OptoFluidic

Real-time optical analysis

Information on the move

Optical analysis in the rainbow: sunlight in spectral colours

The lotus leaf: water droplets act as optical lenses

Optofluidics is a relatively new interdisciplinary technology that combines optics and fluidics. It extends to both the realisation of optical effects and components and the analysis of fluids in motion. Fluids comprise liquids and gases, but also bulk solid materials that flow through pipelines and their fittings.

Optics analyses fluidics
This technology furnishes diagnostic and analytical methods in which certain characteristics, constituents or parameters of fluids in motion such as density, volume, colour, or content of noxious substances are detected and evaluated. For this purpose, the fluid is charged with information that can be subsequently read by optical components. The fluid thus becomes a medium that carries in itself the code for optical analysis. Devices such as cameras and sensors visualize the diagnosis in real time, without the process flow having to be interrupted. In future, optofluidic analysis methods could replace time-consuming sampling and stabilize process flow, while reducing the number of components required and maintenance costs.

Learning from nature
Optofluidic phenomena can be observed in nature: a rainbow is formed when the sun's rays strike raindrops. Here, the sunlight is refracted by the almost spherical water droplets and is separated into its spectral colour components. The sun's rays are analysed by means of the raindrops and become visible as a colourful rainbow. This optical analysis demonstrates that solar radiation is composed of the colours of the spectrum. Conversely, the sun's rays analyse each drop of rain in real time. They present the result in the visual form of a rainbow.

Nature demonstrates with the lotus leaf how fluids realise optics. The leaf's hydrophobic outer layer not only repels water drops, but also shapes them. The drops assume a hemispherical form, and when they are struck perpendicularly by a beam of light, they act as a lens. By modifying the size of the water drops and choosing an appropriate hydrophobic surface, it is possible to generate water drops of a specific shape and thus produce a variety of different lenses.

In the Bionic Learning Network – an alliance with renowned universities, institutes and development companies – Festo is investigating how these principles from nature can be applied to industrial automation processes.

OptoFluidic: demonstration of optical analysis and separation processes

Festo OptoFluidic
To demonstrate processes in the field of optofluidics, Festo has developed OptoFluidic, a bionic test medium. For this purpose, Festo is benefiting from its broad range of optical technology components such as cameras, sensors, LEDs, lasers and photodiodes. These are combined with fluid engineering devices such as valves, pumps and mixers which control the flow of the media.

An intelligent liquid
A transparent liquid is metered into a blue fluid by means of a valve. The two immiscible fluids flow through the lines of the display. The blue liquid is the intelligent medium that conveys the information required for optical diagnosis. Possible steps in optofluidic analysis and separation are demonstrated in the following three stations:

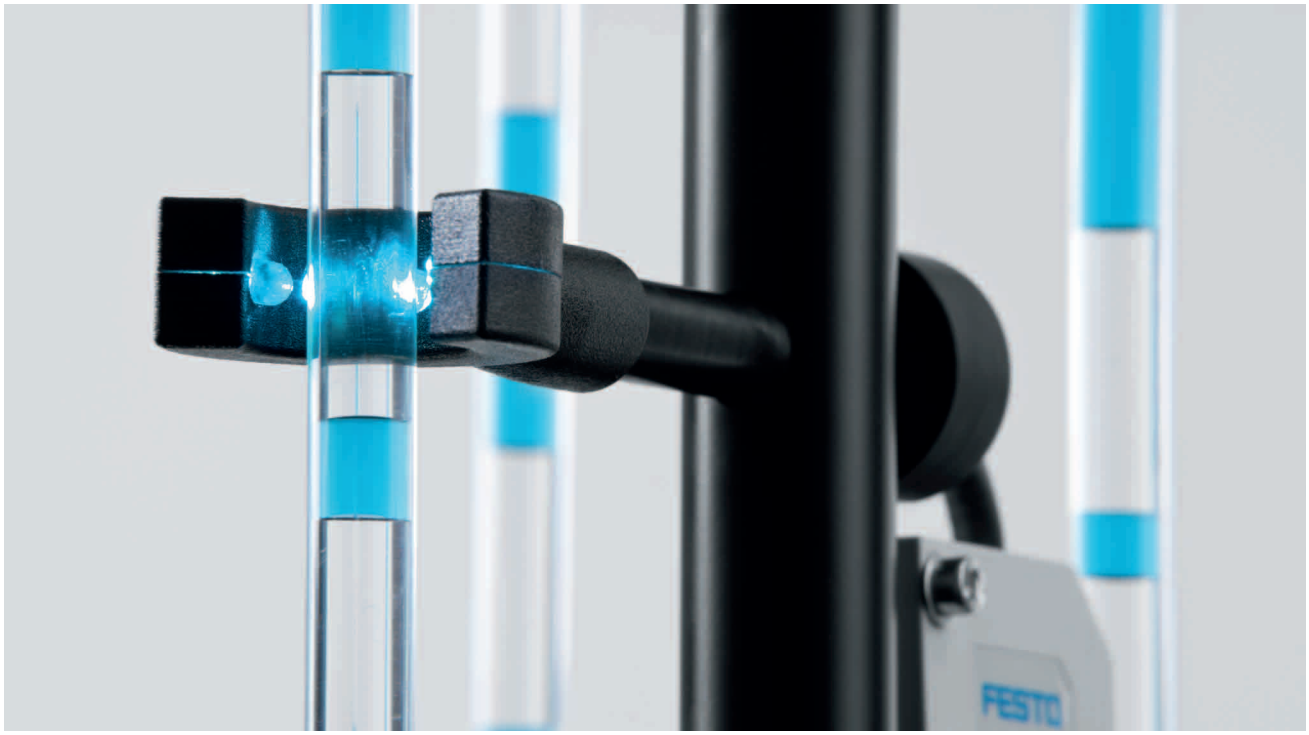
Real-time optical analysis
The first station incorporates an optical sensor SOEC and a compact camera SBOC, which analyse the fluid in real time in terms of its composition and characteristics and evaluates parameters such as the transparent drop's volume. For this the in-house developed Software CheckKon and CheckOpti is used. A monitor connected to the camera system displays the collected data and allows continuous real-time monitoring of the processes.

Solenoid valve, type VODA: precise metering and separation of fluids

Compact camera, type SBOC: real-time analysis with no interruption to the process

Colour sensor, type SOEC: sharp colour detection of different media in motion

Front end controller, type CPX-CEC-C1: control of the overall application

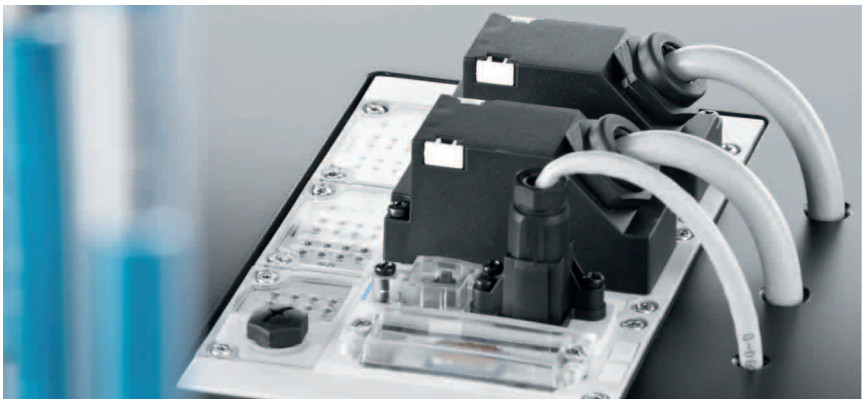


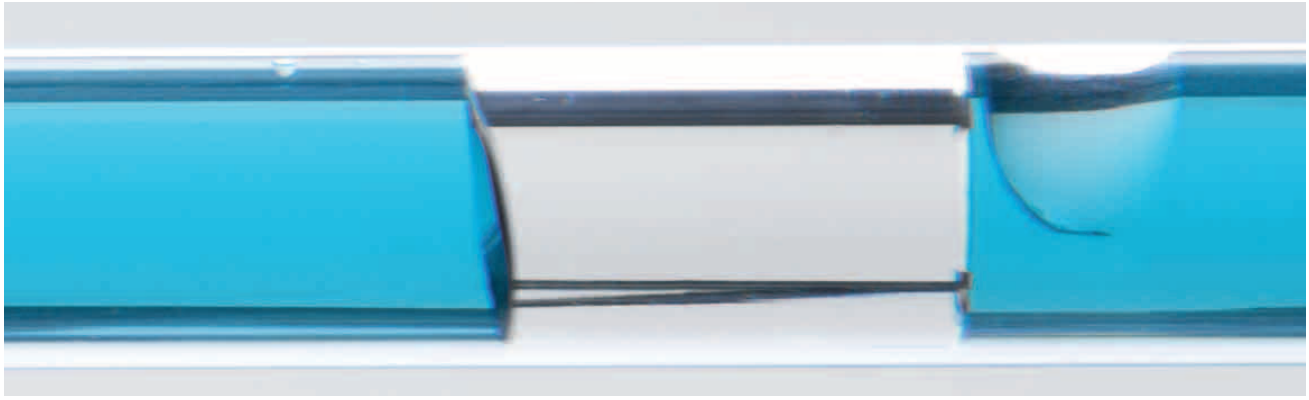
An intelligent medium: the fluid carries its own information for optical analysis

Visualisation of hidden information
At the second station, a blue LED with a wavelength of 490 nm renders a previously implemented fluorescent dye visible. This process shows how optofluidics can allow certain desired parameters and information to be registered and displayed in readable form by means of optical components.

Separation of different fluids
At the third station, the blue liquid is detected by an SOEC optical sensor. By means of a VODA valve, the system separates the blue medium from the transparent liquid. This separation process demonstrates how precisely process automation components from Festo can be used to analyse and control various fluids.

Control of the display
The overall application is controlled by a CPX-CEC-C1 type CoDeSys front end controller and a number of CPX I/O modules. The CoDeSys-capable compact camera is directly connected to the CPX control and communicates directly in real time via Ethernet. The colour sensors are connected to the I/O modules and thus constitute an integrated closed chain of communication and control – a solution package all from the one source.





With the flow: an efficient in-line process
OptoFluidic shows how efficiently this technology can be used for diagnosis and analysis in process automation. It constantly identifies, evaluates and controls various parameters, constituents and characteristics of a fluid in a conservative manner. The data and key figures collected are transmitted in real time with no interruption to the process. By means of real-time analysis, opto-fluidics dispenses with the time-consuming sampling of liquids and their subsequent analysis in a chromatograph or similar measuring device.

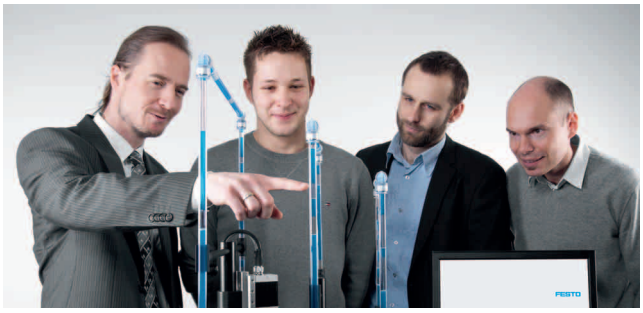
Targeted selection of components according to requirements
The optical elements and components can be used to meet the requirements at hand. The choice of targeted light sources maximises resource efficiency and reduces energy consumption. Festo already has at its disposal a wide range of image processing systems and further optical components of various designs.

Analytical methods for process automation
Optofluidic measurement techniques can play a major role in future – whenever fluids are to be automatically transported, treated, processed, purified, filled or disposed of: at sewage and power plants, breweries, in paper manufacture, at natural gas plants, in laboratory automation or in the chemical, pharmaceutical and petrochemical industries.

Possible application in the food and packaging industries or in the chemical and pharmaceutical industries

Technical data:

Length:	1080 mm
Width:	756 mm
Height:	1570 mm
Colour sensors:	2x SOEC-RT-Q50-PS-S-7L
Pressure sensors:	2x SDE3-D20-B-HQ4-2P-M8
Camera:	SBOC-Q-R3C-WB
Software:	CheckKon, CheckOpti
Solenoid valve:	4x VODA
Pump:	2x hose pumps TP 4000



Project partner

Project initiator:
Dr. Wilfried Stoll, Managing Partner,
Festo Holding GmbH

Project team:
Prof. Dr. Peter Hofmann, Prof. Dr. Dominik Rabus, Florian Zieker,
Festo AG & Co. KG

Design and construction:
Uwe Neuhoff, Simon Hanschke, Dipl.-Des. Elias Maria Knubben,
Dipl.-Ing. (FH) Markus Fischer, Matthias Gehring, Eric Ehrler,
Festo AG & Co. KG

Photos:
Thomas Baumann, Esslingen, Germany
Axel Waldecker, Murr, Germany

→ Film

Festo AG & Co. KG

Ruiter Strasse 82
73734 Esslingen
Germany
Phone +49 711 347-0
Telefax +49 711 347-21 55
cc@de.festo.com
www.festo.com/bionic

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