The Karara Iron Ore Project, located 300 km north of Perth in Western Australia, is a 50:50 Joint Venture between Gindalbie Metals Ltd and Chinese steel producer, AnSteel. Karara is a world-class orebody in terms of its scale, quality, consistency and extremely low waste:ore stripping ratio. The known resources at Karara are sufficient to support production of +30Mtpa for more than 30 years.

**Project overview**

The project involves an integrated development of the world-class magnetite deposit at Karara, Western Australia, to produce both high grade magnetite concentrate on site and blast furnace quality pellets in north-eastern China. Gindalbie and AnSteel remain committed to the future expansion of Karara well beyond its start-up capacity and as such, much of the on-site and associated infrastructure is being designed and built to accommodate production levels well in excess of 8Mtpa. The DSO hematite phase is the first stage of the Karara project and is scheduled for 2011.

**Early involvement in thickener design**

The Karara project development team employed the approach of involving their thickening technology provider early in the process design stage. Such an approach is a successful example of how this close and early integration can improve not only the resulting design but also save money. With innovative designs and thinking, the technology provider goes far beyond simply responding to a request for tender or budget quotes and can truly think “out of the box” for the benefit of the project as a whole.

Karara’s initial request for the tailings thickeners used thickener sizing at a flux rate of 0.18 t/m².hr at a feed rate per stream of 474 tph – resulting in the selection of 2 x 58m high rate thickeners for preliminary plant layouts. Other design considerations included overflow clarity of maximum 500ppm, underflow density of 65% w/w solids and potentially challenging civil costs due to thickener construction in the side of a rock hill. Outotec’s ensuing suite of testwork programmes examined many scenarios for an optimised design and delivery of the project targets.
Initial thickening testwork on a Karara tailings sample was carried out by Outotec in February 2007. The results were within the requirements of the project and provided a “target” for further test work, which was conducted by Outotec in August 2009. The August 2009 testwork included sample preparation to mimic expected site water conditions, comprehensive testwork in flocculant and coagulant optimisation, along with dynamic bench-scale testwork at Outotec’s West Perth laboratory. The following chart tabulates some of the results from the two campaigns.

<table>
<thead>
<tr>
<th>Run No.</th>
<th>DILUTED FEED</th>
<th>COAGULANT</th>
<th>FLOCCULANT</th>
<th>UNDERFLOW</th>
<th>OVERFLOW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flux [t/m²h]</td>
<td>Liquor RR (m/h)</td>
<td>Calc.Solids [%w/w]</td>
<td>Type</td>
<td>Dose [g/t]</td>
</tr>
<tr>
<td>Aug 09</td>
<td>0.40</td>
<td>9.97</td>
<td>4.0</td>
<td>150</td>
<td>AN905SH</td>
</tr>
<tr>
<td>Feb 07</td>
<td>0.41</td>
<td>9.40</td>
<td>4.2</td>
<td>79</td>
<td>M10</td>
</tr>
</tbody>
</table>

Design considerations

One important innovation in the Karara tailings thickener emerged from the August 2009 test work. The flocculated aggregates were observed to be quite sensitive to shear, causing the overflow water to lose clarity.

This problem was addressed by utilising a new feedwell design. The Vane Feedwell design helps dissipate energy and prevents short circuiting and was an important inclusion in the Karara thickener design to improve the clarity of the overflow.

Working closely with the Karara team during the laboratory testing proved the old sizing theories for iron ore/magnetite processing have been superseded with the knowledge and results of the industry’s newest feedwell technology. Increased solids flux and rise rates in the testing process proved very successful, resulting in significantly reduced thickener sizes and lower capital expense for Karara.

Unique design of the Outotec Vane Feedwell™
Flocculant dilution and distribution
Due to the importance of flocculant dosing on optimum thickener performance, discussions were held regarding reliable methods for dilution and distribution of the flocculant solution at full scale level. The Karara team approved Outotec’s proposal to use a bridge-mounted open “flocculant mixing box”, which allows the operator to set the dilution rate accurately and is an inexpensive addition to the thickener supply.

Construction considerations
Again, early supplier involvement in reviewing construction options can bring significant benefits. The early and close collaboration between the Karara and Outotec teams allowed detailed analysis of all thickener construction options and whilst thickeners of sizes larger than normal roadway are normally constructed on-site, this is not always the most economical or expedient solution. An on-ground caisson design was initially considered by the Karara team but was eliminated due to factors such as cost and OH&S. Following comprehensive analysis, the most suitable option for Karara was the bolted tank design. Although the bolted design, with its large modular pieces, incurred higher capital fabrication cost due to the significant number of bolts and flanges, it was a better value proposition overall.

Site risk is also significantly reduced with a fully bolted thickener design. No hot work is required at site, all weights are known and all rigging is performed from permanent lifting lugs or shackles through flange holes. There is a major reduction in the amount of confined space work and also the amount of time spent working at heights during fabrication, welding and surface treatment.

Quality management is also better controlled, with most QA performed in the shop. The fabrication process mimics a full assembly, also reducing site risk. Nightshift work is more easily available to accelerate schedule if required.

Conclusion
The initial selection of 2 x 58m high rate thickeners was replaced by 2 x 42m high rate thickeners. This decision was supported by two campaigns of dynamic test work and a consideration of economic and plant operability factors. Another important outcome from the test work campaigns was the inclusion of the Vane Feedwell design in the thickeners. Additionally, further design innovations, such as the flocculant mixing box, were included in the final design.

Based on a study carried out by Karara personnel and costings provided by Outotec, it was concluded that the lowest overall cost, accompanied by minimum site construction time, would be accomplished by designing the thickener tanks for full prefabrication (welding) in the workshop, and bolted final construction on site.

These units were placed on order in August 2010 and are due for completion in December 2011.

Gena Hart is currently the Technology Leader in Thickening for Outotec South East Asia Pacific. Gena who is based in Perth, holds a double degree in Mineral Engineering and Commerce from the WA School of Mines. With over 20 years of ‘hands on’ mining experience Gena has extensive processing knowledge in a variety of mineral disciplines. Previous technical and commercial global roles in water treatment have ensured Gena has particular specialist knowledge in thickening, with the past two years working extensively in testwork management and process design for the rapidly expanding Iron Ore and Magnetite industries.
Building a solid foundation for your mill

The grinding mill is at the heart of a mining operation, but a poorly designed or constructed foundation will not only affect grinding mill performance but potentially render the mill out of action – thereby costing a mine millions of dollars in lost production.

The following advice will help ensure the foundation is right before you install a new mill.

Foundation load specification

It is the responsibility of the mill supplier to specify the mill related loads. These loads are then used by the engineer responsible for designing the mill foundation. Mill loading diagrams are inherently complicated but most reputable mill suppliers will ensure the diagrams are comprehensive enough to include all necessary information but are still as unambiguous and straightforward as possible. For example, some mill suppliers do not state the dynamic loads generated by an operating mill, ie drive train and charge related load variations. Such a document may be far simpler to comprehend, however will cause problems when it comes to correctly designing the foundation. Consideration of static loads is not enough; capacity to accept the dynamic loads while achieving acceptable vibration levels must also be designed into any mill foundation.

Designing the foundations

A reputable mill supplier will also provide a diagrammatic foundation layout, which can be used alongside the loading diagram and gives the foundation engineer a truly comprehensive picture. This layout diagram should not be mistaken for a fully designed solution; there have been cases where this layout was copied and used, as provided, for the installed foundation arrangement. The supplied diagram can help ensure the foundations suit the mill and do not clash with rotating parts – but there is more work to be done by the foundation engineer...

Some factors the engineer should consider include:

1. Mill supplier data:
   Loadings and directions of loadings are easy to misinterpret, especially in dual pinion mills where one pinion experiences a downward load and the other experiences uplift. Such loadings must be carefully noted, along with critical items such as boundary constraints, displacement and vibration limits.

2. Local conditions:
   Small inaccuracies in strata data can dramatically compromise mill performance, so ensure the data is right. It is also important to perform sensitivity analyses and design-out any potential conflicts. In general, local concrete design standards should be applied, particularly in relation to seismic requirements, and consideration should be given to the quality of the materials being used. The capacity of the concrete needs to be carefully considered as not all concrete and reinforcing bars are the same quality!

3. Outside influences:
   Vibrations from other equipment, and adjacent mills in particular, can accumulate to detrimental effect. Adjacent mills of the same size and speed are particularly prone to generating vibration issues for each other. Installing adjacent mills on separate slabs is not always enough to avert problems. Other structures directly connected to the mill must also be considered and should be included in the mill model. Natural frequencies must also be considered and alignment of the foundation’s natural frequency with the dominant frequencies of the mill operation must be studied and avoided.
The construction phase should be planned so that installation and ongoing maintenance access is considered, and the service line access (ie power, instrumentation and lubrication) is appropriately placed. If service line block outs are omitted or unsuitably placed, it can necessitate expensive core drilling or compromise installation runs.

**Constructing the foundations**

The mill foundation is often the largest monolithic concrete structure on a mine site - and it is also the element most likely to bring a concrete contractor unstuck. Following are some key tips to help reduce foundation construction risk, but there are many areas in which concrete construction can go wrong, so choosing a quality contractor is crucial.

The contractor must appoint an experienced team and work with a licensed surveyor. It is also advisable that a plant manager employs a civil construction manager, independent of the contractor, to oversee the work. Without scrutiny, issues can be literally covered over.

1. **Pre-pour**

   Ensuring correctness of cast-ins is a given, as poorly arranged cast-ins can cause problems such as base plate instability. As a result of a poor cast-in box design, the washers for the hold down bolts in the photo below were located partly on a steel open section and partly on a steel plate - some 8mm difference in elevation. This error resulted in a hold down bolt that could never be kept tight and led to pinion bearing base plate instability.

   Just as important is the proper location of the cast-ins within the reinforcing so as to ensure they do not move during the concrete pour. Core drilling is sometimes needed to correct misalignment, so it’s worth getting this right! It is also important to avoid any air pockets under or around the cast-ins during the pour.
Correct foundation bolt installation with uneven washer support

Likewise, be sure reinforcing is properly installed. Once it is covered by concrete it is virtually impossible to check. Reinforcing must encapsulate base plate shear keys and go all the way to the top of the concrete. Block out profiles should follow the shape of the shear key, leaving 50mm of clearance for later grouting.

Make sure the reinforcing is not too close to the concrete surface. If there is a loss of cover exposing reinforcing to the surface, or if the concrete is allowed to absorb fluids that will corrode the reinforcing, concrete cancer will result.

Misaligned jacking plate set in concrete, this should be horizontal

The above picture shows a badly leveled jacking plate which needs to be removed and reset. As concrete is very dense, a large buoyancy induced force can be generated during the pour that acts against the cast-ins. Vibration of the poured concrete only makes this force higher. The cast-ins must be very securely fastened pre-pour such that the ultimate location of the cast-in is the intended location and not displaced by the buoyancy induced forces.
2. During the pour

Large concreting jobs are generally done in stages – but delays between pours can make it difficult to get a good bond between concrete layers, resulting in a ‘dry joint’ which can lead to serious cracking. A dry joint can allow the concrete section above the joint to move somewhat independently to that below the joint. Once this independence is established, the vibration of the mill equipment connected to the independent foundation quickly increases beyond acceptable levels.

If there is the potential of a dry joint due to the pouring process, there are ways of achieving a good bond between the already-poured concrete and the new pour. The responsible engineer should determine which methods are acceptable.

3. Finishing the foundation

The completed foundation needs to be properly grouted so choose the right grout for the job, ensure the concrete is properly scabbled in preparation, and fit hold down bolts with sleeves to allow tightening stretch.

Only the underside of the base plates should be grouted and it is important to ensure there are no air pockets underneath. Chamfer the grout edges away from the base plate to encourage water dissipation. Base plate grouting should be an integral part of the installation specification.

If there are any process solutions on site which could degrade the concrete over time, the concrete must be sealed. This sealant may take the form of a simple epoxy coating to a more sophisticated vinyl ester resin; the choice depends on the type of process solutions liable to come into contact with the foundation.
Conclusion

Producing a good foundation takes attention to detail in the planning, design and construction phases. If the foundation engineer or installer is ever in doubt regarding specific issues, the most important advice is to seek advice. A competent mill supplier will, at the very least, point you in the right direction. Careful management of those phases will ensure your mill is built on a solid, high quality foundation, thereby avoiding any unnecessary, costly problems.

Jeff Belke is Chief Application Engineer - Grinding Mills for Outotec globally. With a degree in mechanical engineering, Jeff has worked in the mining industry for over 17 years, specialising in equipment design and project management. He has been responsible for a number of patents in equipment design. Most recently, Jeff has focused on the engineering aspects of Outotec’s grinding mills related to operability, maintainability and development.

If you would like more information, click here to contact

Jeff.belke@outotec.com
Secondary copper processing – a more sustainable solution

Steady depletion of the world’s primary copper reserves (i.e. from concentrates), coupled with a meteoric rise in electronic waste (e-waste) generation, has led to secondary copper processing assuming an ever-increasing importance within the global copper industry. This article talks about the pyrometallurgical processing (smelting) of copper secondaries and some of the unique issues facing secondary copper smelters.

Firstly, what is secondary copper?

Secondary copper refers to all non-primary sources, such as metallurgical wastes (low grade slags, anode slimes), industrial wastes, (copper sheeting, bars, pipes etc) consumer wastes (brass and bronze applications) and e-waste (domestic electrical, audio-visual, telecoms appliances, computers etc). The contribution from secondary copper to global copper production has steadily increased in the last 30-40 years and is currently around 35%, as per the International Copper Study Group, 2010.

Drivers for growth in secondary copper processing

Apart from the limited availability of primary concentrates, the increased importance of secondary copper is a result of factors such as the high copper and precious metal content (e.g. Au, Ag, Pt) in secondaries such as electronic scrap and also legislation (particularly in the EU, China and Japan) mandating treatment of secondary copper materials. The meteoric rise in global e-waste production in particular (currently more than 40 ktpa) as a result of the rapid growth of electronic markets and the short lifespan of electronic products (United Nations Environment Program, 2009) has also been a significant driver for growth in secondary copper processing. Additionally, as industry becomes more aware of the environmental impact of its solutions, the superior environmental performance and energy efficiency of secondary copper smelting compared with primary smelting make this a favourable processing option.

Secondary copper processing options

Traditionally, treatment of secondary copper feeds at existing smelting operations was performed in the blast furnace, Peirce-Smith converter and/or anode furnace. In the last 15 years however, due to their superior environmental performance and operational flexibility, there has been a shift towards secondary copper processing using bath smelting technologies such as the Outotec Ausmelt Top Submerged Lance (TSL) and the Outotec Kaldo Top-Blown Rotary Converter (TBRC) processes.

The pyrometallurgical processing of copper secondaries is characterised by a number of issues not prevalent in primary smelting. Impurities associated with these materials are significantly different to those contained in primary concentrates, necessitating differing process flowsheets and operating conditions for impurity removal along with specific gas handling/cleaning operations for capturing NOx,
Halogens, Dioxins etc. Furthermore, unlike concentrates which typically contain Fe, SiO₂, CaO & MgO based gangue components, secondary feeds are often associated with only SiO₂ & Al₂O₃ - necessitating a different approach to fluxing.

These differences and variability in feed composition have implications on the design and operation of equipment and processes, presenting difficulties in the treatment of secondary copper materials within existing smelter operations. To address these factors and the increasing availability of secondary copper feedstocks, a number of facilities have been established in the last decade or more for the dedicated processing of these materials. These operations have focussed on achieving the necessary flexibility to adapt to feed changes whilst tightly managing key process variables for stable operation within best practice in environmental control.

**Secondary copper processing in the Outotec Ausmelt TSL Furnace**

The Outotec Ausmelt TSL process is ideally suited to handling the complex and variable composition of copper secondaries through precise control of the process chemistry, temperature and bath oxygen potential (pO₂). Operating conditions within the bath are regulated via the injection of fuel, air and in some cases, oxygen, directly into the slag phase using a submerged lance. Conditions above the bath ‘splash’ zone are regulated independently of the bath through the addition of air via a dedicated lance ‘shroud’ system. Shroud air also provides for the efficient recovery of heat generated from the combustion of volatile components of the feed without influencing the bath pO₂.

The precise level of process control achievable in the Outotec Ausmelt TSL Furnace enables the recovery of metal values to targeted product phases from which they can be economically recovered. Additionally, impurities and gangue components are directed to a discard slag or by-products which can be safely handled and treated.
Flowsheet options

There are a number of flowsheeting options available for treating secondary copper materials in the Outotec Ausmelt TSL furnace. Typically, lower-grade (‘dirty’) feeds are smelted under reducing conditions to generate a ‘black copper’ intermediate product which may then be converted under oxidising conditions to a clean (raw) copper product either in the same Ausmelt furnace or in a separate vessel(s) such as the PS converter. High-grade (‘clean’) feeds may be introduced during the converting stage in the Ausmelt furnace, with the copper containing slag and fume/dust from this stage recycled to the subsequent reduction cycle.

Ultimately, flowsheet selection is based on the grade of secondaries being treated, the type and concentration of impurities in the feed, the nature and capacity of existing processing/refining infrastructure and client’s preferred product stream/s. Furthermore, the inherent versatility and flexibility of Outotec Ausmelt TSL technology allows for the addition and/or removal of extra stages, even if not included within the original design.

Some recent sites using the Outotec Ausmelt TSL process

The DOWA secondary copper smelter operated by Dowa Mining in Kosaka, Japan was started up in 2007 and is used for the treatment of up to 150 ktpa of secondary copper feeds. The process flowsheet at this facility incorporates multiple stages operated under both oxidising and reducing conditions to produce a high-quality copper product, discard slag and recover Pb, Zn, Ni and PM values during refining.

Another site which uses the Outotec Ausmelt TSL technology to process secondary copper feed materials is LS Nikko’s Global Resources & Material (GRM), facility in Danyang, Korea. This plant operates continuously under reducing conditions to produce black copper which is upgraded to raw copper using Peirce Smith converters. This plant was commissioned in 2010 and has a capacity to treat up to 110ktpa of secondary feeds.

Conclusion

In conclusion, the recycling of secondary copper materials and processing of ‘end-of-life’ consumer goods is a significant contributor to global copper production. Given the variability and complexity of secondary copper feed, smelters must incorporate technology with the flexibility to vary operating conditions and practices with the ever-changing nature of feed materials being treated.

This article is an abbreviation of the paper ‘Secondary Copper Processing using Outotec Ausmelt TSL Technology’ by J Wood, S Creedy, R Matusewicz and M Reuter. The paper was presented at the AusIMM’s MetPlant conference in Perth 2011.

If you would like more information, click here to contact stephen.hughes@outotec.com
Flotation upgrade leads to improved recoveries for Stawell Gold

Northgate’s Stawell Gold mine is located alongside the town of Stawell, northwest of Ballarat in central Victoria, Australia. Stawell has a history of gold mining dating back to the mid-19th century Victorian gold rushes. It is an underground gold mine, with a long 26-year history, having produced its two millionth ounce in March 2010.

At Stawell, one of its main aims is to achieve operational excellence. A change in production profile, requiring the processing of lower grade ore at higher throughput rates, solicited the need for increased recovery condition in the milling environment.

**Flotation circuit**

The original flotation circuit at Stawell consisted of a bank of 8 mechanical trough cells in the rougher circuit, followed by 2 banks of 2 x OK3 Outotec cells as cleaners. The feed rate to the cells was between 90-105 tph, at 50-55% solids. The overall flotation circuit was not performing at optimal rate due to entrainment problems in the rougher cells when feed density increased from 45% to 55% solids, typically at 105 tph. In anticipation of future production levels and as part of Stawell’s focus on operational excellence, it was decided to upgrade the flotation circuit at Stawell. Since site’s testwork had shown that a 12.5m³ conditioning tank was no longer required and could be removed, the new rougher cells were to be installed in that location.

**Rougher circuit optimisation**

Following a site audit from Outotec Services, a 2 x TankCell-20 configuration was proposed to help optimise flotation operation. The old rougher circuit had all cells on the same level and was prone to back mixing, short circuiting and flotation inefficiency. Additionally, the old circuit had to operate with a very shallow froth depth in order to get the froth concentrate to the collection launders.
Outotec Services proposed the existing rougher circuit of 8 cells be replaced by 2 x TankCell -20s cells. These cells were to be equipped with the larger TankCell -30 mechanisms, which would allow operation at very high percent solids (50% and over). The TankCell design also allows a much deeper froth depth and better concentrate grade through optimised launder lip length and surface area.

**Turnkey installation**

Outotec Services were commissioned to handle the complete turnkey solution of the new rougher circuit, including design, supply, installation and commissioning. This comprised all civil works, electrical, instrumentation, mechanical, ancillary equipment, piping and structural steel work. Plant cut-in services were also included in the project scope, along with the supply of two blowers, which were to provide for the complete flotation circuit at Stawell. The schedule was demanding but achievable, with work to commence in February 2010 and complete in September 2010, just 30 weeks later.

**Before the upgrade, the old conditioning tank in a highly challenging footprint**

**Partnership approach**

It was decided to adopt a partnering approach between Stawell and Outotec Services, as this collaborative method ensured open communication, with all parties having greater ownership of the project and its aims. The close teamwork between Stawell and Outotec Services ensured meticulous planning and enabled site to be fully operational at all times. Pipework and electrical easement ducts, for example, were rerouted early in the project and helped ensure continuous site operation. Issues such as tie-in points for new cells and rerouting of pipework were also planned upfront and all disruptive work was completed during shutdowns, ensuring no interruption to production. The connections to the new TankCells, for example, were conducted during one of Stawell’s scheduled shutdowns.

**Challenging footprint**

The planned site for the new rougher circuit was challenging and on an extremely limited footprint. The site was adjacent to a gabion wall, close to the run-of-mine pad and also a reagents shed, which could not be moved. Additionally, existing process requirements at Stawell required specific elevations for the new TankCells. Structural stability was the main issue when designing the tank support structure due to the height of the tanks and the limited footprint. Sufficient stiffness was required such that the operating frequencies of the TankCells would not interfere with the natural frequency of the tank support structure. Through FE modelling of the structure, section sizes and bracing orientations were optimised to produce the required stiffness.
Civil works
The civil work was also highly challenging. An underground slab was discovered during the excavation work of the site. In order to ascertain how to best proceed, core samples from various layers and testing was arranged by Outotec. Fortunately, it emerged that only part of slab needed to be removed for the TankCells’ support civils. Although this caused a delay to site work, all parties worked hard to quickly resolve the issue and stay within the project timelines.

On-time commissioning
The weather proved to be an additional hurdle as site experienced the wettest seasonal weather in recorded history during the project. Simple tasks such as curing of the paintwork, which normally takes 24 hours, took days instead. Despite these challenges, the turnkey installation of the new rougher circuit, along with blowers for the complete flotation circuit, happened within deadlines. As all tie in points had been already carefully planned upfront, commissioning was a seamless exercise. On 13 September 2010, just 30 weeks from commencement, the new circuit, complete with TankCell technology, was commissioned and brought on line – on time and within budget.

State-of-the-art flotation technology
Designed to cope with projected increases in production and considerably more operator friendly than its predecessor, the new TankCell -20 cells have quickly proved their worth at site. The air demand for the old rougher cells, for example, was estimated at over 3,000 Am³/hr, whereas the estimated air demand on the TankCells is a maximum of 992 Am³/hr. The FloatForce rotor-stator mechanism, with its unique design, delivers enhanced flotation cell hydrodynamics and improved wear life and maintenance.
Results from site

Following the flotation upgrade at Stawell, the targeted recovery rate improvement was projected at 3.5%. The actual recovery rate, however, improved instantly by 4.5%. Payback was also impressive, occurring within less than 4 months.

“The projected payback was 5.5 months, so it was a pleasant surprise when it happened so soon” explains Jodie Hendy, senior metallurgist at Stawell.

“Maintenance on the TankCells has also been minimal since the upgrade. Basically we check the cells during shutdowns but there has been no maintenance required in the 9 months since commissioning. The TankCells have really delivered on their reputation. Basically they do exactly what they are supposed to do.”

If you would like more information, click here to contact

wayne.pearce@outotec.com