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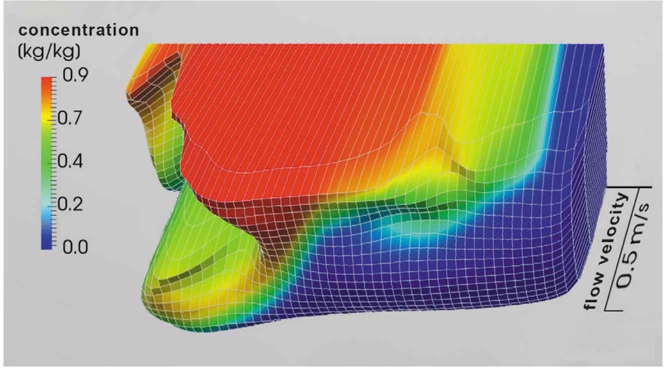
Combined Velocity and Concentration Measurement for Liquids

High resolution measurement of laminar and turbulent mixing processes

Accurate information about velocity profiles and chemical composition of liquids and liquid mixtures in ducts or along a cross-section is essential for many applications in chemical and process engineering. These process parameters are of particular interest for process control and quality management in the chemical and pharmaceutical industries as well as for research and development of new process technologies.

As a standard, velocity/flow measurements and concentration measurements are performed with separate devices resulting in two or more separate probes in the flow channel, and sensor access through various different optical windows or in-line probes are required. Because of the distance in space a direct coupling of the measurement systems is not possible, and as a consequence, precise simultaneous measurements of velocity and concentration profiles are difficult to achieve.



Simultaneous and exact measurement of velocity and concentration in a liquid

Goals

The research group „Separations Engineering and Simulation“ together with the research group “Process Analytics” at TU Wien were aiming at a solution to make a simultaneous measurement of velocity and concentration with a single probe possible. The measurement approach should require a single optical access only, and thus the space requirements for the probe should be significantly reduced.

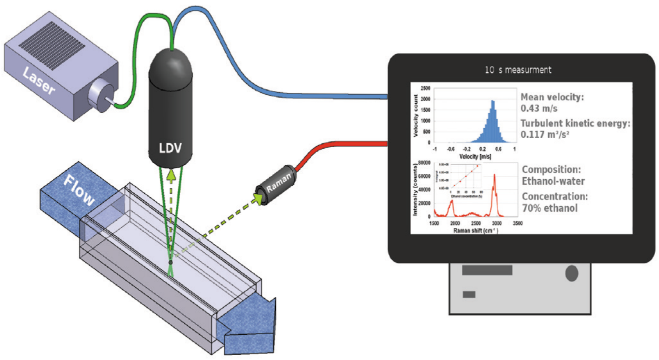
Solution

The researchers started from a suitable, high-resolution, non-invasive, physical measurement principle for each process parameter and tried to find a way to couple these techniques in order to receive signals for both velocity and chemical composition at the same time and place of the flow regime.

The selected solutions were based on well-known high resolution laser-optical methods: Laser-Doppler Velocimetry (LDV) which is a standard method for many fluid dynamic application for more than 25 years, and Raman spectroscopy which has been used very successfully for more than 15 years.

The newly developed technology requires only one laser light source for both measurements. The scattered light is collected and analyzed through a single optical pathway – if needed also separately through two optical pathways. The characteristic so-called LDV bursts are analyzed for the velocity information when a seeding particle travels through the laser focused measurement volume. At the same time, the frequency shift of the scattered light is investigated spectroscopically for Raman shifts, which precisely identify the chemical components in the fluid mixture.

With the new technology the requirements for optical access of the probe has been substantially reduced as only a single optical window is needed for the signal generation and detection. Through an integration of both techniques into a single probe the space requirements could be even further reduced. As only a single light source is needed for both measurements further cost reduction could be achieved. With these advantages a high resolution precise technology has been made available which allows many new applications in process engineering, fluid dynamics, quality management, and research labs.



Measurement principle shown with two probes

Benefits for you

- Time and space synchronized flow and concentration measurements analyzing the same fluid element through a single laser excitation
- Analysis in high temporal resolution of both mixing and concentration fluctuations
- Quality control in vessels as well as in flow lines
- Raman signals can be calibrated for any fluid combination – they can also be used for finger-printing of the flowing phase
- One optical access needed for both excitation laser and signal recording
- Non-invasive technology – fluid flow is not affected by the probe, and the flow channel remains sealed against leakage
- Large numbers of measurement positions can be reached automatically through a traversing system moving the probe with fixed focal length to the position of interest
- Applicable to gas phase measurement with high laser power
- Use in explosive environments possible as only optical access is required – the equipment can be developed to work in potentially explosive atmospheres (ATEX)
- Precise measurement and control for critical processes e.g. mixing processes, streaks (refraction anomalies), chemical reactions, segregation and phase separation

Notes

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