HOW TO GET THE MOST FROM YOUR CHPP FLOTATION CELLS

This article will discuss some simple, cost-effective solutions which can be adopted in CHPPs to maximise flotation equipment performance.

Table 1 illustrates some similarities between coal flotation and the cleaning stages in a sulphide concentrator. In addition the nature of concentrate (or product) removal is similar with most of the mass in coal flotation generally recovered in the first 1-2 cells. Figure 1 presents actual plant data from Australian CHPPs to illustrate this point further.

Given these similarities between coal flotation and sulphide cleaners, Table 1 and Figure 1 (page 2), there should also be benefits in sharing ideas with those in charge of monitoring and optimising these operations.

Text: Jason Heath

Froth flotation is used in many Australian coal handling and preparation plants (CHPP) for upgrading fine and ultrafine coal. Although coal and sulphide ore flotation are very different, there are also some useful similarities.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Sulphide Rougher</th>
<th>Coal</th>
<th>Sulphide Cleaner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence Time</td>
<td>20-40</td>
<td>5-6</td>
<td>8-15</td>
</tr>
<tr>
<td>Pulp % Solids</td>
<td>30-40</td>
<td>5-8</td>
<td>5-20</td>
</tr>
<tr>
<td>Mass Yield (%)</td>
<td>3-10</td>
<td>40-80</td>
<td>40-80</td>
</tr>
<tr>
<td>Mechanical Stages</td>
<td>5-6</td>
<td>2-4</td>
<td>2-5</td>
</tr>
<tr>
<td>Froth Carry Rates</td>
<td>0.8-1.5</td>
<td>&gt;1.5</td>
<td>1-2</td>
</tr>
<tr>
<td>Feed Rate</td>
<td>Fairly constant</td>
<td>Variable</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Table 1: Typical operating data for various flotation applications.

Sulphide concentrators and CHPPs have the following common objectives:

- highest possible yield (recovery) at the required product ash (concentrate grade)
- high equipment availability with minimal maintenance requirements
- ability to handle high variability in loading and feed types (recirculating loads)
- operate with minimal supervision
- lowest possible reagent consumption and hence low OPEX

So, how can we maximise the return for CHPPs based on findings from optimising traditional sulphide flotation circuits?
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CHPP product yield trends
A critical factor in coal flotation is froth management. Over the last four years, Outotec has undertaken pilot flotation work and sampling of existing mechanical cells within Australian CHPPs. One of the key observations was the large variation in the amount of froth being recovered down the bank (i.e. yield profile seen in Figure 1).

This typical yield profile can be looked upon as two flotation extremes occurring in a single bank of cells:
1. High yield on first cells, with rapid kinetics
2. Yield falls off rapidly down the bank - and substantial froth crowding is required to maintain the product ash content

The majority of coal comes off the first cell due to the rapid coal flotation kinetics. After this there is a large drop off in mass yield. It can be seen from Figure 1 that the first cell in the bank recovers around 60–70% of the mass in the feed, and then falls off significantly in the remaining cells. Though they are all in the same bank, the individual cells have to operate under very different duties in terms of froth handling and also solids concentration in pulp. This calls for a tailored approach to the cell design.

CHPP product ash management
Control of product ash in mechanical flotation cells is another important aspect in CHPP operation, with product ash generally increasing down a flotation bank. The primary reason for the increase in ash content down the bank is probably due to the lack of attention to froth stability in coal flotation cell design. In a typical CHPP flotation bank where most of the mass is recovered in the first 1-2 cells, there will be significantly less material available to float and help support the froth stability in subsequent cells. In this case of too low froth stability, operators will typically use level and air to try to pull concentrate from the latter flotation stages, with very little or no froth depth. This tends to lead to higher product ash.

CHPP froth management
Flotation cell launder configuration and froth crowding affects the exposed cell surface area and product removal, and hence the performance of the flotation cell. The correct launder configuration and froth crowding is calculated by determining the froth carry rate (FCR) and lip loading (LL), as defined by Equations 1 and 2. So, with the correct FCR and LL, the float cell will be optimised for its chosen duty.

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\text{FCR} = \frac{\text{Solid tonnes per hour in Product}}{\text{Froth Surface Area (m²)}}
\]

\[
\text{LL} = \frac{\text{Solid tonnes per hour in Product}}{\text{Lip Length (m)}}
\]

In an operating plant, there are five main ways to manage froth in CHPPs:
1. Froth washing
2. Froth crowding and launder configuration
3. Split feeding
4. Froth cameras
5. Reagent addition

1. Froth washing
Froth washing is the addition of water to the froth phase to wash non-floating ash particles back into the slurry phase. It is typically used to combat high product ash levels early in a CHPP flotation bank. The amount of wash water added varies depending on the product requirements, as well as water quality, coal seam type, and other factors. There is an optimum wash water volume and too much water will collapse the froth, or wash out too much product (decrease yield).

Coal flotation testing at an Australian CHPP.
2. Froth crowding
Froth crowding and launder configuration affect the froth surface area at the top of a flotation cell. This is normally determined during the initial equipment design, although there are also solutions to adjust froth crowding for already installed equipment. Optimising froth crowding not only improves ash control but generally improves yield. This works by allowing all cells in a bank to operate with a deeper froth, which increases froth drainage and leads to lower ash in the product. This also gives the operator the option to increase the pull rate on his flotation cells hence increasing yield.

When it comes to froth crowding there are the two basic configurations to consider (Figure 2). The configuration in Figure 2a has a larger froth surface area, more lip length and little or no crowding – it is ideally suited to the first cell in a coal flotation bank to recover a high mass. Conversely the configuration in Figure 2b has less froth surface area, less lip length and more crowding – it is better suited to the middle and end of a typical CHPP flotation bank for recovering a lower mass of product. It is possible to retrofit new froth crowders to existing flotation cells to improve froth recovery and cell performance.

3. Split feeding
Split feeding is another option to control the froth carry rate (FCR). Traditionally all the new feed to a flotation circuit enters the first cell at the front of the bank and this cell can often become overloaded with a high volume of froth and hydrophobic minerals trying to float. Split feeding, which has been employed successfully in base metal cleaner circuits, is the process of splitting a portion of the new feed directly to the second cell. By splitting the feed to both cells, the froth volume and mass yield is split (averaged) over both cells, thereby unloading the first cell and maximising yield at the required ash value.

4. Froth cameras
Froth imaging technology is becoming smaller, lighter and more cost effective. Froth cameras are installed over the cell lip to measure the velocity, colour, and stability of froth. The froth velocity correlates with the mass pull from the flotation process and is used to control the operating parameters of the flotation cell, i.e. air flow rate and froth depth. Benefits of controlling froth velocity include maintaining a high product yield, minimisation of product ash, and reduced operator input.

5. Reagent addition
As with most flotation concentrators, reagents are added to assist in the recovery of coal. Too much can result in a very stable and frothy product, which does not readily collapse. This is analogous to a sulphide concentrator cleaning circuit when frother has been overdosed and the concentrate thickener overflow clarity increases. In this regard, both staged and dosing in the correct locations can assist in optimising the amount of reagents added whilst also avoiding over-dosing.

Conclusion
Many characteristics of fine coal flotation are analogous to sulphide cleaner flotation where the emphasis is on handling high mass recoveries and rapid kinetics. Froth management is one of the key considerations in obtaining an optimal float circuit design. Flotation cells with the correct crowding and lip configuration will maximise yield while minimising the ash reporting to the product.

Additionally, there are a number of options in retrofitting or modifying an existing CHPP float circuit. Strategies such as retrofitting of new froth crowders, improved circuit control through using froth cameras, and split feeding can all help improve froth recovery and the flotation cell performance, with minimal operator input even when encountering feed variations.

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