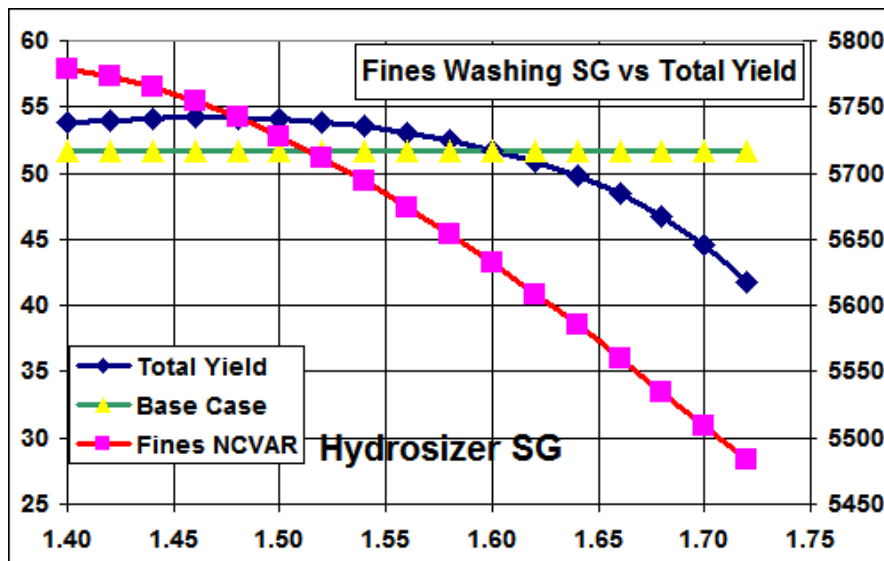


Use of Teetered Bed Separators (TBS) on SA Coal

By Peter Hand & Mark Craddock of QVA Process
Technologies (Pty) Ltd - September 2005

Introduction

The treatment of fine coal (nominally minus 1mm) is very important in the economics of most coal mines as this fraction can constitute up to 20% of the ROM feed (including a slimes fraction, nominally minus 200 microns). However, in an increasing number of cases, the fines are not being treated as the quality after beneficiation is too poor in terms of quality, moisture or both, to add back into the coarser product.



The graph shows a relatively common case, where it would be necessary to treat the fine coal at a density of less than 1.6, otherwise the overall effect of overwashing the coarser material to accommodate the poor moisture adjusted heat value of the fines would be to reduce overall yield. The conventional method of treating fine coal is in spirals, which only effectively treat down to a density of 1.7 and therefore cannot be used in many cases to treat present fine coal which have generally been deteriorating in quality over time.

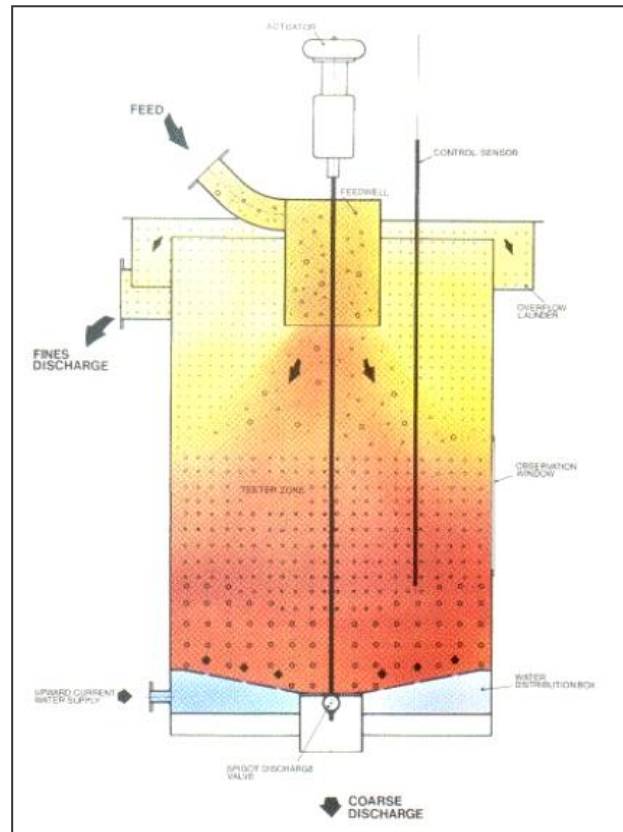
A number of methods can be used to treat fine coal at a lower density, the most obvious being the use of dense medium cyclones, which has been attempted many times, mostly abandoned, but has been revived by Coaltech 2020.

This paper will describe the use of the Stokes Hydrosizer or Teetered Bed Separator (TBS), which has been used since 1934, originally for separating on size for mono density particles. They have been used for coal recovery from waste piles and tailings lagoons since the 1960s and used to treat ROM coal in the UK, US and Europe since the 1980s.

There are over 200 units installed worldwide and applications include coal, iron, sand, foundry sand sizing, glass sand, mineral sands and haematite. There are also many variations on the theme, which often detract from the ultimate simplicity of the machine.

Principle of Operation

The TBS works using by feeding a stream at a density of 50-60% solids (typical classifying cyclone underflow) into a vessel, which has an underflow restricted by a discharge valve. A rising stream of water, across the whole bed meets the falling particles. A zone of particles subject to hindered settling is formed, the teeter zone, the density of which can be controlled by the use of a density probe linked to the discharge valve. The TBS is controlled by a combination of the velocity of the rising water and the apparent density in the teeter zone.



A particle will sink or float against a column of water at a particular teeter density depending on its size and density according to Stokes law (1849):

$$\text{Settling velocity} = \frac{\text{Particle Size}^2 \times g \times (\text{Particle SG} - \text{"Fluid SG"})}{18 \times \text{"Fluid Viscosity"}}$$

An illustration below shows the effect of the water and apparent density in the teeter zone for 2 cases, high (6m³/hr) and low (1m³/hr) water additions. Stokes law has been calculated for each particle combination of size and RD and compared to the upward water velocity in the TBS. Any particle velocity smaller than teeter water velocity will float and any greater will sink.

Australian experience

There are many installations worldwide, of which the Australian experience is the most recent multiple user. There are now 23 TBS installations in Australia, of which the first was installed in 1998 at Stratford in the Hunter Valley, 13 were installed from 1999 to 2003 and in 2004/2005 there are 13 installed or being installed. The



experience is such that a pilot plant is now rarely used and simulations are used to determine guarantees. In Australia, TBS are used to treat coal in the -3 +0.25 mm size range at cut points below 1.60.



Shown is the internals of a 3 metre TBS, showing the feedwell, 3 ceramic discharge valves and the water inlets. The introduction of water from the bottom stops blockages as the bed is lifted on startup. Generally a TBS is stopped under load.

Some commissioning results shown below show the advantage of being able to reduce cutpoint RD, on good coal TBS and spiral performance are comparable, but on poor quality feed the TBS still produces quality.

	Ash %	
	Normal Blend	Stockpile 3
Primary spirals feed	21	30
Primary spirals product (average before desliming)	13	23
TBS feed (average after desliming)	12	21
TBS product (average)	9.5	11
TBS fines centrifuge product	8.5	9
TBS reject	40 to 50	40 to 50

quality easily, very occasional require RD & water flow changes, need little (or no!) maintenance needed, have no blockages as the water coming from the bottom lifts the bed and “Just run”.

Australian separations are normally simple and 1 stage is always sufficient as coarser qualities compensate for any poorer qualities produced in the finer sizes. It has also been shown that TBS plants normally operate better at full than at pilot plant scale.

South African Testwork

QVA decided that in order for the technology to gain acceptance, multiple tests would have to be run, despite the experience derived in Australia.

Consequently two trailer mounted test units were built with full control of density and teeter water



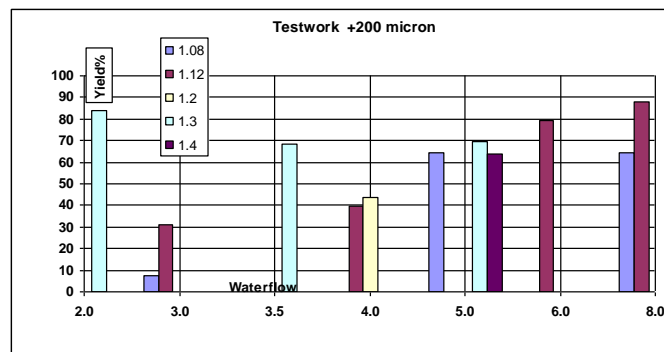
addition on both and one with a feed pump, controlled by VSD feeding a classifying cyclone to ensure a high feed density to the unit.

		Water Flow M3/hr					
		2.50	3.00	3.50	4.00	4.50	5.00
Probe Density (NOT Cutpoint)	1.12						
	1.15						
	1.18						
	1.21						
	1.24						

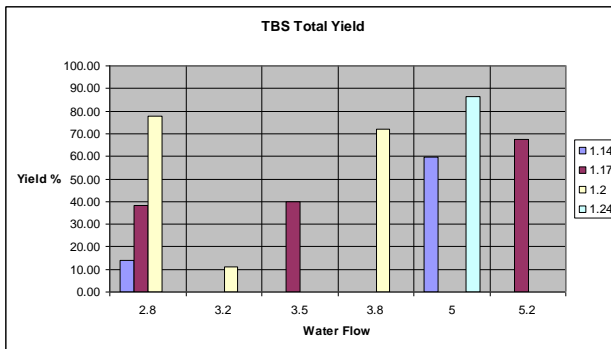
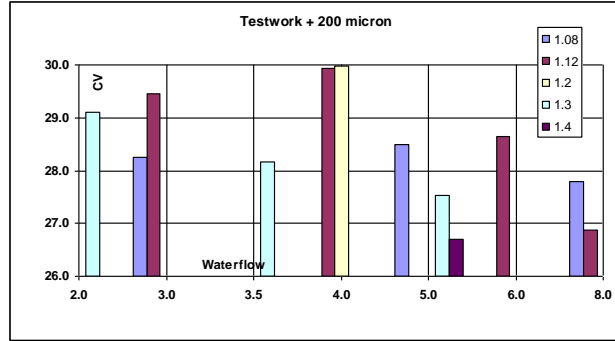
A test matrix is drawn up for each feed coal and tests conducted at a number of points on the grid, not all points on the grid needs to be tested.

Testwork so far has taken place at Landau, Tavistock, Koornfontein, Tselentis, South Witbank, Kleinkopje, Rietspruit, Douglas and Tshikondeni; some typical results are shown.

The results on the right show that potentially a 30 CV product can be made at a yield of nearly 50%. On the other

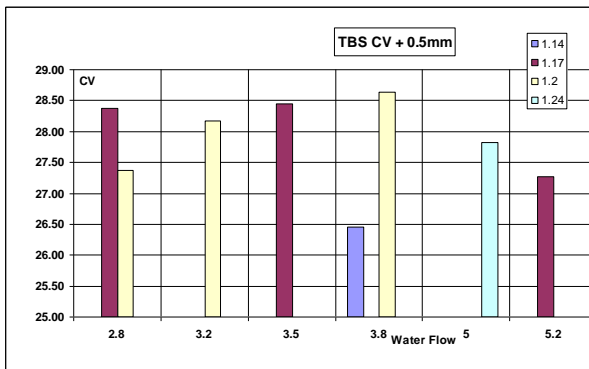


hand a 28 CV can be made at yields of greater than 70%. This was conducted on a plant where spirals had been turned off as they could not make close to required quality.

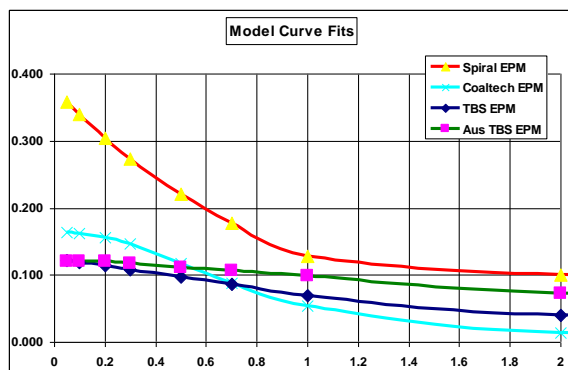


In this case, the qualities are not as good, but were produced from very poor feed coal and are still making better than 28 CV at 60% yield.

Probably, the first case will produce good enough coal overall that a 1 stage TBS down to 200 microns could be used, whereas the second case would probably require the finer coal to be treated at lower teeter water rates.



Economic evaluations have been done in each case and typical paybacks are in the order few months.

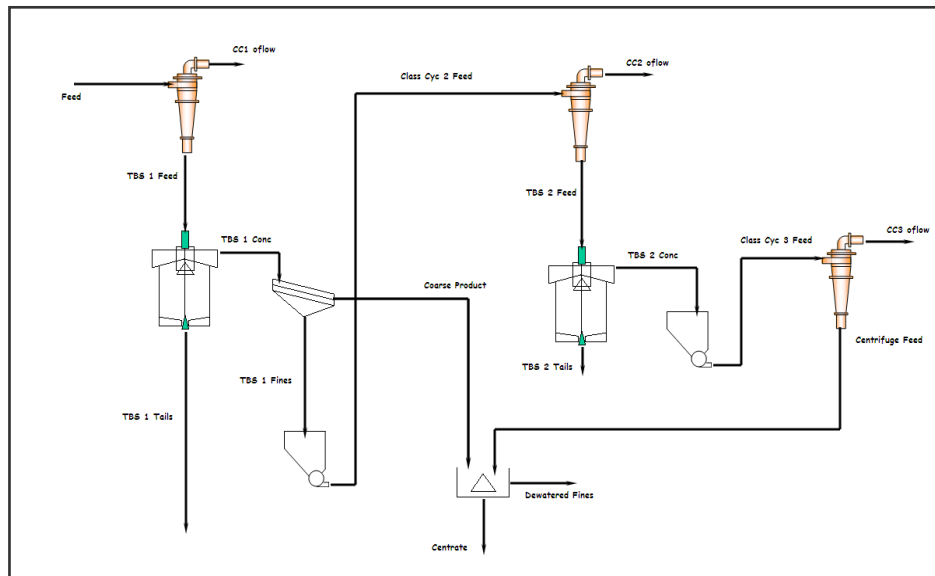


During the testwork various efficiency tests have been conducted. The South African Ep results are comparable with those obtained in Australia and may be modified by using different combinations of teeter water and RD.

Two Stage Testwork

Based on the original testwork and an understanding of Stokes law and its effect on particles of various size and density, it was decided that testwork needs to be conducted on coarser and finer sizes. This is currently under way and seeming to confirm our work.

Basically, more water pushes fines to the overflow with little if any upgrading and a second stage with finer material only would use lower water flows and upgrade finer particles. The combination of coarser & finer fractions gives the correct overall quality.



The circuit above would be the ideal for a difficult feed coal. The total feed would be fed to the first stage operating at higher teeter water rates (which will push all the fines to product as well) and the product screened. The oversize is already at quality, while the undersize is fed to a second stage, at lower teeter water rates. Classifying cyclones are used to thicken TBS feed and to remove the maximum amount of slimes.

Advantages of Using TBS

Over and above the major advantage of being able to produce quality from varying feeds the TBS has a number of major advantages. They can take larger top size than spirals, up to 3mm (although 5mm has been reported). This means that the ever larger cyclones that are being used can have a larger bottom feed size, which may increase efficiency below DSM cyclone breakout point and increasing throughput through existing plants.

The teetered bed separator has a high capacity per footprint area, ease of installation, simple control, mostly unattended and a very simple feed, not requiring distribution to multiple starts.

A major advantage is capital and operating cost as there are no extra operators required and maintenance is minimal and simple. Primary installation or retrofitting is straightforward should be as simple as possible. Footprint is small for the capacity.

An example of payback time is given below using reasonably conservative numbers (especially capex and yield) and adjusting product revenue for moisture adjusted heat:

<table border="1"> <tr><td>ADCV</td><td>28</td></tr> <tr><td>IM</td><td>3.2</td></tr> <tr><td>Total H2O</td><td>13</td></tr> <tr><td>Hydrogen</td><td>4</td></tr> <tr><td>Fines NCVAR</td><td>5760</td></tr> <tr><td>TBS yield @ 28CV</td><td>60</td></tr> </table>	ADCV	28	IM	3.2	Total H2O	13	Hydrogen	4	Fines NCVAR	5760	TBS yield @ 28CV	60	<table border="1"> <tr><td>Coal price</td><td>50</td></tr> <tr><td>Rand / Dollar</td><td>6.5</td></tr> <tr><td>Off Mine costs</td><td>50</td></tr> <tr><td>FOR cost</td><td>275 rands per ton @ 6000</td></tr> </table>	Coal price	50	Rand / Dollar	6.5	Off Mine costs	50	FOR cost	275 rands per ton @ 6000
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Conclusions

Fine coal is being discarded, but can be treated at minimal cost in Teetered Bed Separators. Dewatering is critical for steam coals, but better heat values produced can lessen the need.

Teetered Bed Separators are established, have a large installed base, simple to operate, produce quality and have short payback times.

RSA coals probably need more sophisticated washing than Australian coals. The use of large DSM cyclones makes the bottom size cut off very important if TBS can wash up to 3mm.

Coarser particles & finer may need different TBS regimes, depending on the testwork carried out.

In general, the treatment of fines will be a case of horses for courses; some fines will always be discarded, spirals will work well in some mines and some fines will have to be treated using DMS.

However, the majority should use TBS/Hydrosizers, either in single or 2 stage operation, sometimes in combination with spirals or DMS.

The first TBS in the Witbank area is presently being installed at Anglo Coal's Landau Colliery and is due to be running in December of this year.