Rank Brothers Ltd.

PHOTOMETRIC DISPERSION ANALYSER PDA 2000

The Photometric Dispersion Analyser PDA 2000

is a simple, rugged, but very sensitive monitor for flowing suspensions and emulsions, based on a new optical technique developed at University College London. The unit is compact and lightweight (width 380mm, depth 200mm, height 140mm, weight 4.5 kgs).

Applications include:

* Selection of optimum flocculant dosages
* Control of dispersion and emulsification processes
* Assessment of the strength of aggregates (flocs)

Some of the advantages of the PDA 2000 over more conventional techniques are:

* Very simple to operate—little attention needed
* A very wide range of suspension concentrations can be directly monitored (from ppm levels to several per cent solids)
* No orifices to clog
* Minimal problems due to contamination of optical surfaces
* Flow-through operation—ideal for on-line applications
* Novel flow cell using inexpensive, disposable plastic tubing—no connection problems.

Nature of the Technique

The flowing suspension is illuminated by a narrow beam of light perpendicular to the direction of flow. For the PDA 2000, a novel flow cell has been developed; transparent flexible tubing fits in a perspex block which houses two precisely-aligned fibre-optic probes. The optical fibres carry the incident and transmitted light, as shown in fig. 1. The light source is a high intensity light-emitting diode and the transmitted light is continuously monitored by a sensitive photodiode.

The output from the photodiode is converted to a voltage, which consists of a large dc component, together with a small, fluctuating (ac) component. The dc component is simply a measure of the average transmitted light intensity and is dependent on the turbidity of the suspension. The ac component arises from random variations in the number of particles in the sample volume (i.e. that volume illuminated by the light beam—typically of the order of $1mm^3$ in the PDA 2000). Because the suspension flows through the cell, the actual sample in the light beam is continually being renewed and local variations in particle number concentration give fluctuations in the transmitted light intensity. These fluctuations cease when the flow is stopped.

It can be shown (refs. 1 and 2) that the root mean square (rms) value of the fluctuating (ac) signal is related to the average number concentration and the size of the suspended particles. For fairly uniform suspensions, estimates of particle size and number concentration can be made, but the main use of the PDA 2000 is in the monitoring of flocculation and dispersion processes.

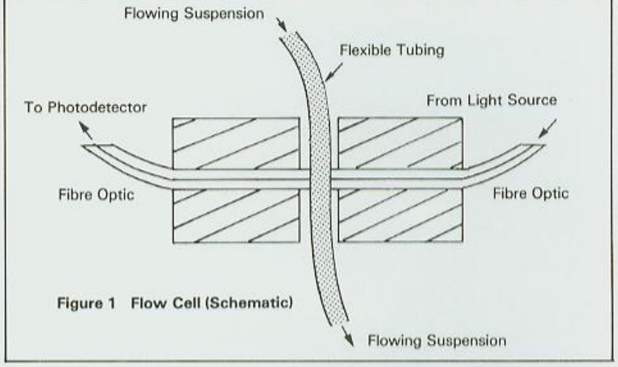

Figure 1 Flow Cell (Schematic)

When aggregation of particles occurs, the rms value of the fluctuating signal increases (ref. 1). Measurable changes in the rms value occur long before any visible signs of aggregation are apparent. Conversely, when aggregates are disrupted, the rms value decreases, reaching a minimum when disaggregation (or dispersion) is complete. The dc value (related to the turbidity) is much less sensitive to changes in the state of aggregation.

Operation of the PDA 2000

The flow cell supplied with the PDA 2000 can accommodate standard plastic tubing of either 1mm or 3mm internal diameter. The choice of tubing depends on the nature of the suspension and the amount available. The 3mm tubing requires a minimum suspension flow rate of 20ml/min and would be used in many industrial applications. However, for highly turbid suspensions, the transmitted light intensity might be too low and the 1mm tubing would then be chosen because of the shorter optical path length.

Flow rate in the 1mm tube can be as low as 2ml/min, so this might be chosen for laboratory applications where only small sample volumes are available. Because of the high shear caused by flow in narrow tubes, some disruption of weak aggregates might occur in the 1mm tube at quite low flow rates. This effect can be exploited to give an empirical measure of floc strength. The dc and rms readings are available as outputs on the PDA 2000. Both readings can be adjusted by precision 10-turn gain controls, enabling a wide range of suspension concentrations and conditions to be monitored. Another output is the result of dividing the rms value by the dc reading. This *ratio* output is the most useful one for routine monitoring of flocculation or dispersion processes. The ratio varies with solids concentration in a fairly straightforward manner (ref. 2) and is almost entirely unaffected by contamination of the tube walls in the flow cell or by drift in the electronic components. These effects cause changes in the dc value (and can be a serious problem in flow-through turbidity measurements). However the rms value of the voltage fluctuations is changed in the same proportion, so that the ratio of the two values does not change. This means that the ratio output can be monitored for long periods without the need for re-calibration or re-checking of the zero reading. Having established the appropriate gain settings for the suspension under test, the dc, rms and ratio outputs can be continuously monitored on a chart recorder, data logger or other device. Any one of the outputs can be selected for digital display on the front panel of the instrument by push-button switches. Smoothing of the outputs can be selected by another switch. A *limit* switch is provided which enables effects due to air bubbles or non-representative large particles to be partially compensated.

Response of the PDA 2000

Useful readings can be obtained over a very wide range of suspension concentrations. The limits depend on the nature of the particles and the tube diameter, but, as a rough guide, concentrations from a few ppm to several percent solids can be directly monitored. For more concentrated suspensions some form of in-line dilution would be necessary. The limits of particle size are roughly 0.5 to 100 microns, determined largely by the diameter of the light beam (1mm in the PDA 2000). In non-uniform suspensions, larger particles give the dominant contribution to the rms and ratio values. The concentration and particle size limits are inter-related to some extent. Thus, for larger particles, lower concentrations can be detected.

Aggregation of particles can easily cause changes in rms (or ratio) output by a factor of 5 or more before any visible changes in the suspension become apparent (ref. 1). Corresponding changes in the dc output are only of the order of a few percent.

Suggested Applications

In laboratory studies of flocculation and dispersion processes, the PDA 2000 can be used in several ways. A very simple approach is to sample continuously from a stirred vessel as in Figure 2.

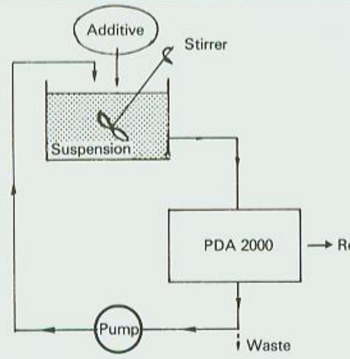

Figure 2
Experimental arrangement for batch testing of flocculation and dispersion.

After passing through the flow cell the sample can be returned to the vessel by means of a peristaltic pump or can go to waste. A range of different dosages of additive (dispersant or flocculant) can be explored and the response of the PDA 2000 (usually the ratio output) can be monitored. The speed of response depends on the suspension concentration—from as little as a few seconds for concentrated suspensions to a minute or two for dilute samples. Optimum flocculation corresponds to a maximum in the ratio reading after a standard stirring time. For dispersion processes, the dosage giving the minimum reading is chosen. As well as giving a rapid indication of the optimum dosage of a particular additive, realistic comparisons between different additives can be made with the simple set-up in figure 2.

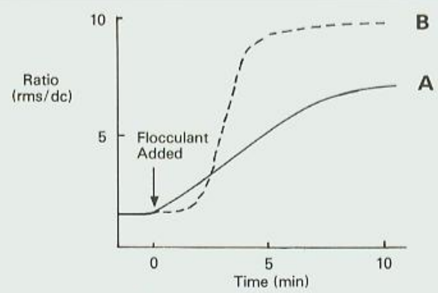

Figure 3
Response of the PDA 2000 (Ratio output) for Kaolin suspension dosed with (A) Calcium nitrate (B) Cationic polymer.

Figure 3 shows a typical response of the PDA 2000 used in this way. The suspension is of clay (kaolin) and the additives are a calcium salt and a cationic polymer. Both of these cause flocculation of the kaolin particles and the ratio response begins to show an incease very shortly after addition of the flocculants. In the case of the polymer the rate of increase is greater, indicating a more rapid flocculation, and the ultimate value attained is greater than with the calcium salt, showing that the flocs formed by the cationic polymer are stronger (they can grow to a larger size in the stirred vessel).

An alternative arrangement is shown in Figure 4 where the suspension and additive are mixed continuously and then flowed through a length of coiled tubing, where flocculation (ref. 3) or dispersion may occur.

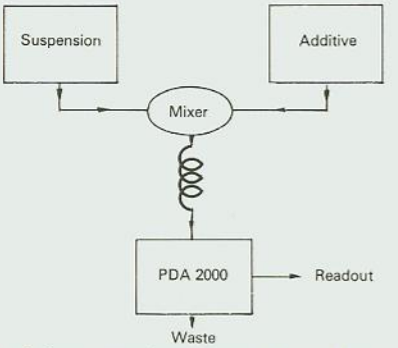

Figure 4 Arrangement for continuous testing of flocculation and dispersion.

Tube flow is a very convenient basis for a laboratory flocculation test and the PDA 2000 is an ideal monitor for such applications. Changes in flocculant dosage cause a corresponding change in the ratio output after an interval which depends on the residence time in the tube.

The results of such a test using a latex suspension and a cationic polymer, are shown in Figure 5. In this case there is a clearly defined optimum dosage, which

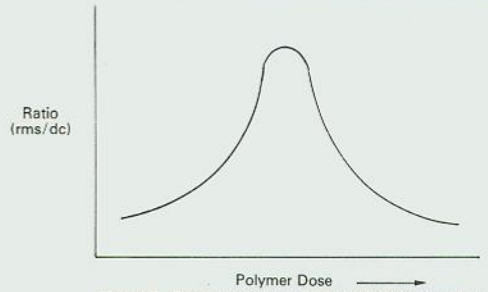

Figure 5 Response of the PDA 2000 (Ratio output) for latex suspension with varying dose of cationic polymer.

corresponds with the point of change neutralisation of the particles.

By changing the flow rate through the tubing, keeping the flocculant dosage constant, useful information on the strength of flocs can be obtained.

In plant applications, a process stream can be sampled at any convenient point and passed directly to the flow cell of the PDA 2000, often by one continuous length of tubing using gravity flow. This provides a very simple, on-line method of monitoring the state of aggregation of a suspension. Once a desired reading is established, departures from this condition are immediately apparent by changes in the ratio output. This output could be used to activate an alarm, or, for control purposes, to change the speed of a dosing pump.

The turbidity fluctuation technique as used in the PDA 2000, has been shown to be an effective method of monitoring flocculation processes in water and effluent treatment applications (refs. 4 and 5). Several other industrial applications are being evaluated. With an effective, on-line monitor of flocculation and dispersion processes, the need for routine measurements of particle charge (or zeta potential) is largely eliminated.

References

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The PDA 2000 is manufactured by Rank Brothers Ltd., under a licence agreement with University College London, where the technique was developed. Electronics designed by Quotronics System Engineering. PDA 2000 is a registered trade mark of Rank Brothers Ltd. Protected by patents.

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