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Laboratory Evaluation of the CleanProTech Online Slurry Particle Density Meter (OSPDM)

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Aim

To analyse the provided coal samples using the CleanProTech Online Slurry Density Meter (OSPDM) and examine its applicability for use within the existing CHPP.

Samples

CleanProTech were sent coal samples from a CHPP for analysis using the OSPDM.

Samples included;

- Flotation Feed – 1x 20 L bucket (dry material)
- Flotation Reject - 1x 20 L bucket (dry material)
- Fines Product - 1x 20 L bucket (dry material)
- Spirals Reject - 1x 20 L bucket (dry material)
- Clarified Water - 1x 20 L bucket (wet)

This enabled testing of each stream individually at varying solids concentrations and also combining streams to make a composite sample. This can emulate situations which may occur in a processing plant, for example, when product coal is being lost to tailings.

The samples were split using a rotary sample divider to ensure each fraction was representative of the original lot.

The fines product sample had one fraction split again to allow small amounts to be added in during the testing procedure to gauge trending performance with coal being 'lost to tailings'.

Test Procedure

The following diagram shows the equipment setup used during the test program.

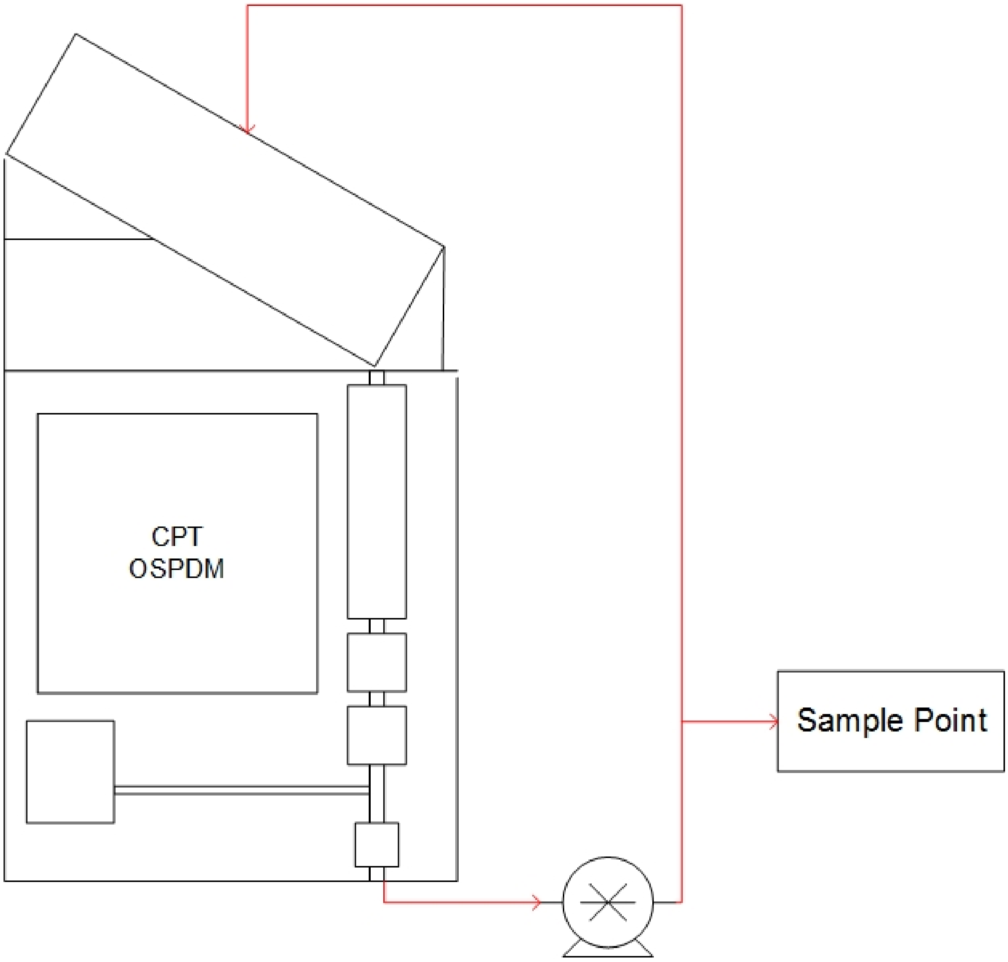


Figure 1 - Equipment setup for test work.

There was a pump installed on the outflow of the OSPDM to recirculate the sample through the device. A sample could be collected from this feed line. The slurry was fed into the OSPDM head tank, where any entrained air is removed before flowing into the measuring tube section of the device. Slurry then exists the measuring tube and into the pump once more. This allows us to lengthen the analysis time by recirculating the slurry around the system. It also allows us to easily add in different material and note changes over time.

Each of the four samples were tested through the OSPDM at varying solids concentrations and the outputs recorded. Each sample was generally started at ~10 % (m/m) and water was gradually added to bring the solids concentration down. Values were recorded and samples taken at each condition.

The final sample to be processed by the OSPDM was the flotation reject. This is the stream that the OSPDM is used on in existing applications within Australia. We began with analysing a sample of ~10 % (m/m) flotation reject material and recorded the OSPDM values. Small samples of fines product material (at roughly the same solids concentration) was added to the OSPDM and the response investigated. Each addition of product material saw the particle density decrease, as would be expected by having more coal reporting to reject.

All samples were then analysed by the CleanProTech laboratory for slurry density, solids concentrations on both a mass and volumetric basis, conductivity and particle density.

Data collected from the test procedure was then plotted against the laboratory data and results investigated. A simple calibration was developed, similar to what would occur during installation of an OSPDM on site. This gives an idea of expected equipment performance once installed.

Results

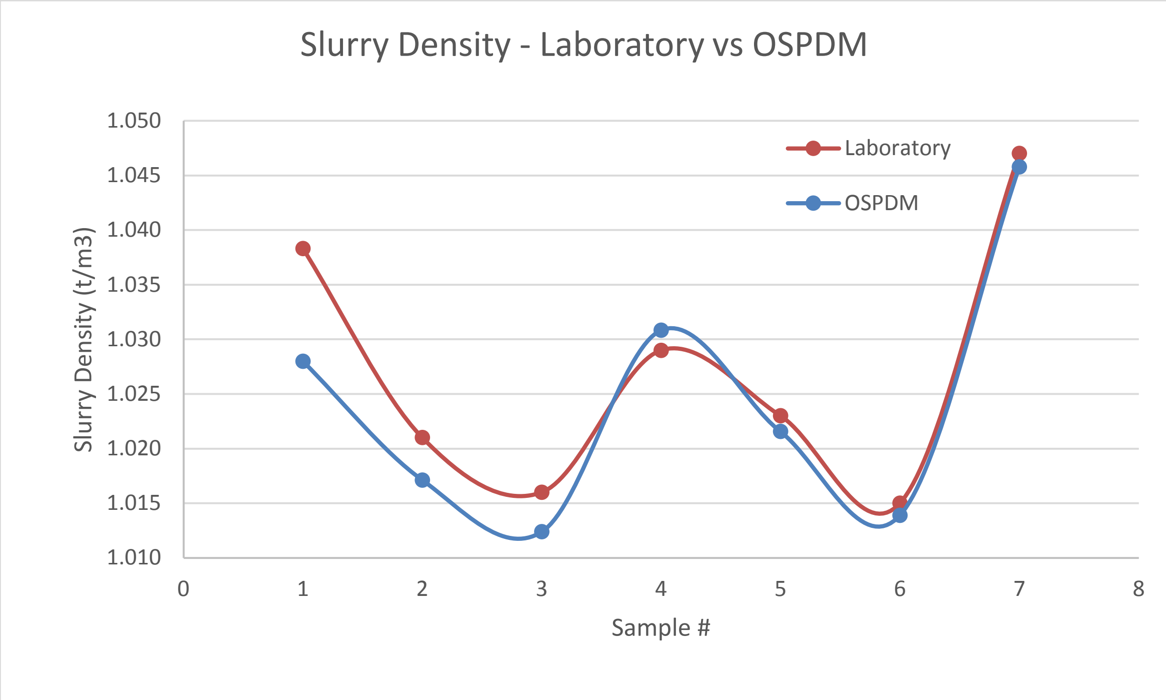
The following graphical trends are the best way to demonstrate the OSPDMs performance.

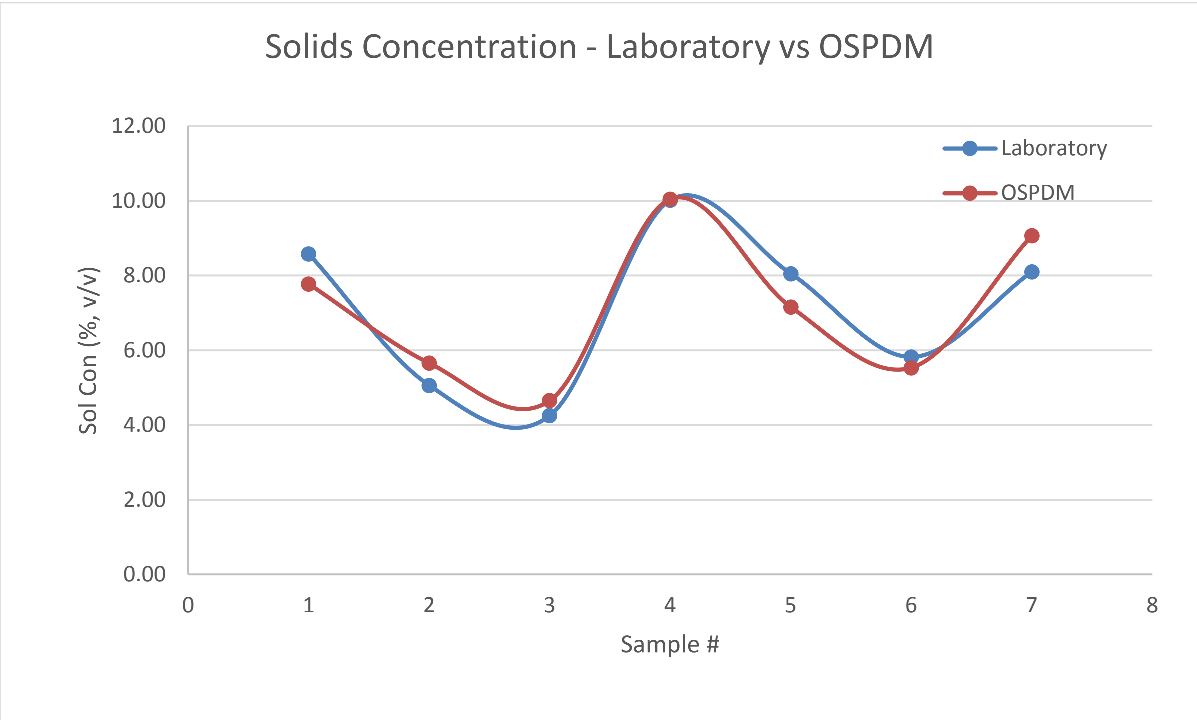
Although the absolute values are quite accurate and important, the trending aspect of the OSPDM is the most valuable tool for a CHPP operator. This allows changes to be made to the circuit and the response monitored online.

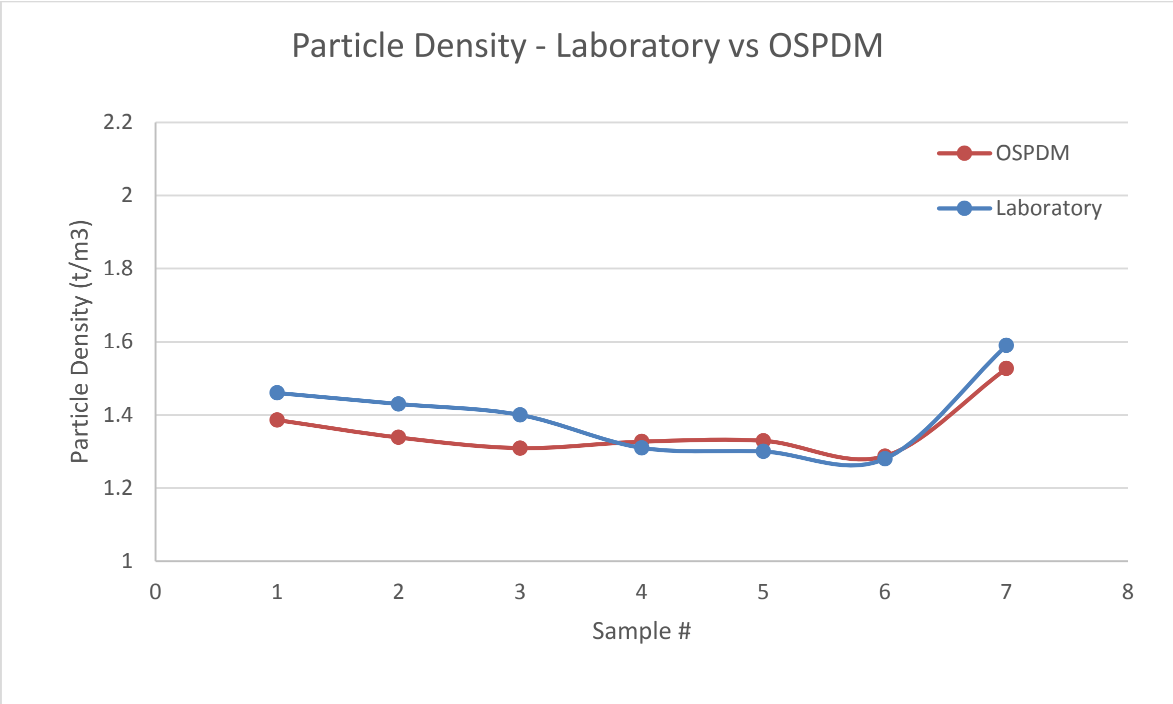
The graphs below shows the measured OSPDM values for each sample analysed (solids concentration, slurry density and particle density). It can be seen that the values track quite closely and trend very well. This is without any calibration specific to the analysed samples.

For this test work, a calibration curve was developed using just the 7 samples collected. A greater number of calibration samples would be ideal for an accurate calibration curve, but it gives an indication of what sort of results are possible from the OSPDM, even using a very basic calibration.

(At the Bloomfield installation, there have been well over 100 individual samples taken throughout the operational period of over 2 years, which all form part of the calibration equation. Each sampling campaign adds new data to this calibration set and minor adjustments are made to continually improve the equipment's accuracy.)


Slurry Density - Laboratory vs OSPDM
Slurry Density (t/m3)
1.050
1.045
1.040
1.035
1.030
1.025
1.020
1.015
1.010
0
1
2
3
4
5
6
7
8
Sample #
Laboratory
OSPDM


Solids Concentration - Laboratory vs OSPDM
Sol Con (%, v/v)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
1
2
3
4
5
6
7
8
Sample #
Laboratory
OSPDM



It can be seen that even with a very basic calibration (only 7 samples), the OSPDM performs well on the provided samples, in particular the flotation reject.

We are confident that the OSPDM could operate accurately on any of these streams within the CHPP and that accuracy would only improve over time with more refined calibration data.

Table 1 - Sample identification for above charts.

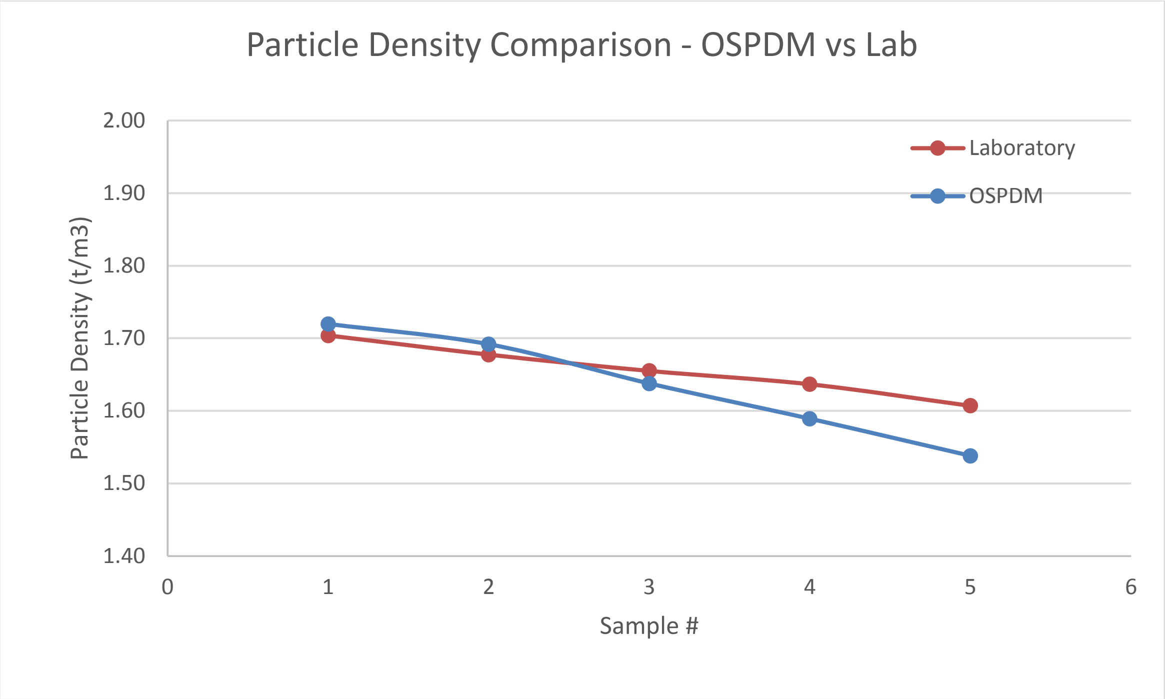
Sample No	Sample Description
1	Flotation feed, ~10 % m/m
2	Sample 1, 10 kg water added, ~7 % m/m
3	Sample 2, 10 kg water added, ~5 % m/m
4	Fines Product, ~11 % m/m
5	Sample 4, 5 kg water added, ~9 % m/m
6	Sample 5, 5 kg water added, ~7 % m/m
7	Flotation Reject (~2 kg) with fines product added (~1 kg) – Final sample

'Real World' Example – Coal Losses to Flotation Reject

During the OSPDM test work program, it was a good opportunity to perform a trial which shows the 'real world' advantages of monitoring online with the OSPDM.

The flotation reject stream was taken and monitored by the OSPDM. To this stream, fines product was added in stages to emulate saleable coal being lost to the flotation reject. This is a common occurrence on the majority of plants and often goes unnoticed, as reject is not monitored online, or generally at all.

The graph below shows the particle density trend as product coal was added to the flotation reject stream.



The masses of solids and water was accurately recorded for each sample. Particle density was analysed in the laboratory on the original samples. Using these masses and particle density values, we can calculate what the particle density is at each stage during the trial.

Table 2 - Sample identification for above chart. Fines product being added to flotation reject.

Sample #	Description	Reject Mass (kg, ad)	Prod Mass (kg, ad)	Sol Con (%, m/m)	Particle Density Calculated - Lab (t/m3)	Particle Density OSPDM (t/m3)
1	Flotation Reject	2.06	0.00	10.27	1.70	1.72
2	Added (1)*	2.06	0.20	10.16	1.68	1.69
3	Added (2)*	2.06	0.41	10.09	1.66	1.64
4	Added (3)*	2.06	0.61	10.03	1.64	1.59
5	Added (4+5)*	2.06	1.04	9.98	1.61	1.54

*For details of fines product sample being added, see Table 3 below.

Table 3 - Details of fines product material being added into flotation reject.

Product Sample ID	Product Solids Mass (g, ad)	Water Mass (g, ar)	Slurry Mass (g, ar)	Solids Concentration (m/m, ad/ar)	Particle Density (calculated) (t/m3)
1	199.4	1987.13	2186.6	9.1	1.45
2	207.4	1988.04	2195.5	9.4	1.40
3	205.5	1989.62	2195.14	9.4	1.35
4 and 5	427.2	3979.79	4407.04	9.7	1.30

Conclusion

From the provided data, it can be seen that a Clean Process Technologies OSPDM could be implemented within the existing CHPP to successfully monitor the streams in question. Even with an extremely basic calibration data set (7 samples), the OSPDM produced acceptable results and trended the changes very well.

The ‘real world example’ gives an indication of unit performance on a flotation reject stream and the ability to monitor and detect coal being lost to the reject stream. This gives plant operators and engineers the tools needed to detect changes to which they can optimise the process, receiving feedback online to evaluate if the change was beneficial.

These benefits have been shown during the installation at Bloomfield CHPP in Australia.

Table 4 - Example calculations for OSPDM payback period.

	Case		Basis			
Plant Feed		Solids	ar	t/h	800	
Fines Proportion			ar	%, m/m	45	
Fines Feed		Solids	ar	t/h	360	
Tailings	1	Particle Density	d	t/m^3	1.78	measured by OSPDM
	2		d	t/m^3	2.2	measured by OSPDM
Feed		Solids Flowrate	ar	t/h	360	
		Particle Density	d	t/m^3	1.47	measured by OSPDM
Product		Particle Density	d	t/m^3	1.33	measured by OSPDM
(Mass Yield -	1		d/d	%, m/m	62	
Particle Density)	2		d/d	%, m/m	76	
MY Increase			**d/d**	**%, m/m**	**14**	
Extra Product Recovered			ar	t/h	48.9	
			ar	$/h	4892	
Product Value			ar	$/t	100	Assumed for simplicity
Operating Hours				annually	5000	
Purchase Price				$	190000	
Installation				$	25000	
Total Price				$	215000	
Estimated Payback Period				**hours**	**44**	
				days	**2**	

*Case 1 is prior to plant optimisation. Case 2 is performance after optimisation using the OSPDM. All values are given in Australian Dollars ($AUD) and exclusive of any goods and services tax.

It can be clearly seen in the above example, using the OSPDM to monitor and optimise preparation plant performance can lead to large amount of extra coal being recovered. Even small changes in particle density has the potential to see large increase in production which leads to a very short payback period. This payback example has only taken the fines circuit into consideration, but using the OSPDM for optimisation of the fines circuit can also result in increased production from the coarse coal circuit.