Real-Time Yield Stress Measurement for Enhanced Process Control

Problem statement

Effective control of slurry rheology in industrial operations, particularly in mineral processing and tailings management, is essential for maintaining efficiency and avoiding process disruptions. Traditional methods of estimating yield stress using slurry density are limited in accuracy due to laboratory-to-operation variability and sensitivity to material and process fluctuations. Operators often rely on lab-based or in-line measurements of slurry density to approximate yield stress. However, this method fails to capture real-time variations in the yield stress caused by operational fluctuations and changing quality of the mined material. These inaccuracies can lead to suboptimal process conversions, control, and higher operating costs due to viscosity-related process failures. An instrument that can provide rapid feedback, in real-time and without the need would for human intervention would be immensely valuable in these operations.

Experimental

This OnLine Rheometer Series 1000 (OLR), which provides continuous, inline measurement of slurry rheology in real-time [1, 2], was piloted on a high-clay, gold process slurry that is fed to pressure oxidation units. Inline measurements were validated against bench-top vane yield stress tests over a concentration range of 49.4 to 64.5 wt%. The slurry was circulated in a pilot scale instrumented pipe-loop where the OLR was installed. An image of the installation is shown in the Fig. 1(a). The red arrow in the Figure 1(a) shows the direction of flow. The internal configuration of the OLR is shown in Fig. 1(b). The instrument consists of a flow cell that is fitted to the pipeline and houses two endplates that face each other. The shaft attached to the top endplate is connected to a piezo actuator which imposes a vertical oscillation. The shaft fitted to the bottom endplate is fitted to a load cell that measures the force. At the beginning of a measurement cycle, the top plate is driven by the actuator to a specified distance of the bottom plate and when the slurry is flowing in the pipeline, this motion “sandwiches” a sample of the liquid, and the deformation is imposed by the piezo while the load cell senses the force. All rheological parameters can then be calculated based on these measurements. A schematic of the pipe-loop is shown in Fig 1 (c). The slurry is agitated in the section of the loop A-B-F-G, and the main measurements are done in the section A-B-C-D-E-F-G. A sampling port in this segment is used to extract samples for testing in the laboratory. The slurry was progressively diluted, and measurements were made both in-line and also in the laboratory.

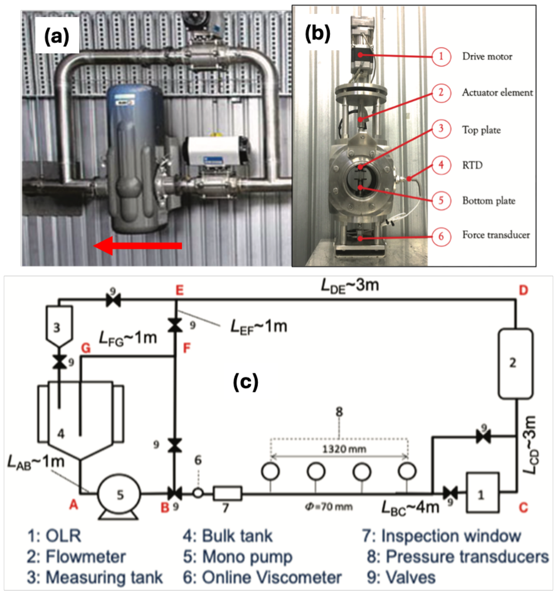

Figure 1. *(a) The OLR installed in the pipeline (b) The internal components of the OLR (c) The schematic of the pipe loop. Details in text.*

Results

The results of the laboratory tests are shown in Figure 2 with the measured yield stress plotted against the concentration of slurry. The inset in Figure 2 shows the mean-particle size in the slurry.

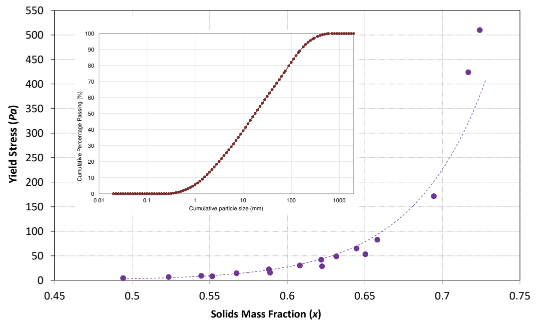

Figure 2. *Variation of Yield Stress with solid mass fraction. Inset shows particle size distribution.*

In Figure 3 we show a comparison between the yield stress measured in the laboratory and that indexed in-line with the OLR. The OLR software offers a built-in function, the OLR-YSI, that indexes the inherent elasticity of the material under flow conditions and uses in-house AI to provide an estimate for the yield stress. It can be observed from Figure 3 that the OLR-YSI correlates linearly, with a factor of approximately 1.8, with the yield stress measured in the laboratory using the well-established vane method.

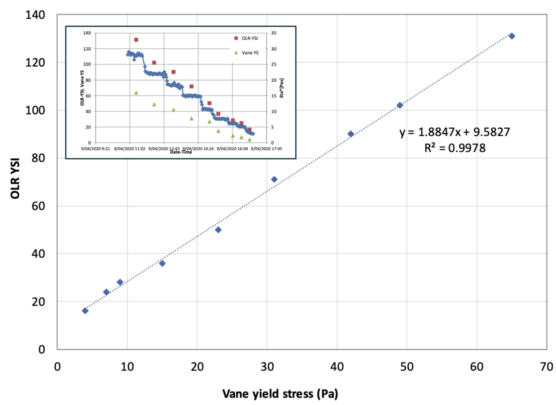

Figure 3. *Main figure shows the variation of the YSI with the yield stress value measured with a vane sensor in the laboratory. The inset shows the change in the complex viscosity (blue symbols), YSI (red symbols) and vane yield stress (green symbols) as the slurry is progressively diluted with water.*

Conclusion

The work demonstrates the use of the OLR technology to index the yield stress of a clay-rich flowing slurry sourced from an active gold-mining operation. The demonstration opens a way to index the Yield stress in a flowing slurry in real time, without manual intervention or laboratory testing. By obtaining a rapid feedback, remedial strategies can be implemented, in an automated manner, to keep the operations at optimal levels when the slurry quality changes without notice. The technology is expected to influence a wide variety of process operations, including those encountered in mining and mineral process where the correct consistency and yield stress of the slurry greatly influences productivity and economic viability.

This note is based on work published in Ref [3].

References:

[1] D Konigsberg *et al*, Applied Rheology, 23, 35688. (2013)

[2] T. J. Kealy, P. K. Bhattacharjee and P. Griffin, PASTE 2017: Proc 20th International Seminar on Paste and Thickened Tailings (2017)

[3] F Sofrà, P Bhattacharjee, PASTE 2021: Proc 24th International Conference on Paste, Thickened and Filtered Tailings, 119-130. (2021)

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