APPLICATION OF FRAME-TRAK® CLOTH FIXING TECHNOLOGY WITHIN THE PRODUCTION ENVIRONMENT: THE WORSLEY EXPERIENCE

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Abstract

An extended production trial of Frame-Trak® cloth fixing technology has been undertaken at Worsley Alumina. The Frame-Trak® system of fitting filter media has been designed by Clear Edge Filtration and Bokela GmbH, to replace existing caulking rope and retaining plate locking mechanisms on rotary vacuum filters. Frame-Trak® aims to eliminate Occupational Health and Safety (OH&S) issues associated with the existing methods of cloth affixation while promising filtration efficiency improvements by providing an improved vacuum seal. Frame-Trak® was retrofitted to a single 60m^2 vacuum drum filter performing first stage fine seed filtration duty in late 2005.

Installation of Frame-Trak® was labour intensive and resulted in significant downtime. Design oversights contributed to poor filter performance and difficulties with drainage grid and cloth fit. The combination of these factors resulted in repeated failures, hydrate scale forming in the profiles and lengthy re-cloth times, contrary to design intent. Refinements to cloth design and fitting techniques, along with tooling modifications and education of personnel have since led to improved quality and ease of installation. Consequently, hydrate scale in profiles and failures in operation have been largely eliminated while cloth life has been extended.

Trial of Frame-Trak® at Worsley has delivered OH&S benefits by eliminating forceful re-cloth tool use. Re-cloth times are now comparable to the previous cloth fixing method and in terms of performance the technology offers extended cloth life, equivalent throughput, improved cake release and reduced cake recycle. Frame-Trak® is emerging as a convincing alternative to traditional cloth fitting technology.

1. Description of Frame-Trak® Technology

Frame-Trak® is a new method for attaching filter media to rotary vacuum filters designed by Clear Edge Filtration and Bokela GmbH to replace existing caulking rope and retaining plate locking mechanisms. Tebbutt (Tebbutt, 2005) has previously described the Frame-Trak® design (Figure 1).

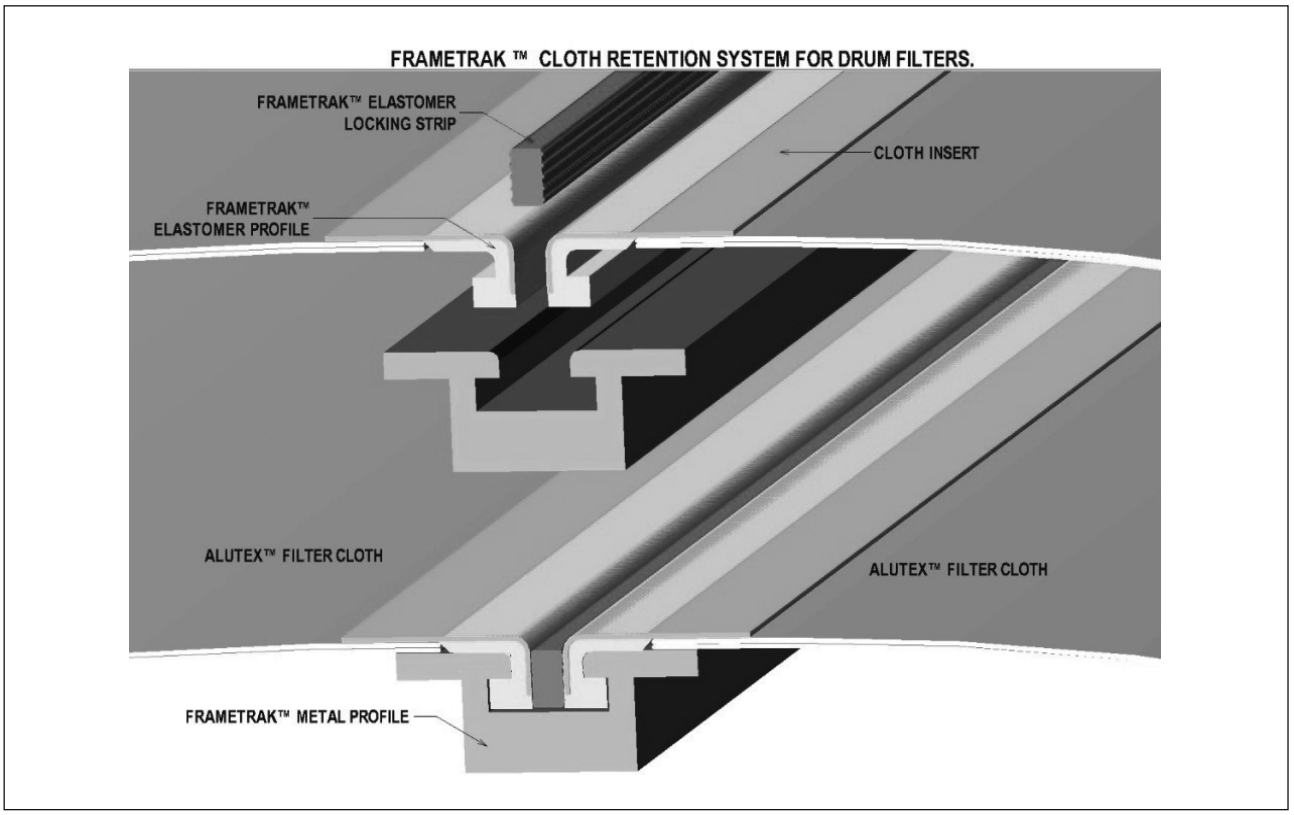

Figure 1. Frame-Trak® Component Assembly

2. Introduction and Background

The Worsley Alumina precipitation circuit employs oxalate co-precipitation and hydrate classification producing a fine seed stream rich in solid phase oxalate (SPO). This stream is subjected to two stage fine seed filtration and oxalate dissolution to produce a clean fine seed and a wash filtrate stream rich in liquor phase oxalate (LPO) for oxalate removal from the circuit. First stage consists of 6*60m^2 drum filters, and second stage a further 4*40m^2 drum filters.

Initially Worsley's fine seed drum filters employed a caulking rope mechanism for cloth fixing. The caulking rope system presented a number of safety risks as evidenced by the frequency of hand and wrist injuries incurred by operations personnel during re-cloths. In an endeavour to mitigate this risk the filters were converted to a hybrid caulking rope and threaded stud/metal retaining plate mechanism. The caulking rope was retained for cloth affixation around the ends of the drum (circumferential profiles) while threaded studs and retaining plates were employed for inter-panel cloth affixation (lateral profiles).

The hybrid system provided safety benefits by reducing percussive tool use, but presented new problems:

- frequent stud weld repairs during re-cloths resulted in extended re-cloth times and eventual cracking in segment dividing channels
- scale would build up in the channels, which, if not removed before cloth replacement could contribute to cloth perforation
- necessitated use of pneumatic hand tools which were heavy and subjected the operator to sustained vibration
- safe handling and storage of retaining plates (4m length) during re-cloths was difficult
- studs required for fastening of the steel retaining plates protruded at least 20 mm from the drum surface increasing required clearance between the drum and cake discharge scraper contributing to cake recycle and reduced filter capacity
- required punching of holes in the filter cloths to allow fitting over the studs. If not effectively sealed during re-cloth, these channels could allow short-circuiting of feed to the filtrate contributing to elevated filtrate solids.

Prototype Frame-Trak® disk filter segments were successfully trialled at Worsley during 2004-05. Subsequently, a long term production trial of the system on a fine seed drum filter was approved with the main aim of improving re-cloth OH&S.

4. Frame-Trak® Installation

Three segments on a single drum filter performing first stage fine seed filtration duty were retrofitted to Frame-Trak® in May 2005 as a pre-trial. Initially, ingress of hydrate into the metal Frame-Trak® profiles was a problem but was manageable if cloth panel installation of high quality was achieved. It was decided to proceed with complete conversion of the drum to Frame-Trak®, but full installation and recommissioning of the filter in December 2005 was labour intensive and took significantly longer than expected.

Removal of existing Omega profiles and replacement with Frame-Trak® profiles was planned to take 8 days. Work was performed by an existing Worsley Alumina engineering contractor under Bokela supervision. Arc air gouge removal of the initial Omega profile welds was expected to be effective but slag from the stainless steel welds proved difficult to remove from the drum surface. Subsequently, the Omega profiles were ground off the drum, extending the conversion to 12 days (including 3 night shifts).

Fitting of the first Frame-Trak® panels after the conversion proved very difficult with only 5 panels completed during the first shift. Discussion between Bokela and Clear Edge Filtration representatives revealed that a design error had occurred whereby cloth panel dimensions had been calculated from the drum circumference as opposed to the effective circumference inclusive of the new Frame-Trak® profiles. In response Clear Edge Filtration immediately commenced manufacture of revised cloth panels of corrected width.

The design oversight that has contributed most significantly to difficulties in applying the technology at Worsley has been the lack of consideration given to drainage media. The metal Frame-Trak® profiles installed at Worsley are of different width to the original Omega profiles and provide less lip depth to retain drainage media. It was assumed that Worsley's stock drainage grid would be compatible with the Frame-Trak® system but this has not proven to be the case in practice.

When installed in the Frame-Trak® profiles, Worsley's standard drainage grids bowed out from the drum surface 10-20mm. This was deemed unsatisfactory due to increased risk of cloth damage from contact of the bowed cloths against the cake discharge scraper. Drainage grids were manually modified by shaving of a small length off each retaining lip. Because of urgency to get the filter back in service, initial drainage grid modification was crudely performed with a hacksaw in the field. Modifications were effective at reducing grid bow but detracted from grid firmness of fit.

When subjected to caustic and elevated temperatures during prolonged service, standard polypropylene grids have been found to mould to the curvature of the drum and shrink slightly (based on ambient temperature measurements of new and old grids). Mechanical grid testing by Bokela has also confirmed that the grid lip displays significant loss of stiffness at elevated temperatures (90-95°C) as expected. These factors are believed to be the causes of grids dislodging during drum rotation after cloth removal (especially during caustic cleaning).

Drainage grid incompatibility has been compounded by variance in lateral profile spacing across the drum which is a result of the difficulty of the in-situ conversion and the techniques employed. Worsley's drum filters are 4m wide and during installation Frame-Trak® profiles of this length displayed deflection under their own weight making accurate alignment for welding difficult. Consequently, it has proven impossible to determine a set of dimensions to which the standard grids can be modified to give the quality of fit required to guarantee retention during caustic cleaning.

Insufficient durability of the roller wheels on the prototype locking strip insertion tool resulted in it also failing during the initial re-cloth. Clear Edge Filtration promptly despatched a new tool as there was no spare tool on site. The replacement tool was different to the original and required modification by Worsley, but the modification was performed incorrectly and the tool proved difficult to use. Operators eventually resorted to inserting a large amount of locking strip by hand in a manner similar to that employed for caulking rope.

Additionally, maintenance personnel had to postpone relocation of the cake discharge deflector closer to the drum due to seized support bearings.

Due to these problems, conversion of the drum to Frame-Trak® (including re-cloth) took 3 weeks.

5. Initial Performance

When recommissioned, the Frame-Trak® filter's cake pick-up and cake discharge was poor and composite filtrate solids were

significantly elevated. Poor performance was due to the poor seal achieved by the newly installed Frame-Trak® metal profiles resulting in impaired vacuum (drying zone) and feed slurry ingress to the filtrate (forming zone) as evidenced by liquor issuing from the drum ends during blowback at locations corresponding with the junction of the lateral and circumferential profiles.

Initial Frame-Trak® installation plans called for seam welding of only three of the internal edges of each vacuum segment, with stitch welding of the leading lateral edge. This proved a design fault. Arrangements were made with Bokela to carry out weld modifications to the filter but were delayed for two weeks over Christmas. Then, in an attempt to avoid full cloth panel removal for weld repairs and due to the difficulty encountered during the initial re-cloth, initially only 10cm fillet welds were made at the end of each stitch welded seam. It was thought that the channel under the profiles adjacent the fillet would fill with hydrate and seal the leaks but the problem persisted when the filter was again brought online. Filter performance was finally restored by full seam welding of the upper lateral of each vacuum segment.

6. Early Operating Campaigns

The first complete Frame-Trak® filter re-cloth was compromised by the installation of 6 cloths that were too small for the duty (due to the original sizing error and subsequent shortage of raw materials to produce a full replacement set of correctly sized cloths) and a proportion of poorly fitting locking strip (caused by operator inexperience and poor design/durability of the locking strip insertion tool). This allowed hydrate ingress and scale growth within the metal profile. The ends of the lateral locking strips also gradually worked loose. During the first few campaigns, loss of cloths in service was intermittent and commonly associated with dislodged drainage grids. On multiple occasions lost cloths and grids that could not be easily recovered from the bowl required recovery via removal of the bottom bowl inspection ports to prevent subsequent cloth damage.

Ingress of hydrate into the profiles meant that subsequent cloth fixing operations were time consuming and difficult. Where scale was not fully removed cloths were difficult to fit (or left poorly fitted) and cloth losses during operation were repeated, allowing scale to again develop. It is clear from Worsley's experience that prevention of scale build up in the metal profiles and correct fitting of cloth panels and locking strips are mutually dependent.

Scale removal for the second re-cloth was performed using primarily manual techniques (wire brush, chisel and mallet) largely because the extent of scaling was underestimated. While manual scale removal appeared effective, during cloth fitting small amounts of difficult to observe hard hydrate scale, primarily within the lateral profiles, hindered cloth attachment.

For the third re-cloth a concerted effort was made to ensure the metal profiles were completely scale free prior to attempts to re-fit cloths. A portable high pressure water cleaner was initially employed but found ineffective on hard scale. Next an extended 4 hour caustic clean was employed which proved effective. Caustic cleans of shorter duration had previously provided unsatisfactory results, likely related to inefficient liquor agitation around the internal Frame-Trak® profile surfaces.

With correctly sized cloths and effectively de-scaled profiles the third re-cloth was a significant improvement. There was good acceptance of the procedure by all four operators involved. Time spent actually fitting cloths amounted to 1.5 shifts and secure locking strip insertion was achieved. Following the third re-cloth no cloths were removed during operation (apart from an incident of operator error where three consecutive cloths were ripped from their profiles when the drum was rotated from a bogged position with the forming zone vacuum open).

For this campaign it was decided to run the cloths to failure to evaluate their maximum service life. The Frame-Trak® cloths performed well, achieving 11.5 weeks operation, much longer than cloths installed with the hybrid system.

7. Refinement

Although the third Frame-Trak® re-cloth was more successful, long re-clothing times relative to the hybrid system and general lack of operations acceptance were still major concerns. Refinements have since been made to the Frame-Trak® technology to address these and other problems.

Negative Frame-Trak® feedback was recognised as largely attributable to insufficient training of the crews performing the re-cloths. Basic training had been performed around the time of the initial conversion but this had encompassed mainly coordinators and shift supervisors instead of the operators performing the work. A formal training package was developed and deployed to two members and the coach of each operations crew. The training sessions included an audio-visual presentation of the Frame-Trak® concept and practical re-clothing demonstration using a full scale demonstration segment. Training sessions also provided a good opportunity for open dialogue between operators and Clear Edge Filtration staff, which proved useful for further refinement of the technology. With deployment of the training sessions, the standard work instruction (SWI) for Frame-Trak® re-clothing was revised.

Minor changes to the planned re-cloth procedure have helped to reduce total re-cloth time to a single shift. With better quality cloth panel installation minimising scale growth, caustic cleaning on continuous circuit for at least 4 hours is practical for preparing profiles for cloth fitting given caustic brew strength and temperature are maintained. The filter is now taken offline and stripped (cloths and grids) late day shift or during night shift immediately preceding planned re-cloths. The filter can be stripped of cloths in 30 minutes and although at least twice this time is required to also remove grids, this procedure enables a re-cloth to be completed the following day shift.

The locking strip insertion tool has been simplified to now consist of only two roller wheels of greater durability (Figure 2). Worsley also have the design drawings to allow fabrication of additional tools as necessary. As the tool now has only two wheels it does require more operator control to maintain upright. While there is general operator acceptance of the tools, it is likely further development of the design is possible to optimise ergonomics. Lowering the filter re-cloth platform height has also improved ergonomics by making re-cloth posture more erect while increasing the number of panels that can be completed before drum rotation is necessary.

Possibly the simplest and most significant refinement has been the use of a mild detergent solution (dishwashing detergent) to ease locking strip insertion. The solution is brushed onto the metal profiles prior to fitting cloth panels and again used to coat the panels prior to locking strip insertion. By reducing the frictional resistance to movement of the elastomer when in contact with other surfaces, the detergent reduces the physical force required to achieve locking strip insertion without affecting cloth panel reliability in service.

Modifications to the Frame-Trak® elastomer gasket have been made to improve durability. While operating campaigns as long as 13 weeks have been achieved between complete re-cloths, several individual cloth panels typically require replacement before this time. The major failure modes have been:

- splitting of the mitred elastomer welds in the cloth panel corners (Figure 3)

Figure 2. Photographs of the simplified locking strip insertion tool

- splitting of the elastomer gasket longitudinally between the cloth stitching and the outside panel edge
- fraying of the fabric "spine" of the panel gaskets starting from the cloth stitching (Figure 4)

The frequency of failures has been reduced by increasing elastomer thickness on the leading surface of the gasket extrusion to improve resistance against abrasive wear (fraying) and to improve the strength of the mitre welds. Modifications have also been made to the gasket cross-section at the location of cloth stitching to provide added resistance to splitting (believed to be due to cyclic flexing during repeated blow cycles).

Figure 3. Frame-Trak® gasket splitting at mitred elastomer weld

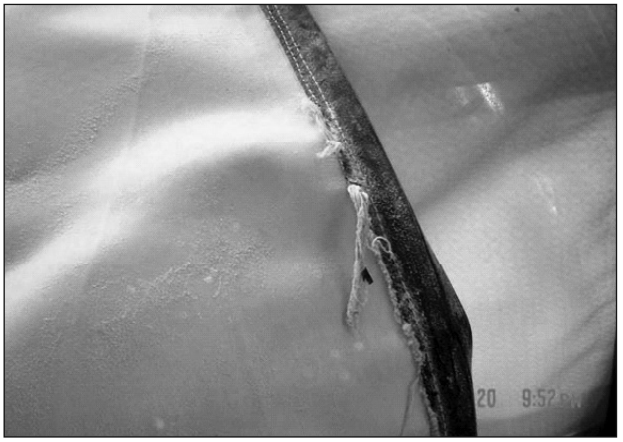

Figure 4. Fraying of Frame-Trak® panel gasket adjacent stitching

The locking strip has been modified to improve dimensional stability (especially stretching and narrowing under tension) through the addition of a rope cord 'spine' (Figure 5). This modification has reduced locking strip rippling during insertion and would logically improve the normal force applied by the locking strip against the cloth panel gaskets, providing a tighter seal.

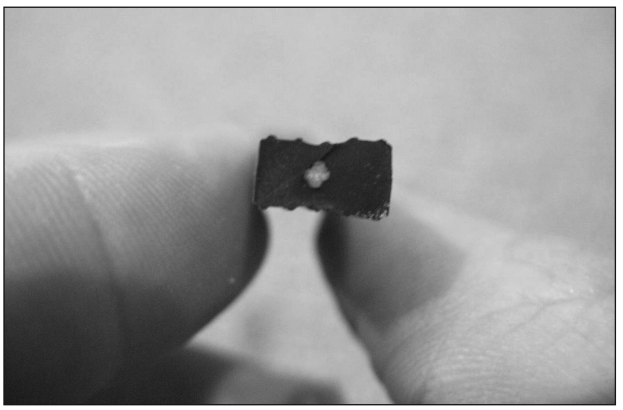

Figure 5. Close-up view of Frame-Trak® locking strip showing rope cord 'spine'

The cake discharge scraper on the Frame-Trak® filter has been moved slightly closer to the drum surface. Although this represents one of the greatest process advantages afforded by the Frame-Trak® system, in Worsley's case the scraper cannot be moved as close to the drum as desired because it deflects centrally under its own weight. Although it is only 10-15 mm from the drum surface in the centre, clearance at the ends of the drum increases. Unfortunately, this does not allow Worsley to realise the reduced cake recycle potentially deliverable by the system.

8. Current Performance

Currently, the Frame-Trak® filter is operated with a target re-cloth interval of 12 weeks (although re-cloths are consistently performed between 10 and 12 weeks). This is almost double the target re-cloth interval of six weeks for the hybrid system. When the locking strip is inserted well during re-cloth, hydrate observed within the metal profiles during the following re-cloth is mostly powdery in nature and can be easily washed clear using process water. Cemented hydrate generally only forms in the profile corners where a small gap exists at the point where the lateral locking strip terminates and abuts the circumferential locking strip (Figure 6), but this is effectively removed during caustic cleaning.

Figure 6. Scale formation in metal profile corners

Analysis of available data indicates the Frame-Trak® filter provides equivalent throughput to filters using the hybrid system (Figure 7). Multiple parameters including filter speed (variable), doctor spray condition and forming zone vacuum affect fine seed filter performance, complicating this analysis. From subjective visual observation, the Frame-Trak® filter also appears to provide improved cake release over the other first stage filters although this is impossible to quantify.

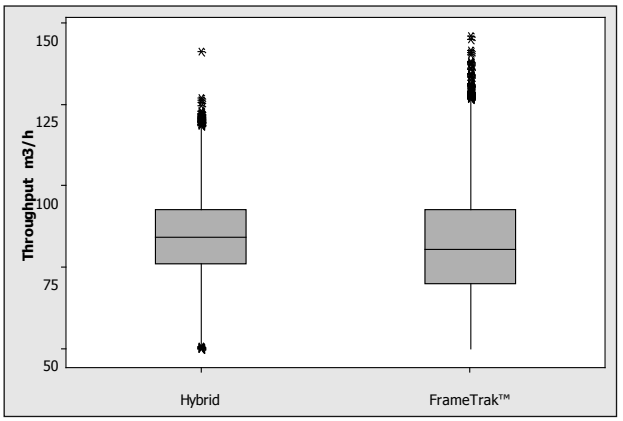

Figure 7. Filter throughput – Box-plot of Frame-Trak® vs hybrid system

The Frame-Trak® system has been shown to provide similar performance in terms of filtrate solids to the filters employing the hybrid system. Individual filtrate samples are not routinely taken from the fine seed drum filters and there is some doubt over whether they are representative for solids analysis. Regardless, comparing Frame-Trak® filtrate spot sample results to the composite first stage filtrate solids results (Figure 8), it is difficult to conclude that Frame-Trak® is providing consistently poorer performance.

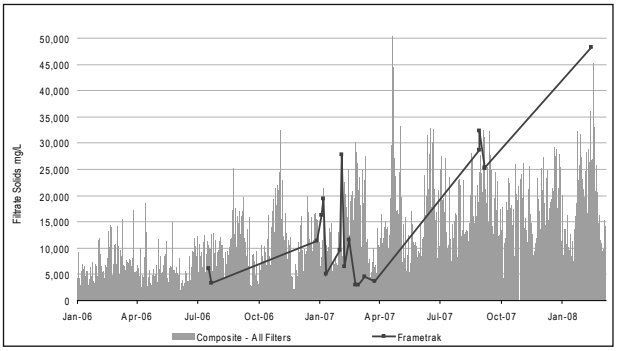

Figure 8. Filtrate solids - Frame-Trak® vs composite sample of all filters

9. Future Developments

Although significant progress has been made with Frame-Trak®, Worsley believes further refinement of the system is possible.

Trial injection of different silicon/rubber/polymer adhesive compounds into the small gap at the junction of the lateral and circumferential locking strips has been undertaken aiming to improve the liquor seal in metal profile corners to minimise hard scale growth and improve the long term retention of the lateral locking strip ends. Although some compounds have provided benefit, no compound has yet been discovered that will remain intact for a full cloth campaign. An effective compound of this nature would require additional curing time to guarantee maximum adhesion but this time would be outweighed by the potential benefits. These trials should be continued.

Some cloth fraying and splitting is still being observed in the later weeks of a cloth campaign. Further modifications to the gasket design are expected to provide further improvements to cloth life in terms of both extended campaign length and fewer intermittent panel replacements during campaigns.

Additional capital has been sought by the Worsley technical department for replacement of the existing lateral metal profiles with a revised design. Bokela is confident that replacement of these profiles, along with a new, substantially reinforced drainage grid design, will solve the persistent problems associated with drainage grid incompatibility. Although stakeholders are optimistic that this modification will greatly improve Frame-Trak® operability, capital has not yet been approved given the expected Worsley Efficiency and Growth Expansion.

10. Conclusions

Frame-Trak® cloth fixing technology has proven viable during a long term production trial on a drum filter at Worsley Alumina. Initial faults with the Frame-Trak® design and the complicated nature of the in-situ filter conversion resulted in significant labour costs and filter downtime, however most of these faults have been resolved and need not present problems for future installations. Frame-Trak® would be simple to incorporate into new filter installations. For existing filters, based on Worsley's experience, it would be preferable from the perspective of both safety and mechanical precision to remove the filter (especially drum filters) from the process plant to perform the conversion.

Frame-Trak® is now delivering OH&S benefits by eliminating forceful & percussive use of re-cloth tools. Re-clothing times are now comparable to the previous cloth fixing method and the technology is providing up to double the cloth life, equivalent throughput and reduced cake recycle. Further Frame-Trak® refinements, which should improve operability and cloth life, are also believed to be possible.

Frame-Trak® now represents Worsley Alumina's preferred cloth fixing technology for rotary vacuum filters. Frame-Trak® conversion of all remaining drum filters is being considered as part of Worsley's upcoming Efficiency and Growth expansion project and there are further plans for installation on product pan filters. Any new filter installations at Worsley are likely to also incorporate Frame-Trak®.

Frame-Trak® is emerging as a convincing alternative to traditional cloth fitting technology.

References

1. Tebbutt, D., "New filter cloth fixing methods for drum filters, disc filters and pan filters for the alumina industry", International Alumina Quality Workshop Proceedings, 2005, pp. 165-167.