Micro-optical technology for measuring forces in powder, non-Newtonian and multiphase flows

A Robust Process Analytical Technology (PAT)

Drag Force Flow (DFF) Sensors

Wall Shear Stress (RealShear™) Sensors

LOI Optical Sensor Interrogator

www.lenterra.com
Innovation by any measure

Lenterra was established in 2002 and is a privately owned R&D company specialising in the development of sensor instrumentation based on a range of patented optical and ionised gas/plasma-based technologies.

Lenterra has now introduced a family of sensors for direct measurement of flow forces. Using micro-optical resonators as force-sensing elements, these sensors can provide critical, real-time measurements for a variety of applications.

**PAT system overview**

Lenterra’s Drag Force Flow (DFF) and Wall Shear Stress (RealShear™) probes send a continuous, real-time stream of data via optical fibre cable to an optical interrogator which allows the user to make process decisions - without the need to stop and restart the process.

The benefits to all stakeholders involved in pharmaceutical manufacturing are significant and are congruent with FDA’s vision to:

- Improve compliance (reduce deviation reports)
- Improve assurance of quality
- Reduce cycle times (operational efficiency)
- Reduce costs (reworks, resample, retesting, etc.)
- Increase throughput
- Improve equipment utilisation

**Technology**

- The probes
  - (DFF - immersion, RealShear - mounted flush with the wall)
- Optical detection principle
- Temperature compensation
- Directional measurement
- Measurement system - **Interrogator**

**Drag Force Flow (DFF) Sensors**

Mounted on a stationary base, the thin DFF ‘needle’ contains two fibre optic gauges which are connected to a controller via a fibre optic cable. When immersed in a powder or flowing material, the DFF bends under the force of the flow and quantifies the drag force. The amount of bending is measured real-time in-line, allowing the user to determine immediately whether or not any adjustments are necessary, eliminating the need to stop the flow operation so that an offline measurement can be taken.

**Advantages**

- Direct, precision measurement of flow forces over a wide range of sensitivity
- Directional sensitivity
- In-line, continuous measurement with no disruption of process flow
- Stainless steel construction - sterilisable and chemically resistant
- Fibre optic sensing means no electromagnetic interference and no ignition hazard
- High measurement rate (500+ measurements per second)
- Self-calibrated for temperature variations
- Turn-key operation when coupled with a Lenterra Optical Interrogator and software
APPLICATION EXAMPLE - High Shear Wet Granulation

- Ability to measure single granules in wet mass at a high data acquisition rate
- Measured signal is related to wet mass consistency and granule densification, distinct from granule particle size distribution
- Readily capable of differentiating batches with different formulation composition
- Able to differentiate slight differences in batches with same formulation
- Determine process parameters (e.g. % w/w water used for granulation)
- Identify different stages of processing
- Able to define granulation endpoint - a parameter to enable robust formulation, process design and process control
- Efficient scale-up of wet granulation processes

Wall Shear Stress (RealShear™) Sensors

A family of sensors that measure a force exerted on a floating element installed flush with the construction wall.

Mounted flush with a pipe, vessel wall or rotor-stator workhead, the RealShear Wall Stress Sensor provides real-time measurement of wall stress. The sensor relies on a floating element attached to a cantilever beam that deflects in response to shear force as powder flows across its surface. The cantilever transmits the shear force to a Fiber Bragg Grating (FBG). The shift in wavelength is proportional to the shear stress.

Efficient scale-up of wet granulation processes

APPLICATION EXAMPLE - High-Shear Mixing

High-Shear Mixers (HSMs) are increasingly being used across numerous industries, including the production of pharmaceuticals, food, and cosmetics. They can provide significantly shorter mixing cycles and may radically improve throughput compared with conventional mixers. HSMs are often of the rotor-stator type, in which one element (the rotor) rotates in close proximity (as small as 0.2mm) to a stationary element (the stator). Mix components that pass between them experience high shear stress, which is the lateral force exerted by a surface on the material or vice versa. The desirable characteristics maybe a certain viscosity, granularity, or in the case of food products, qualities like spreadability or ‘feel on the tongue’. In pharmaceutical manufacturing, high-shear mixers can additionally facilitate crystallisation by creating supersaturated liquids, and can be used to produce particular drug polymorphs during mixing.

RealShear sensors installed through the stator are able to monitor the wall shear stress of the HSM and serve as a PAT tool in the manufacturing of emulsions and other liquid substances.
LOI Optical Sensor Interrogator

An integral part of Lenterra’s innovative in-line PAT technology, the LOI Interrogator uses fibre optic technology to communicate with the micro-optical resonators inside the DFF and RealShear sensor products.

Equipped with an optical source, the controller receives data from the micro-optical resonators built into the housing of DFF and RealShear probes. The unit interfaces with a PC via USB for measurement display and analysis. Designed for the high resolution interrogation of optical sensors (Fiber Bragg Gating sensors) in laboratory or industrial environments, LOI delivers high accuracy, long term stability, streamlined installation, and premium performance under harsh environmental conditions. LOI is controlled by any standard PC and utilises a fast, low noise distributed feedback diode laser with narrow linewidth for spectrum scanning. Custom software is used to control the Interrogator, and to process and store collected data. Adjustable photodiode gains allow for measurement of returned light intensity in a wide dynamic range.

**FEATURES**

- LabVIEW remote software to display real-time data and capture and save for analysis (Microsoft Windows compatible)
- Fast measurement rate to capture high frequency periodic effects and transients (up to 500 Hz)
- USB interface with remote PC
- Simple turnkey operation
- Available in 1 or 2 channel versions (LOI-2F and LOI-4F)
- Source code available for user-customisation of software

**APPLICATIONS INCLUDE:**

- Pharmaceutical
- Chemicals
- Biotechnology
- Food
- Cosmetics
- Toners
- Metals
- Ceramics
- Plastics
- Powder Coatings
- Cement

**BENEFITS**

- View real-time shear stress or viscosity data
- Manually capture and save data or program automatic acquisition of data
- Set measurement rate appropriate for your application
- Calibration data for individual controllers and sensors
- View and analyse previously stored data

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