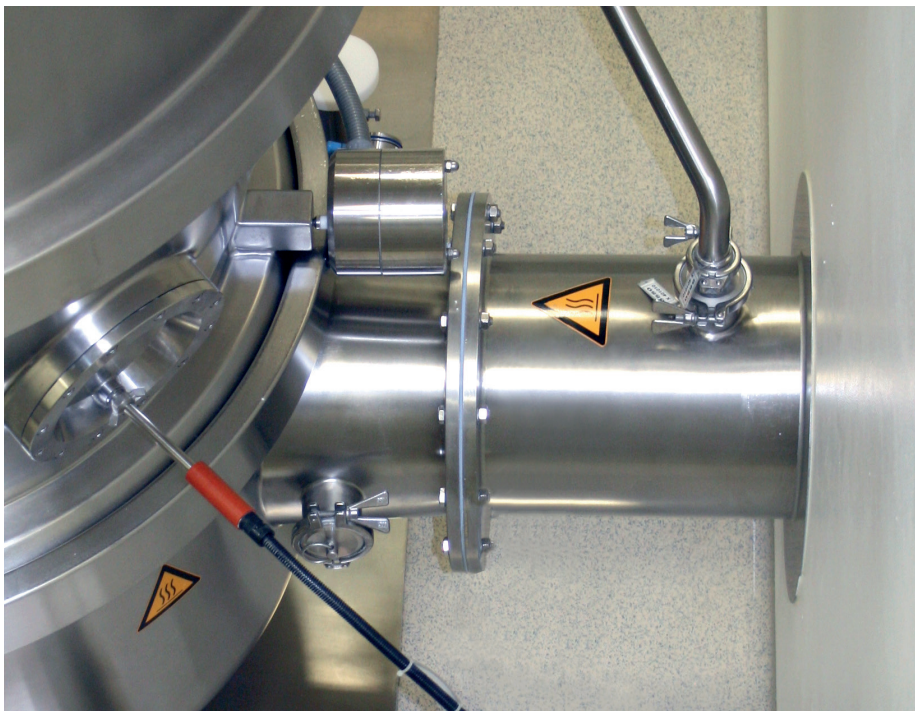
The final gasoline contains several additives for optimal performance. Typical quality parameters monitored by FT-NIR are the research

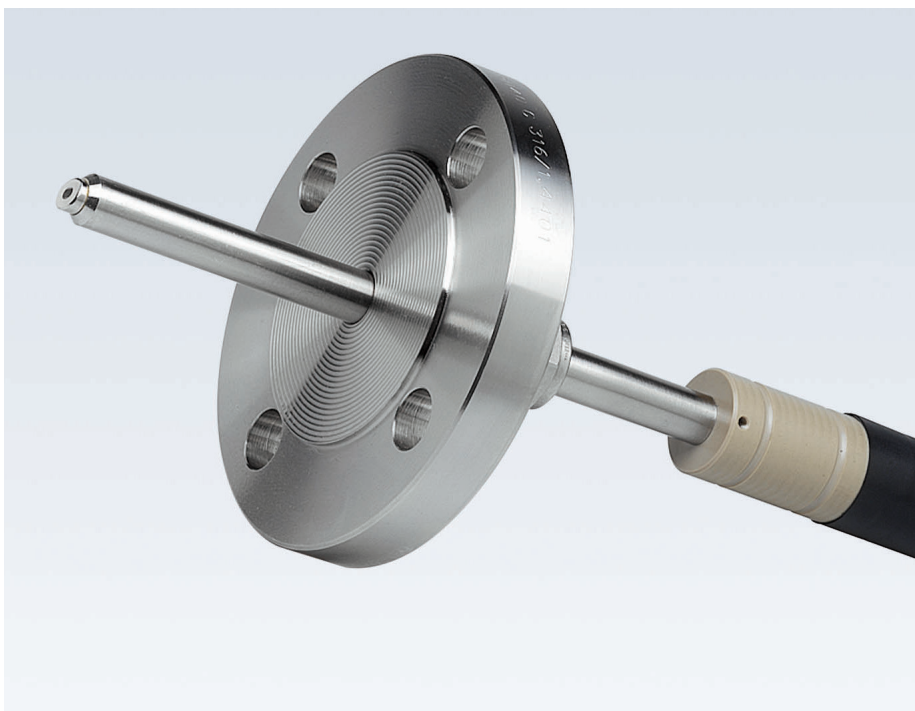
or motor octane number (RON and MON) and density as well as the analysis of PIONA. Moreover, FT-NIR is widely used for monitoring gasoline and diesel blending processes.

Example: Pharmaceutical Tablet Production

The production of tablets in the pharmaceutical industry involves mixing, granulation, drying, compression and coating. These different processing steps can be monitored online with a MATRIX-F II in combination with a diffuse reflectance probe or a sensor head to ensure the product safety and minimize the risk of faulty batches.

Fluid-bed reactor with process probe measuring in reflection mode





Example of a reflection probe (photo: Solvias AG)

Applications: Agriculture, Food & Feed

In the agri, food and feed industry there has been a rapid adaption of near infrared spectroscopy for laboratory use from the first commercially available NIR grain analyzers in the early 1970s to today's modern FT-NIR spectrometers. However, most food production facilities still use univariate sensors like temperature, flow rate, pH etc. to monitor the process. These parameters are nonetheless often not relevant for assessing the food quality.

FT-NIR spectrometers are able to provide information about identity, conformity and quantitative chemical composition of the material at the various production stages. Especially the main constituents of interest, such as fat, protein and moisture or total solids can be analyzed simultaneously, a huge cost benefit compared to conventional analyses.

Typical application areas for FT-NIR analysis are:

- Feed and Feed Ingredients
- Oilseeds and Cereals
- Edible Oils and Frying Fats
- Dairy Production
- Biofuels
- Sugar Cane and Beets

Example: Milk Powder Production

A key process in the milk powder production is the spray drying step, which has characteristically a high energy consumption. By installing FT-NIR sensors e.g. in the storage tanks, the inline feed of the spray dryer as well as at the powder outlet of the fluid bed dryer, the moisture content can be monitored and continuously tracked. This will lead to a better controlled drying efficiency in respect to the target value of the moisture content, reducing not only the energy consumption, but also leading to less down time, fewer out-of-spec batches and in an increased overall productivity of the process.

Example: Oil Seed Processing

Depending on the oil type, the seeds/fruits are either cold-pressed or heat-treated before applying mechanical or solvent extraction procedures. Monitoring moisture and oil levels of the material going into extraction as well as of the expeller cakes after pressing by online FT-NIR enables a quick and reliable indication of the efficiency of the process.

The extracted crude oil can then directly be analyzed for parameters like free fatty acids, phospholipids or waxes to find the optimal conditions for the following refining process. This will avoid costly rework of out-of-spec production batches.

Sensor head mounted over a conveyor belt for the continuous analysis of soybean meal

Example: Screening of Frying Oil

Frying fats and oils, used continuously and repeatedly at high temperatures, are subject to a series of degradation processes. Increasing amounts of free fatty acids, total polar components, and polymerized triacylglycerols indicate oil degradation leading to a deterioration of the sensory quality and to potential health issues.

Monitoring the frying process online with FT-NIR spectroscopy is today an estabilshed method to assess the quality of deep-frying oil. It helps to optimise the time of discarding the frying fat, thus running the lines economically, while ensuring consumer safety.

Example: Monitoring of Butter Production

From an economic point of view, it is crucial to keep the water content as closely as possible to the statutory limit of 16 %, as water is of course much cheaper than the butter fat. To monitor the moisture as well as salt content with FT-NIR spectroscopy, a reflection probe or sensor head can be built into the butter stream using a standard flange.

Taking the high throughput and 24/7 operation into account, the return on investment of FT-NIR technology is normally reached within months.

Sensor head for contactless measurements

Quality to rely on

Today´s regulated environments must comply with extensive regulatory requirements. Bruker offers comprehensive system validation options to provide the documentation and procedures to achieve systematic and cost-effective compliance with current regulations.

Qualified hardware

Bruker's FT-NIR spectrometers are equipped with an automated filter wheel which houses standard materials and filters for testing instrument performance. Included in the OPUS software is OVP (Optics Validation Program), an instrument test program which executes a series of performance tests using the standards in the filter wheel. This program evaluates the instrument performance and determines if the spectrometer is operating within specifications.

In addition, Bruker's Validation Program provides the user with a complete package of qualification routines that meet the demands of qualification such as USP and Ph.Eur. OPUS allows a customized setup to satisfy your individual qualification requirements and the status is always indicated to the user.

Full GMP and 21 CFR Part 11 compliance

OPUS spectroscopy software comes equipped with the necessary routines to assist laboratories that must conform to GMP standards. Extensive user management with multiple security levels, non-editable data files and complete audit trails are some of the many features of this comprehensive spectroscopy software. OPUS fully supports the demands of the 21 CFR Part 11 regulation (Electronic Records, Electronic Signatures) issued by the FDA.

Process software solutions

All Bruker Optics' software product for the process industry, including the OPUS (OPtics User Software) as well as CMET and the Reaction Monitoring software are fully validated to reliably meet the requirements for their intended use.

Certification

Bruker Optics' products and services meet all quality standards, such as the ISO 9001 and ISO 13485, successfully audited by several pharmaceutical corporations and regarded as a fully approved hardware and software supplier.

Each customer receives a full set of certificates for the instruments and accessories.

Caring for the environment

Demonstrating Bruker's ecological and environmental commitment to our customers and clients, we also achieved the certification for ISO 14001.

Moreover, our constant striving for reducing our energy use, and therefore our greenhouse gas emissions, were rewarded with an ISO 50001 certification for achieving continual improvement of energy performance, including energy efficiency, energy security, energy use and consumption.

Your Partner for Success

Bruker understands that customer support means more than just installing, maintaining and fixing equipment. It is a commitment to our customers to provide detailed, expert knowledge and understanding of each and every aspect of our systems. We are in the business of not just selling analytical instruments, but implementing and supporting complete application solutions. From configuring, demonstrating and installing the best instrument for your needs, to training your users and providing ongoing support, we strive for the utmost customer satisfaction in everything we do.

Our instruments are designed to provide years of dependable trouble-free operation, but should a problem occur, a network of Bruker companies and representatives throughout the world are ready to promptly respond to your needs. Professional installations and high standard of post-delivery services are our commitments to our customers. Service is available either on a time & material basis or one of our service contract offerings.

On-Site Visits

In the event that we are unable to remotely diagnose a problem, or when you simply need immediate response, our field engineers around the world will give you access to fast, local support. We also realize that time is money. Our timely service escalation process lets you rest easy knowing that Bruker will be there on-site when you need us.

Preventive Maintenance

To minimize unplanned downtime, reduce costs and control risk, planned maintenance is still the number one option. During planned maintenance visits, our factory-trained engineers will completely review your system's installation, allignment, and cleanliness, and verify that its performance meets specification. They follow a detailed maintenance checklist to ensure that your system is operating correctly and safely.

Contract Services

Bruker provides a wide array of contracts to meet your specific needs. We are open to customizing a contract for a specific situation and will work to find a way to meet your unique needs. The strength of the Bruker Contract is that, while helping to control the cost of ownership, we deliver significant value and truly meet the spirit of a partnership to maximize uptime. Contracts typically include Preventive Maintenance and deliver superior on-site response to your operation.

Bruker's FT-NIR Product Range

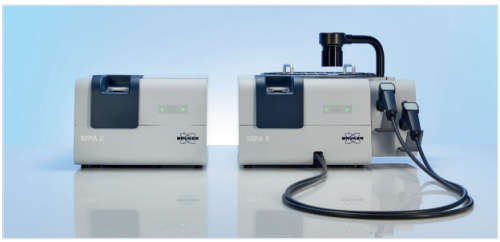
FT-NIR offers a practical alternative to the time-consuming, wet chemical methods and chromatographic techniques.It is non-destructive, requiring no sample preparation or hazardous chemicals, making it quick and reliable for quantitative and qualitative analysis.

It is ideal for rapid raw material identification and is also a powerful analysis tool capable of accurate multi-component quantitative analysis. Its online capabilities based on fibre optic probe technologies allow a deep look into the process.

Bruker's FT-NIR product line includes TANGO and MPA II spectrometers for lab and at-line applications as well as the MATRIX-F II series for process control:

TANGO

Faster, simpler, more secure – with TANGO your NIR analysis speeds up. TANGO has exactly what users require of an FT-NIR spectrometer suitable for industrial use: robustness, high precision and straightfor-ward operator guidance.



MPA II

Choosing the best possible sampling method is crucial when solving a specific analysis task. With the MPA II, you have a complete solution at hand for your daily QA/QC work, but also for sophisticated method development studies.

MATRIX-F II

The MATRIX-F II FT-NIR spectrometer allows the direct measurement in process reactors, pipelines or over conveyor belts – in contact or contact-less. This will help to gain a better understanding and control of the process.

Laser class 1 product.
Technologies used are protected by one or more of the following patents:
US 7034944; US 5923422; DE 19704598

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