

A Case Study in the Implementation Of Novel Technology: Teetered Bed Separators

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What is a teetered bed separator?

Most people are familiar with elutriators, which permit the separation of particles on the basis of particle size. This is achieved simply by subjecting a slurry of a mixture of particles to an upward current of water in a vertical column. Under these circumstances, particles whose settling velocity is greater than the upward current report to the underflow while those of lesser settling velocity report to the overflow. Particles in such devices are separated primarily on the basis of particle size and to a lesser extent on particle density.

If a constriction is introduced into such a column in a manner which

restricts the material exiting via the underflow, material will build up at the exit and a bed of slurry will be formed. This bed of slurry now acts as a dense-medium so that downward moving particles experience a density gradient different from that of the pure liquid. The consequence of this is that a density effect now dominates the separation process.

In practice, the density of the slurry bed can be controlled by an upward water current introduced through a distributor plate. Reject material exits through the distributor plate via a spigot valve. This upward water current is referred to as the teeter water flow and the bed as the teetered bed. A further refinement is added in the teetered bed

separator (TBS), which is that of a density sensor which - in combination with the actuator operated spigot valve - permits the bed to be maintained at a controlled pre-set density. An overall schematic of a teetered bed separator is shown in Figure 1.

What's new?

Nothing! Separators operating on the above principle have been around for over 100 years. Taggart, in his early classic text on mineral processing, describes more than six such devices including the:

- Richards-Janney separator
- Fahrenwaid sizer
- Bunker Hill classifier

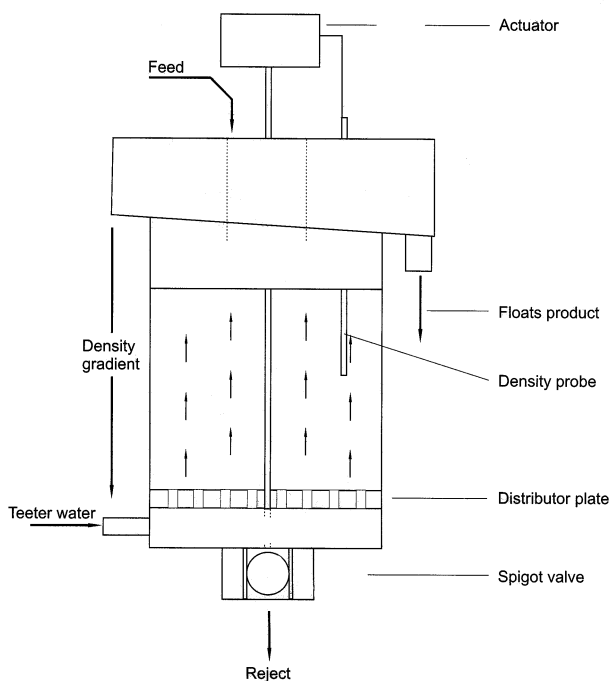


Fig. 1: Schematic of the Stokes/ASE teetered bed separator

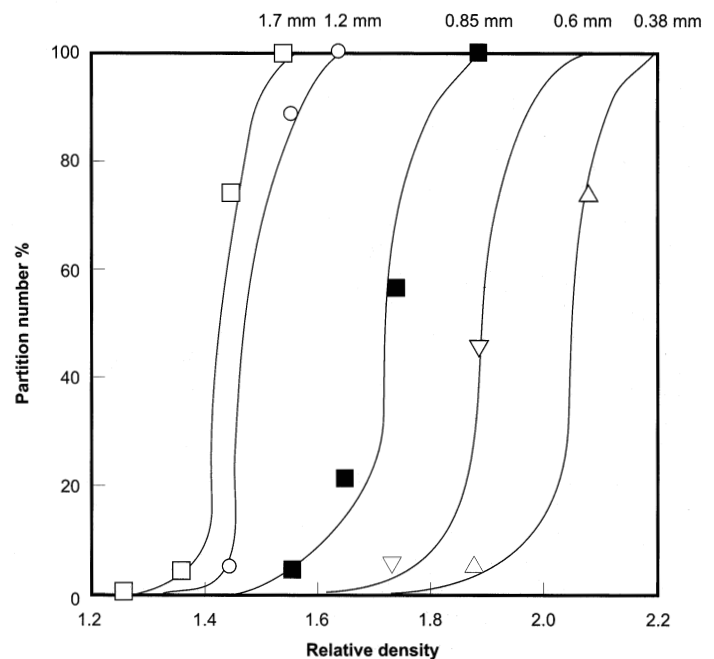


Fig. 2: Partition curves for a teetered bed separator (after Pratten and Galvin)

- Pellet classifier
- Conenco classifier
- Chance cone
- Stokes hydrosizer.

Other devices have been described in the literature over the years but only one device has been used extensively for fine coal separations at commercial scale [Hyde et al; Newling et al; Nicol, 1997]. Over 90 of the latter device have been sold to the coal industry from the UK.

However, while there is little new about the principle on which these separators operate, the manner in which they have been operated has been modified from the situation of 'classifying' on the basis of particle size to

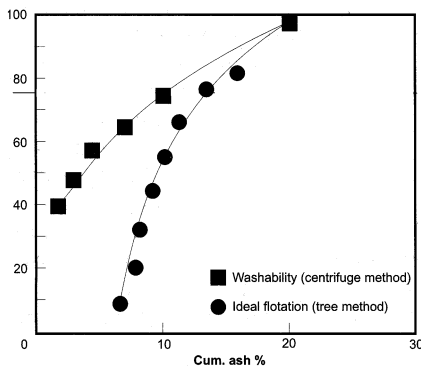


Fig. 3: Comparison of gravity concentration with flotation (after Nicol, 1998)



Fig. 4: A 2.1 m teetered bed separator assembly

being used for separations based primarily on particle density.

This has been achieved by control of underflow removal rates. Considerable refinements have also occurred, over the years, in the associated control systems and in incremental design modifications to the units.

What are the operational advantages?

The principal advantages of these devices are:

- controllable density cut points as low as 1.38,
- good separation efficiency (Ep) (Figure 2),
- high solids handling capacity in a single unit - a 3 m diameter unit will handle up to 150 t/h solids,
- small footprint area, and
- minimal feed slurry distribution problems.

What are the specific advantages to the Australian coal industry?

Most Australian coal operations hold supply contracts which carry ash specifications of less than 10% on coking coal products. These products enjoy a price premium. Mines which produce a coking coal component generally employ a separation process consisting of dense medium separation on the coarse coal fraction (+2 mm), hydraulic concentration on the small coal fraction (-2 mm +0.125 mm) and flotation on the fine coal fraction (- 0.425 mm). The relative proportions of feed coal directed to these individual processes are determined by the washability characteristics of the coal in question. For many coals, these characteristics dictate that a low gravity cut point ($D_{50} < 1.5$) will produce additional yield of low ash coal. A number of years ago, some debate arose concerning the optimum size at which to resort to the treatment of material by higher cost froth flotation. The corresponding question, concerning the appropriate particle size to terminate dense medium separation with its high magnetite losses at fine sizes, was also debated. Nowadays, it is generally agreed that, from an economic point of view, the maximum amount of coal should be treated by gravity based separation simply because these processes have the lowest operating costs and generally produce the higher yields at lower ash content (Figure 3).

It is within this scenario, that the opportunity for the teetered bed separator emerges because of its ability to

treat material in the size range -5 mm +0.125 mm at lower density cut points than other available separators.

What is the status in the Australian industry?

The first teetered bed separator unit was installed in Australia at the Stratford coal preparation plant in 1997. An example of such a unit is shown in Figure 4.

The Stratford unit has a capacity of 80 t/h and is used to re-treat spiral product to produce an enhanced yield of low ash coking coal component. Details of the operation are described elsewhere [Newling]. The operating company has claimed a pay-back period of only a few months was achieved. The unit has been operating for over one year without any operating problems.

Impediments to the introduction of TBS technology in Australia?

The introduction of the first commercial unit to the Australian industry took some five years to achieve. Its ultimate introduction was the outcome of a straightforward consultancy enquiry from a plant metallurgist during the course of one of the Australian Coal Preparation Society's (ACPS) advanced coal preparation programs. At that time, little was generally known about these separators apart from information contained in old textbooks. Subsequent enquiries revealed that there was no active supplier of this technology in Australia and that many of the equipment supply companies had not heard of the separators. In one case, an equipment supplier had such a device in their brochure but did not know its function. In another case, one supplier referred the author to another supplier for operational details! While this situation may seem unusual, it does not necessarily reflect badly on the equipment supply sector because of the economic issues involved in the technical support of technology in an environment of low profit margins and small turnover. In the past, equipment supply to the coal preparation industry was provided by a number of small specialised companies and the industry could often look to these for the introduction of new technologies. Examples of this are provided by the introduction of spirals, horizontal belt filters, belt press filters and ash and moisture gauges.

Nowadays, economic rationalisation has led to the situation where many



Fig. 5: Pilot-scale 0.6 m teetered bed separator at CSIRO

equipment supply companies are forced to offer a much more diverse range of products. This situation is driven by the opportunity to discount prices to purchasers. Unfortunately, this policy can often lead to the situation where technical back-up staff are over-extended to support the sale of this wider equipment portfolio and their ability to introduce new equipment is somewhat diminished.

The costs associated with the marketing of new equipment at commercial scale cannot be over-emphasised. This cost is associated with the construction and development of demonstration equipment and in salaries of specialised support staff. Part of this cost must be passed on to the ultimate purchaser and part must be borne by the supplier. The costs associated with this component of technology implementation will often be much higher than the original R&D costs. This situation leads to perceptions of disappointing and proportionately low returns for researchers without whose endeavours the technology may not have been created. This dilemma acts as a serious

deterrent to the entrepreneurial spirit of potential equipment developers.

During the five-year development period associated with the introduction of teetered bed technology to Australia, extensive pilot-scale demonstration testwork, using a unit similar to that shown in Figure 5, was carried out at numerous mine sites.

All the testwork validated all the claims regarding cut points and E_p values claimed by previous workers. Still, no mine site was prepared to risk installation largely because there was no commercial operating unit in the coal industry. In other words, the classic 'chicken and egg' situation was evident. This was in spite of the fact that the system represented commercially proven technology from the UK. Two of the mines which were seriously examining the possibility of an installation did not proceed because of financial difficulties.

The final breakthrough occurred at Stratford largely because of a fortunate combination of events including:

- provision of an extensive bank of operating data both from within Australia at pilot scale and from over-

seas operation at commercial scale,

- favourable overseas experience with these separators on the part the mine owners,
- the drive of the plant manager to find better ways of doing things, and
- luck - insofar as the correct combination of people and events occurred to permit the implementation of this now demonstrated technology.

Conclusions

Teetered bed technology has now been introduced to the Australian coal industry. Hopefully it will enjoy a successful future as the industry becomes more familiar with its advantages and local expertise finds ways of adapting it to suit industry's needs. Although the technology is old, review of the literature reveals that very little information has been published in the public domain. It is hoped that a project currently funded by ACARP at the University of Newcastle will go a long way to amending this situation, and that the suppliers will publish further information as it becomes available.

With regard to industry implementation of new or different coal preparation technology, this remains a problem which many minds have addressed over time, but for which there is no simple solution. However, a few generalities can be drawn from the teetered bed exercise. These are:

- There is a need for trained people within the industry to recognise technological opportunity when it is presented. This must occur in spite of the current trend for minesites to reduce coal preparation plant manpower. This task is currently an ongoing mission of the ACPS but needs continuing reinforcement and quarantining by mine managers to ensure that the everyday problems of plant operation do not exclude continuing professional staff development.
- There is an urgent need within the industry for greater awareness of the published literature and early dissemination of new information as it arises. This function is partly fulfilled by ACPS conferences and workshops and by the annual ACARP reviews. These roles must be maintained by the industry.
- There is always a need for managers/superintendents with the drive to implement change rather than to maintain the status quo. This is, of course, easy to say but difficult to achieve in tight market situations where production is paramount.

Nonetheless, if it is not done Australia will not maintain its competitive market position.

- Implementation of new technology at commercial scale involves financial risk. This must be the single largest impediment to the adoption of new or different technology. This risk can best be taken by the industry as a whole rather than by individual companies. Many schemes, in many countries, have attempted to do this but with varying degrees of success. Government schemes based on subsidies and tax incentives are obviously attractive but are open to exploitation. Most government schemes focus on R&D but with little emphasis on the D. This needs to change.
- The key to any solution to implementation hysteresis must ultimately rest with the judgment of some form of decision-making panel. It is here that many systems fail. After all, technology developers are most likely to pursue those processes for which fund-

ing is available. It is therefore inappropriate to criticise R&D providers for poor objectivity, in this regard, when their performance is controlled by the decisions of others. It is suggested that possibly some form of peer group election can be introduced to the membership of development grant and tax incentive boards which should include the R&D sector and the equipment supply sector on a strictly non-self interest basis. It remains to be seen how this latter qualification can be achieved in Australia, where the technical population is relatively small.

- Finally, luck plays such an important role, particularly in the kinetics of implementation, that failure to recognise its role would be naive. In an ideal world, its role can be minimised but never eliminated. While clichés concerning the favouring of prepared minds and intestinal fortitude abound, at the end of the day it is the determination and vision of genuinely inter-

ested groups of individuals which will achieve the desired results.

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