PROJECT IS TO INCREASING THE FLOW CAPACITY OF PREGNANT LIQUOR PURIFICATION FILTERS BY INSTALLING A NEW DESIGN OF FILTER BAG FRAME

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Abstract

Objective

To increase the flow by >20% through a conventional horizontal or vertical pressure filter by the installation of a new design of filter cloth frame. Previous trials of frames with increased filter surface area had produced encouraging flows but had all failed due to cloth damage after a few days on line. The failures where caused by the extra material in the filter bag not evenly conforming to the undulating surface of the frame.

For this reason particular attention was paid to the method of attaching the filter cloth to the frame so that it conformed to the new frame shape and retained its position throughout the filter bag life.

Key conclusions

A small size frame was manufactured in the new design and all trials where conducted in a vertical filter that had flow valves fitted to 2 of its small frame filtrate outlets, this allowed the flow from the new frame and a standard flat filter frame to be continuously monitored. The first trial produced increased flows though the new design of between 30-15%, with most cycles averaging 26 – 20%.

Trials are ongoing to confirm these flow performance figures and also to provide online cloth hours comparable to conventional flat filter frames.

1. Introduction and Background

The aim of this development project is to increase the flow though the conventional pressure "kelly" filters that are installed in most of the world's alumina refineries on Bayer liquor clarification duty. It has focused on the frames used to support the filter bags. The basic design of the metal frames has remained unchanged over the last 50 years. They consist of a flat filtration area, typically wire mesh, surrounded by a support frame that also acts as a filtrate delivery system. Over time the mesh and frame internals gradually scale up to the point where flow is adversely affected and are either hydro blasted clean of discarded.

The concept of increasing the surface area of the frame was seen as potentially having the biggest impact on flow. The basic design concept of a pleated element to increase the filtration area has been well proven in the dust abatement industry. It is easy to see that a simple corrugated surface can increase the filtration area by 20 – 35% dependant on the angle and number of corrugations. However once you look at designing such a surface that would also be compatible to a typical textile filter bag that is operating in a very dynamic environment you can see why frames have remained flat!

The following paper details the design of the prototype frame, the initial series of trials conducted in an on line filter at Worsley Refinery and the ongoing development program.

2. The Frame Design

The design parameters where:

- A sine shape drainage surface rather than a pleated surface.
- Some form of bag retention method that allowed the bag to be anchored in place at both the top and bottom of the frame.
- Reduce the surface area of the support frame.
- Improve the long term drainage of the filtrate by reducing the scale build up in the filtrate drainage area.
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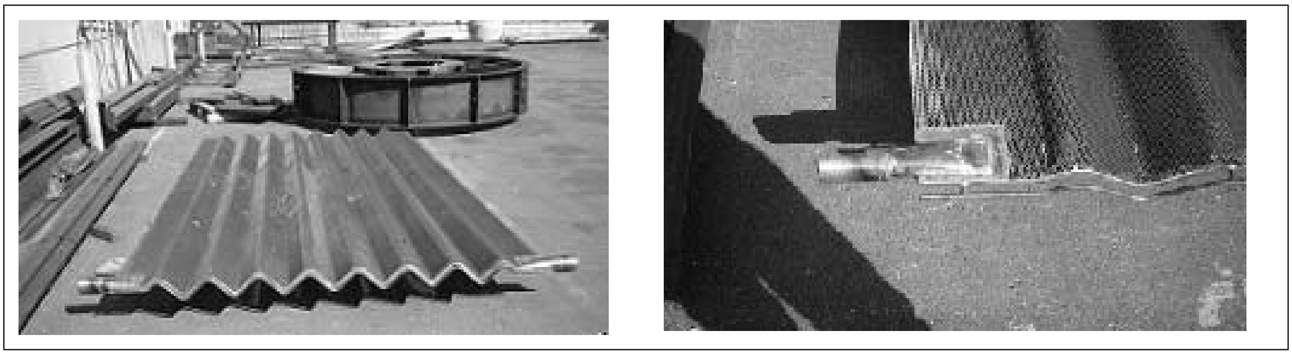
To enlarge on these design parameters:

(a) Sine v pleated. A pleated surface would deliver the largest increase in surface area but it would be impossible to get a textile material to conform uniformly to a surface with so many acute angles. As mentioned unless the cloth is supported the working pressure of the filter would rupture or at the very least open up the weave of the cloth. It was therefore decided to use more of a sine shape profile to round of the bottom and top of each shape. This delivered about a 25% increase in filter area. Further increases could be made dependent on the surface area of the existing support frame.

(b) Bag retention. The increase in filtration area had to be matched by a corresponding increase in the width of the filter bag. The biggest challenge of the design was to find a way of retaining the extra material in place on the frame and ensure it stayed in position throughout its service life. If it was allowed to move about the extra material would ether fold over or bridge across one of the "valleys", resulting in cloth failure. The solution was to introduce a retention rod external to the filtration area at the top and bottom of the frame.

(c) The support frame and the scaling issue where addressed by selecting punch plate instead of wire mesh as the drainage surface. Punch plate has proven a very effective drainage surface for pan filters and disc filters and is relatively easy to keep scale free with periodic caustic washes. The punch plate chosen has an open area of 51%. Anybody who has walked on a corrugated steel roof knows how rigid a sine shape makes a thin sheet of steel. These well tested concepts allowed the two drainage surfaces to become the main strength of the structure and the outer frame surface area to be greatly reduced. The void between the two punch plates has a few support spacers but otherwise offers no barriers to the flow of filtrate to the outlets at the top of the frame.



Photographs of the prototype Sine Shape Frame

This project development was encouraged by the production management at Worsley Refinery who saw the advantages a potential flow increase of >20% would have in the way they ran their filter building. Worsley have vertical pressure filters and I think where the first refinery to exclusively use verticals in their original flow sheet. The vertical filters have 21 frames installed, 6 x small 6 x medium and 9 x large, the large frames are 4m high x 3.5m wide so they are quite large pressure filters. They had previously fitted flow meters to two small frame outlets in one filter to evaluate filter cloth trials. It was therefore decided to manufacture a prototype frame to match their small size frame and conduct comparative on line trials on the two frame styles. Both frames would be fitted with bags manufactured from the same filter cloth approved in the building. The trials had two basic objectives.

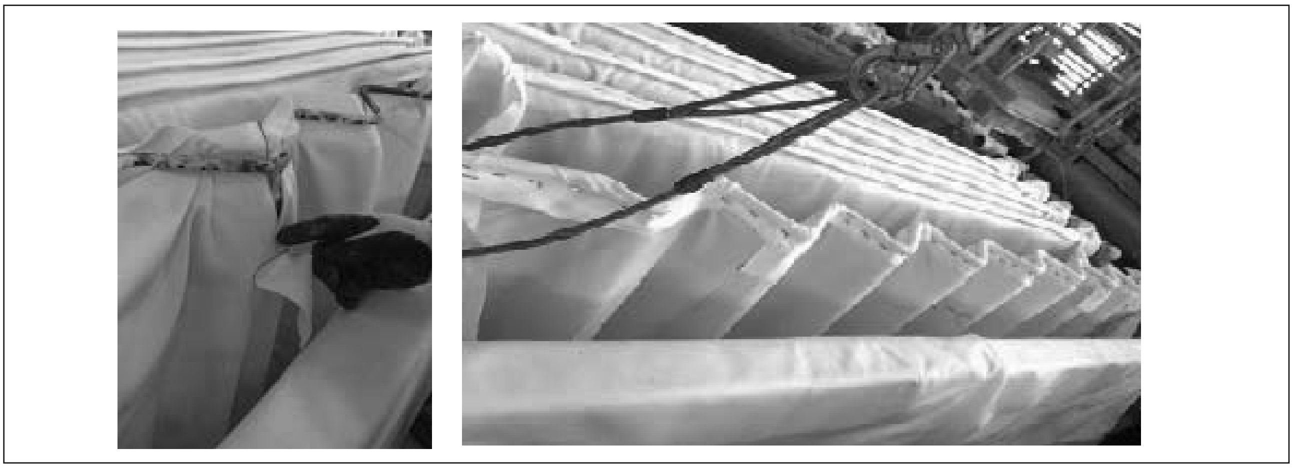
(a) Establish what difference in flows the new frame delivered.
(b) Establish the life of the filter bag, the minimum criteria being the life of the approved media.

The frame design was submitted to Worsley for mechanical strength calculations and subsequently manufactured and delivered to site in early 2011.

Discussion had meanwhile taken place with Albany Filtration Technologies, one of the approved suppliers of filter bags, to manufacture a bag to fit the frame. As the method of attaching the bag to the frame was quite different to the existing frames the bag also had to be redesigned.

The reclothing area at Worsley is a very well designed facility with all frame movements being handled by overhead crane from the filter directly to a cloth discharge chute where the used cloth is cut loose from the frame and drops into a collection bin at ground level. The frame is then placed in a holding bay set into the floor so that the reclothing crew work at the correct height when installing the new bag on the frame. Reclothing is a relatively simple procedure of retaining a new bag in the holding bay and lowering the frame into the bag by the crane so that it is secured in its cradle. The crew then lift the bag up the frame, roll the two sides of the open bag together a couple of times and close the bag with an air driven industrial stapler.

A similar procedure is required for the new frame with the following differences. The retention rods are joined to the frame by 4 short " legs", two 100mm from each side of the frame and two evenly spaced between them. These legs also act as location points for the correct placement of the bag on the frame. The bag has 4 vertical slits in one side of the bag at the open end, the procedure is to pull up the bag and position the slits each side of the central legs, pass the flap through the gap between the top of the frame and the retaining rod, pass over the top of the rod and back down on its self. The other side of the bag in brought over the rail, the two sides are pinched together and stapled in place. Having centred the bag on the frame the bag is progressively closed out to the outer legs, the bag slit and leg should line up. This ensures the filter bag is evenly distributed across the frame and will be fully supported by the frame surface.



Photographs of the reclothing procedure and bag/frame ready for service

The bag is then closed at the bottom of the frame by first bringing any bag overhanging the sides onto the frame and then distributing the bag evenly across the surface to eliminate creasing and ensure the bag sits evenly on the surface. A staple is then inserted at the bottom and top of each sine shape and immediately inside the two outside legs to retain the bag in place.

3. Trials

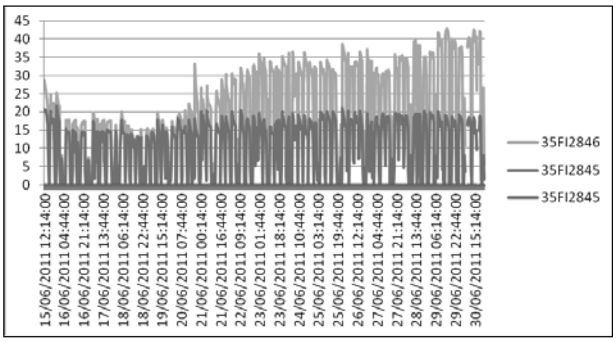
The first trial took place in April 2011. The first issue to be highlighted was a potential leak point around the retention rail support legs, the solution was to have a flap of material sewn onto the bag which could be passed over the top of the rail and stapled in place. This proved to be effective with all subsequent trials meeting the stringent Worsley filtrate solids requirements.

The first trial ran for 6 days and was removed by the building operators when the clear filtrate tank showed high filtrate readings. The timing for the trial was not ideal as it was removed over the Easter holiday when the area engineer was not on site. Subsequent visual inspection of the bag could find no obvious bag damage. Other filters where in fact responsible. The trial did however deliver a couple of useful bits of information. One was that the retention system had worked and the bag had not moved from its installed position. Two the flow through the sine shape frame had increased between 15 and 25% dependant on the time since the last caustic wash.

The next trial started on June 15th 2011.

The cloth installation procedure, in particular the method of positioning and retaining the bag at the bottom of the frame became an issue. The existing reclothe facility had not been designed to have operator access to the bottom of the frame, the existing bag being closed along the top of the frame only. To gain access to the bottom of the frame the bag was fitted onto the frame and closed along the top, it was then taken out of the holding bay by the overhead crane and laid down across the top of the holding bay and the bottom of the bag adjusted and stapled into position. This procedure was obviously not viable for normal operations but was adopted to facilitate the trial. The trial started on the 15th June and was terminated on 30th June due to high filtrate solids. This time individual Millipore's where taken and it was confirmed that the trial was causing the issue before it was removed. During the time of the trial the main filtrate tank had shown high solids and test work had identified two other filters where the cause. Initial feedback from site indicated the bag had been damaged at the apex of the sine shape closest to the sides towards the bottom of the frame. The theory was the damage had been caused by the frame banging against the adjacent frame during operation. On closer visual inspection the position of the holes in the bag where located in the valley of the last sine profile from the frame edge. The cause was the bag had moved sideways and a portion was overhanging both sides of the frame. This had then caused the bag to bridge across the valley of the sine shape, not being supported by the frame the operating pressure had ruptured the bag.

This was particularly disappointing as the trial up to the sudden failure had been very successful. The clear filtrate tank returning to 1mg/l after the two other filters had been changed out. The flow data had also shown a sudden and dramatic increase from around 30% increase to up to 100% increase compared to the standard frame. This change had occurred from the 22nd June and continued until the trial was terminated.



Flow graph showing the flow from each filter cycle, 35F12846 is the sine shape frame and 35F12845 is the standard frame.

The conclusions from this trial are:

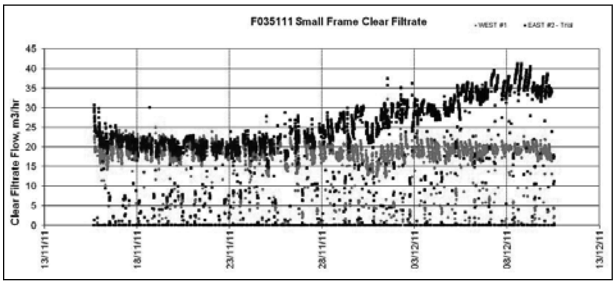
(a) The failure of the bag could be directly attributed to the bag being allowed to move from its original installed position. This confirmed the necessity of a bag retention system.

(b) The sudden increase in flows though the trial frame approximately 7 days into the trial is assumed to be preferential flow caused by the general loss of flow across all the other frames as the bags became progressively blinded. This cannot be proven at this stage as we do not have any comparison data. The first trial having been terminated after 6 days.

(c) The sustained increase in flows, up to 100%, in the second half of the trial demonstrates that the overall design of the trial frame is a very efficient drainage surface with the potential to handle flows well in excess of the design target of 20% to 35%.

A third trial started on 15.11.11.

This trial lasted the normal life cycle of the filters and was removed from service on the 10.12.11. The flow followed a similar pattern as trial 2 with a significant increase in flows after 8 days on line, this trend continued until the end of the trial.



Graph showing the flow data from the Nov. Trial. The standard frame was the West #1 data, the sine shape frame was the East #2 data

Conclusions from this trial.

(d) The method of retaining the bag on the frame had to be changed to overcome the obvious issues of removing the staples at both the top and bottom of the bag to allow the used bag to be removed from the frame.

(e) The design changes needed to allow the current accepted practice of attaching the bag to the frame to be retained. That is, pulling up the two open sides of the bag, rolling them into a sausage shape and stapling together. This would allow the release of a used bag from the frame by cutting the bag along the top of the frame to effect its release, the traditional reclothe procedure at this site.

The following design change was proposed.

(f) A second retention bar was added to the top of the frame above the existing bar, this allowed the one side of the open end of the bag to be passed through the lower gap and then though the smaller gap between the lower and upper rail. The other side of the bag was passed between the upper and low rail. The two sides of the bag where rolled into a sausage and staples together. The physical bulk of the sausage shape preventing the bag from being pulled back through the narrow gap.

(g) A number of alternatives to stapling the bottom of the bag to the bottom rail where considered, none could be found that would eliminate the need to have the bag secured to the frame at the outer edge of the frame at the bottom to prevent the bag from " creeping" off the frame sideways during operation. This had proven to be the major cause of failures in the filter cloth due to "bridging" across valleys in the sine shape frame. A compromise solution was to insert an eyelet below the filtration surface and just inside the support leg of the bottom rail. A simple cable tie suitable for the operating conditions was then used to secure the bag to the two outer legs of the bottom rail. The cable tie could be easily cut prior to lowering the bag into the discharge chute during a cloth change.

(h) Worsley want to find out exactly what increase in flow the punch plate design provided over the traditional woven wire drainage surface. To this end they will trial a flat frame version of the sine frame and compare its flow with an unused standard kelly frame. If this version provides a suitable flow increase it gives them the option of continuing with their existing reclothing procedure and standard stock filter bags.

4. Summation

The sine shape frame project is still a work in progress, until a full set of frames is installed we do not know the extent of the flow increase delivered by this design, other than it is likely to be in excess of the original design target of 20%-30%. The significant preferential flow increase after approximately 8 days on line indicates both cloth life and cycle times may also be increased as both are directly governed by filter throughput.

The trials at Worsley Refinery have been conducted on vertical filter frames that are very large and present specific OH&S issues for operators working on the bottom of the frames during reclothe duties. Modification to the reclothe area to allow the clothing crew safe access to the bottom of the frames would be required.

The vast majority of installed filters in the alumina industry globally are horizontal filters with a maximum frame depth of less than 2.5 meters, operator access to the top and bottom of the filter frame during reclothing is not an issue. Therefore the use of this design in most refineries would not require major changes to current work practices or reclothing infrastructure.

The trials to date show the potential to significantly increase flows in a very critical filtration building by simply replacing the frames. Compared with the option of addition filters this low cost alternative is worth ongoing investigation, I look forward to the opportunity of a full set trial of the sine shape frames.

5. Acknowledgements

I would like to thank the management and production staff of Worsley Alumina Refinery for their generous help and ongoing assistance with this project. In particular I would like to mention the red side engineers, the area supervisors and re-clothing crew for their valuable suggestions and cooperation.

References

Production Control Department, Worsley Alumina Pty Ltd, WA. Australia, flow data from trials.