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Inline Monitoring of Particulate Product Flows. Concentration, Velocity & Rate Measurement in Industrial Applications

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Abstract: MSE Meili is an ETH spinoff company established in 1995 focusing on instrumentation for multiphase flows. The 'Labasys® instruments' – backscattered laser light intensities are the basis to determine solid concentrations, velocities and flow rates – have been enhanced continuously make them suitable for industrial monitoring purposes. For example, both the accuracy and the application range have been extended by a more sensitive optic, efficient cleaning units have been added to avoid soiling of the optics. Among other enhancements, a direct calibration procedure and explosion protection have been implemented. Examples showing the application of 'Labasys® instruments' in R&D and production monitoring are provided for illustration. Through an aligned palette of services, *e.g.* calibration or test measurements, MSE Meili supports their customers in the energy production, chemical and food industries to realize the large potential for cost reductions by optimizing their processes monitoring with 'Labasys® instruments'.

Keywords: Dust concentration measurement · Fiber optic measuring system · Inline process monitoring · Mass flow measurement · MSE Meili · Velocity measurement

Focus on Multiphase Flows

MSE Meili was founded in 1995 with the objective to make advanced measuring techniques for multiphase flows developed at ETH available to the process industries, in particular the chemical, energy, and food industries. Multiphase flows – especially gas/solid flows – are crucial in these industries as they *determine the efficiency* of common processes (*e.g.* spray drying or fluid catalyst cracking) and operations such as pneumatic transport, mixing, grinding, separation, *etc.* While single-phase flows like liquid or gas flows may well be described by today's modeling techniques, a reliable quantitative prediction of the complex multiphase fluid dynamics will not be attainable in the near future. A more thorough understanding of these flows would allow for *substantial optimization* steps reducing, *e.g.* raw material or energy consumption. The cost savings achieved are the *economic motivation* to use measuring techniques describing or monitoring multiphase flows.

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Academic Roots

Like many other groups world-wide, the group of Prof. Reh at ETH used fiber optic probes measuring backscattered light intensities to characterize gas/solids flows during the early 1990s. The focus of these developments were the optical configuration at the probe tip to establish an *unambiguous relation between measured signal and concentration* and the integration of all optical and electronic components in one robust instrument. With such instrumentation good results were obtained characterizing model systems such as glass beads suspended in air at moderate temperatures. The project won an award from 'Technologie-Standort Schweiz' in 1996.

Developments to Meet Industrial Demands

Under difficult industrial conditions with *e.g.* dark, abrasive or cohesive powders possibly at elevated temperatures, the results with early instruments were often unsatisfactory or measurements were not possible at all. In an enduring development effort MSE Meili addressed the key issues identified as being essential for a reliable and accurate measuring system under industrial conditions. These efforts led to the

following significant, patented improvements:

– *higher signal to noise ratio* for accurate measurements even with low backscattering, *i.e.* dark material such as *e.g.* coals
– *efficient cleaning units* with low flow and signal disturbances for moist or fine and thus cohesive products
– reliable, '1-to-1' *calibration procedure* also covering the difficult accessible dense concentration range (Fig. 1)
– *2-dimensional velocity* determination procedure for non-directed flow fields such as in spray dryers.

The developments listed above were incorporated in the measuring system *'Labasys® 100'*, which is mainly used for *industrial R&D* tasks such as characterization of flow fields in production vessels for process optimization or validation of modeling efforts. Through the *modular concept* of the 'Labasys® 100' system, the instrument can easily be adapted to the varying needs of different measuring tasks by using *e.g.* probe tips with different configurations (length, number of channels, material, cleaning unit, flexible probe tip, *etc.*).

Fig. 2 shows exemplary data measured with the 'Labasys® 100' instrument during the 'blast-in' of 10 kg of maize starch pressurized at 20 bar into a 10 m^3 vessel. The results show the quick rise and decrease of concentration, velocity and RMS turbulence of the blown-in dust cloud as a time series. Such data enable *e.g.* the initial conditions of dust explosion models to be quantified.

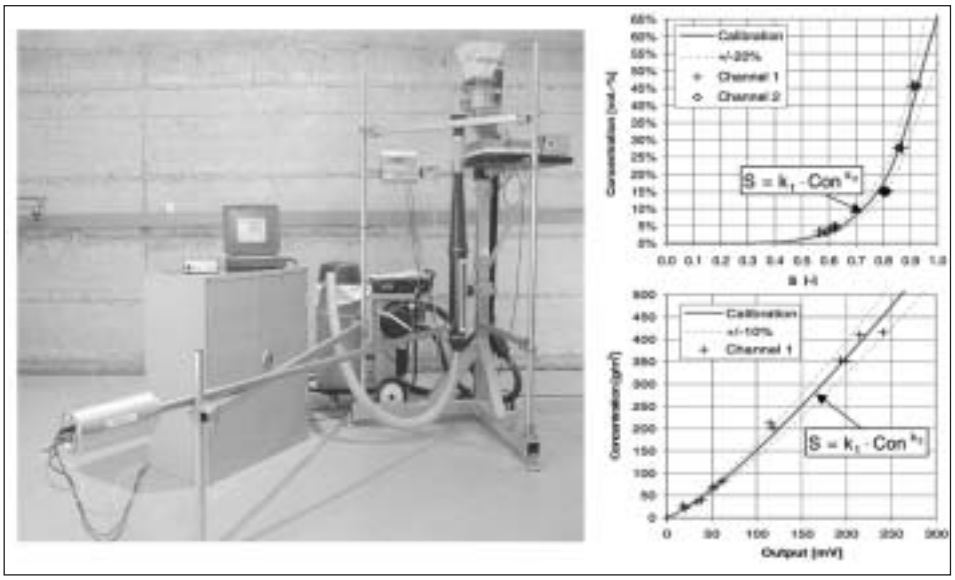


Fig. 1. Measuring system 'Labasys® 100' with calibration unit for custom calibration measurements (left); exemplary 'dense' (top right) and 'dilute' flow calibration data (bottom right).

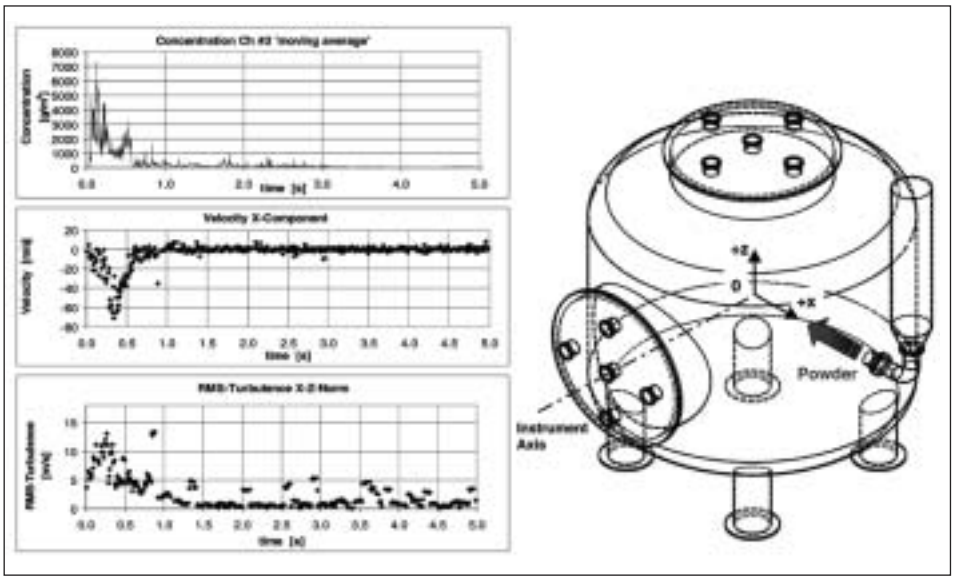


Fig. 2. Blast-in of 10 kg powder into a 10 m^3 vessel observed with the 'Labasys® 100' instrument (velocity component 'x' negative in direction of initial powder flow).

From Industrial R&D to Production

Again new requirements had to be fulfilled that arose from the demand for an instrument capable of *inline monitoring* product flows in *production* plants. Important features in this context are robustness, high reliability and lifetime, explosion protection and of course interfaces to the various automation systems being used.

To meet these specifications the new instrument *'Labasys® Control Ex'* was developed together with a pilot customer (Fig. 3). The 'Labasys® Control Ex' measuring instrument features one or two measuring channels (for concentration only or concentration, velocity & rate determination) and may be used for difficult measuring tasks thanks to its solidity, the built in, one or two stage pneumatic cleaning unit and an optional cooler. The key features of the 'Labasys® instruments' are summarized in Table 1.

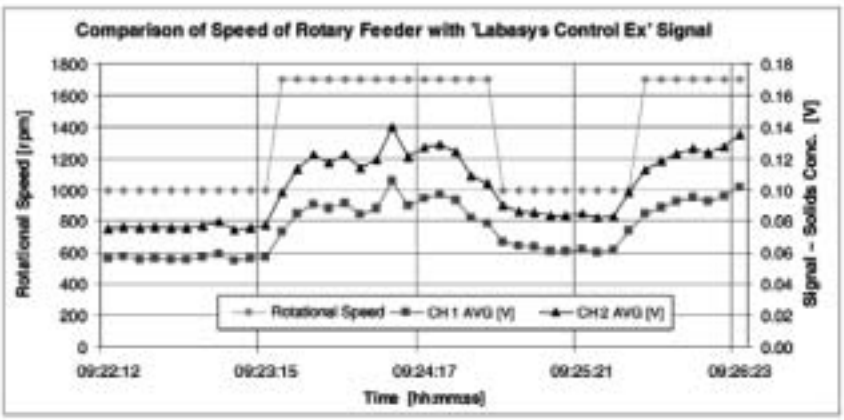
Table 1. Key Features of the 'Labasys® Instruments'

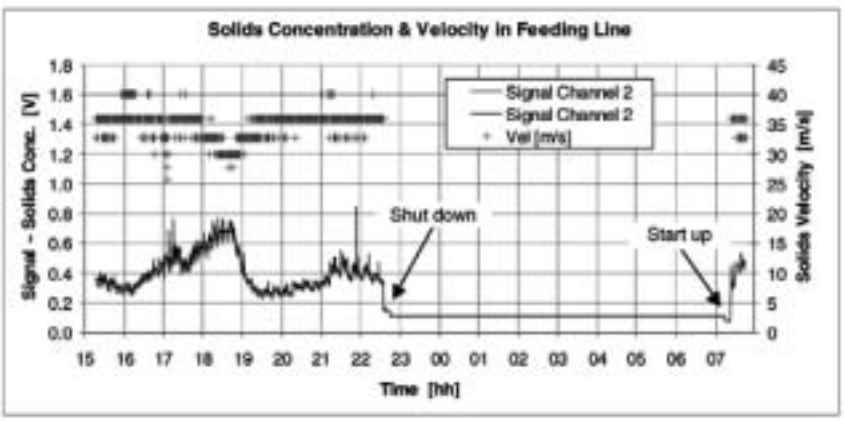
- simultaneous & local 1- and 2-dimensional **concentration** and **velocity** determination with one handy instrument (pat. pending)
- concentration range (g/s systems): *ca.* 1 g/m^3–1500 kg/m^3
- velocity range: *ca.* 0.05–200 m/s
- wide dynamic range:
  – concentration: up to 100 kHz
  – velocity: up to 5000 Hz (moving average)
- instrument insertion into operating plant without production stop
- robust instrument for industrial use
- 2-stage **efficient cleaning unit** avoids soiling of the optics (pat. pending)
- temperatures up to 350 °C, since only rugged probe tip is inserted containing no electronics
- **modular design** allows flexible adaptation to various measuring tasks
- user friendly & powerful acquisition, analysis & monitoring software 'LabaSoft'
- CE and Ex (zone 0 gas & 20 dust) approved ('Labasys® Control Ex')
- cost efficient

Fig. 3. Measuring instrument 'Labasys® Control Ex' for inline monitoring of particulate product flows.

An application example for *inline monitoring* of powder flow in a BASF production plant is shown in Fig. 4: A 2-channel 'Labasys® Control Ex' instrument is mounted at a DN50 pneumatic conveying line, feeding coating powder into a spray formulation process. The knowledge of the *instantaneous feed rate* is important for an efficient production with controlled product quality, since even short flow interruptions of a few seconds may cause costly plant shutdowns. The close correspondence of the 'Labasys® Control Ex' signals (in this case not calibrated) with short time variations of the rotational speed of an upstream rotary feeder, illustrates the undelayed reproduction of the powder flow by the instrument (Fig. 4, upper graph). Inline insight into the feeding line shows so far unknown fluctuations of the powder flow rate, which gives a perspective for substantial additional optimizations measures of the process (Fig. 4, lower graph).

Fig. 4. Monitoring of powder fed into a spray formulation process. The 'Labasys® Control Ex' instrument is mounted at a DN50 feed line in a BASF production plant.





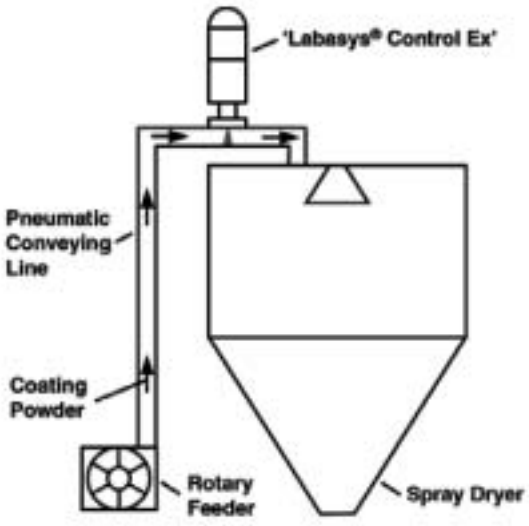


Table 2. Main application areas for 'Labasys® Instrumentation'

Gas/Solid Systems	Liquid/Solid Systems
• Spray Dryers	• Stirred Tanks
• Fluid Catalyst Cracking (FCC)	• Crystallization
• Fluidization / Circulating Fluidized Beds	• Pulp Processing
• Mills	• Separation Devices: Sedimentation, Hydro Cyclones *etc.*
• Mixers	• Pulp Processing
• Air Separators / Cyclones / Classifiers	• Mills
• Pneumatic Transport	• Slurry Handling
• . . . ?	• . . . ?

Table 3. Infrastructure and services of MSE Meili

Our Infrastructure . . .	Our Services . . .
• 'Labasys® 100' and 'Labasys® Control Ex' instruments in different configurations	• Consulting with focus on Process Optimisation, Project Studies to Quantify Optimisation Potential
• Mobile PCs for data acquisition and analysis in industrial environments	• Instrumentation Rental and Measuring Service
• Test units for accurate 'dilute' and 'dense' flow calibration measurements	• Calibration Service & Test Measurements
• Circulating Fluidized Bed (CFB) unit for cold tests with various measuring inlets	• Training for Labasys® Instruments
• Laboratory for gas/solid and liquid/solid experiments	• Development & Engineering
• Workshop for mechanical, electric & optical development and manufacturing	***"The process is in the centre. You focus on throughput, quality and costs."***
• Hard- & software for program development, 3D-design, simulation & data analysis	***"We measure the relevant flow quantities and develop solutions – together with you!"***

Applications – from Energy to Food

The main application areas for 'Labasys® instruments' are *energy production* (*e.g.* coal and ash handling), *oil* (fluid catalyst cracking), *bulk* and *specialty chemistry, cement* and *food* industries. Table 2 gives an overview on the processes with estimated high optimization potential and thus high customer benefits – companies operating in market segments *with low margins* and therefore subjected to high pressure to reduce productions costs will benefit in particular from optimization steps through improved process control, since in these industries even cost reductions in the low percent range will increase margins substantially.

Services Focused on Process Optimization

To realize the described cost reductions through optimization measures, the combination of our customers' specific knowledge about their processes with MSE Meili's unique measuring technology and broad experience with inline monitoring applications is crucial. Close co-operation together with an aligned palette of services as listed in Table 3 offered in well-defined packages at attractive costs – our contribution to our customers' efforts to produce particulate matter in optimized processes and meet the rising demands concerning product quality, process sustainability and competitiveness.

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