Plant Expansion Through Progressive Equipment Upgrading

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The constantly changing world of the 21st Century presents us with an endless number of challenges to maintain our competitive edge in a dynamic global marketplace. We have survived the environmental changes and the energy crisis of the 1970's and 80's and we have dealt with the globalization of our markets to find that in many cases, survival is truly only of the fittest. As a means of survival we have become even more focused on operating costs and efficiency of our chemical plants and are now managing these assets, to maximize their output and lifecycles, to ensure continued profitability of our respective corporations.

The pressures on the sulphuric acid plant operator are no less; emissions have been reduced, energy efficiency improved and routine maintenance diligently performed to keep our plants operating. However, sulphuric acid plants are in one way a little unique, when we think that every day a little of the plant is shipped out in the product acid, as corrosion takes its toll in many forms within the plant.

As ageing equipment reaches the end of its useful life, it presents the operator with an opportunity not only to upgrade the plant in terms of newer technology to improve reliability, operability and reduce maintenance, but also to explore opportunities to increase plant capacity by de-bottlenecking undersized equipment to relieve pressure drop and provide additional heat transfer surface or volumetric capacity.

No 4 Sulphuric Acid Plant at Sasol Agri Phalaborwa

This paper describes one such recent opportunity at Sasol Agri's No.4 sulphuric acid plant in Phalaborwa, South Africa. The plant built in 1975, had a nameplate capacity of 1600 MTPD and by the mid 1990's was struggling to achieve close to design capacity. Despite regular and routine maintenance and prior equipment restoration, the plant was showing its age. The Converter had deteriorated over the years, as had the gas ducting, with both having experienced several gas leaks. Close internal inspection of the Converter vessel, revealed that the catalyst support system of posts and grids were distorted to the point where their mechanical integrity was highly questionable. The two Heat Exchangers were also at the point of replacement, as was the Primary Economizer, which cooled the gas entering the Inter Acid Tower and the integrity of the 20+ year old Acid Towers themselves was causing concern.

Bent posts in lower Converter pass

Following their bi-annual maintenance shutdown in May 1997, Sasol began developing a plan to address the major maintenance issues facing them and decided to tackle the project to restore and upgrade the plant in two phases.

Phase one of the project addressed the most pressing issues of replacing the Converter, Hot Heat Exchanger and Primary Economizer. Replacing a major vessel like a Converter would not only require extensive plant down time but would also require space to execute the project. Consideration was given to building a new converter on an adjacent new foundation, but the resulting sub-optimal ducting arrangement would have meant higher installation, maintenance and operating costs. Like most plants space for this type of undertaking was at a premium.

Chemetics presented a proposal to Sasol in October 1998, whereby the main project objectives to replace the Converter, Hot Heat Exchanger and Gas Ducting were addressed on the basis of installing a new converter on the existing foundation, within a prescribed 24 day shutdown window and were subsequently awarded a contract in early November.

One of the main design criteria set out for the project was to design the new equipment to achieve an ultimate 1750 MTPD production rate.

While the process and mechanical design was being completed in Canada, the project methodology was developed with the local subcontractors. The final plan required re-grading of part of the adjacent roadway to create the space to allow for a new Chemetics proprietary all stainless steel Converter to be erected during normal plant operation, then during the shutdown period, to slide the existing 450 tonne converter, complete with catalyst, off the existing foundation and replace it with a new vessel, which would also be slid into position.


New grillage system

Work began at site early February 1999 with the excavation and installation of a new concrete pad and preparation of a new steel grillage system, which would facilitate the new Converter move and ultimately become part of the permanent support structure. Erection of the Converter vessel began soon after with completion scheduled for early May. One of the difficulties encountered with the Converter fabrication stemmed from the fact that locally available 304H stainless steel was only available in 1,500 mm plate widths, which would dramatically increase the length of welding to make the vessel and fabrication time. This was partially overcome by importing 3,000 mm wide plate from North America for the shell assembly.


Converter fabrication

Heat Exchanger Assembly

During this same time period, the major internal stainless components of the proprietary Gas Heat Exchanger were manufactured at Chemetics Equipment Division in Toronto, Canada and shipped with the stainless tubes to a local fabricator near Johannesburg for assembly of the exchanger. KCED provided specialized technical support during the exchanger fabrication including, the orbital tube-to-tubesheet welding equipment.

The plant shutdown date arrived with the Converter and Exchanger ready for installation. In preparation for moving the old Converter, four jacking points were added to the existing grillage to facilitate the first phase of the move. After the plant was ‘blown cold” the ducting was removed and work began to switch the Converters. The old vessel was gently coaxed from its foundation using hydraulic jack at the previously installed jacking points. Once clear of the foundation, slide rails were positioned and the vessel lowered. Then came the slow process of nudging the 450 tonne vessel off and clear of the foundation with hydraulic rams, a process that took 20 hours.

Once the foundation had been cleared, this gave unimpeded access to the Heat Exchanger and Economizer, which were then swapped out with their replacements. With the new Exchanger and Economizer in position, then came the process of positioning the new Converter on the existing foundation. Using the same procedure as employed in moving the old Converter, the new 120 tonne vessel presented far less of a challenge and was in place within 10 hours. With the major new vessels in place, catalyst loading, ducting installation and final insulation work were completed to allow the plant heat up process to commence.

Old Converter sliding off foundation

New Converter & ducting installed & operating

Twenty-four days after cutting the sulphur feed, production resumed. The revised plant immediately demonstrated its potential. Production rates exceeded the design rating of the new equipment, the Blower discharge pressure was substantially lower and steam exports increased. The plant continued to operate at a sustained rate in excess of 1750 MTPD up until the next scheduled shutdown in May 2001. Table 1 at the end of the paper shows comparative operating data.

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With phase one of the retrofit completed and operating well, Sasol then began planning for the next major shutdown and phased upgrading of the No 4 acid plant. The next equipment items scheduled for replacement were the Dry and Final Acid Towers and the Cold Heat Exchanger. The Acid Towers had experienced several shell leaks and the integrity of the brick lining was in doubt. The Gas Exchanger has suffered several tube leaks. Sasol elected to set the design criteria of the new equipment for a 1750 MTPD production rate. Time was again to be an important project factor, with 24 days maximum from sulphur off to sulphur on.

Cold Exchanger Installed

Replacement of the Heat Exchanger presented minimal challenge as there was good access from the newly installed concrete work pad and the adjacent gas ducting and its partner exchanger had just been replaced.

The Acid Towers on the other hand were not so straightforward. Sasol had replaced the original cast iron trough distributors with silicon stainless units three years earlier and wanted to reuse them, as was their position to reuse the existing mist eliminators and housings, tower packing and access platforms.
Reusing the distributors gave little opportunity to change the internal tower diameter leaving material of construction as the only major issue to be decided. Plant layout was the one major factor in deciding the type of tower to be installed. Access to the acid area of the plant was restricted by the Sulphur Pit and Water Cooling Tower at the end adjacent to the Final Acid Tower but had reasonable access adjacent to the Drying Tower. There was no space whatsoever to build a new Final Tower adjacent to the existing tower and no possible way to lift a completed brick lined vessel into that location, as crane access was extremely limited. The access issue determined the only viable option to be metallic towers. As in all retrofits, this work had to be scheduled around the other routine plant maintenance being conducted in the same area.

Kvaener Chemetics developed a proposal, which was later accepted by Sasol, to supply and install two Saramet® Acid Towers and a proprietary Gas Heat Exchanger. Material selection for the towers was based on the extremities of service [i]. The Final Tower was fabricated entirely from Saramet®23, while the lower section of the Dry Tower, including the packing support, was fabricated from Saramet®35 with a Saramet®23 upper section. The new Gas Exchanger was fabricated entirely from 304H stainless steel.

Dismantling Final Tower

Design work began late November 2000 with a projected start-up of end of July 2001. Critical internal stainless steel components for the Gas Heat Exchanger were again manufactured at KCED in Toronto with local assembly by the same fabricator in Johannesburg used in the first phase of the project.

Completed Towers ready for installation

The Saramet® Acid Tower shells were also prefabricated in Johannesburg, with Chemetics providing technical support and supervision, before being shipped in two sections with a final circumferential weld completed at site. The Saramet® injection type packing support for both towers was manufactured at KCED in Toronto and shipped to site for installation prior to commencement of shutdown activities.

The critical path for the project revolved around the Final Tower. Because of the extreme limited access to that area of the plant, the maximum crane capacity that could be used was 300 tonnes, but with the long reach over the pump tank area, the maximum "hook weight" was limited to 25 tonnes. This resulted in the tower having to be stripped of its brick lining and cut into relatively small pieces for removal.

Work commenced on July 15 with the Mist Eliminator housing on top of the Final Tower being removed to give access to the distributor and packing. The packing and distributors were removed for cleaning and reuse and the existing access platforms were taken offsite for sandblasting and repainting. The tower lining was then broken up and removed and the tower cut into appropriate sized pieces. Once the old tower was removed the existing grillage was inspected and cleaned before the new Final Tower was lifted and lowered into position. With far better access around the Dry Tower, replacement of that vessel was completed in a similar fashion without incident.

New Final Tower being lifted into position

Ducting fit up at Final Tower

The old Cold Heat Exchanger was removed and cut up for disposal in time for the new replacement exchanger to arrive from Johannesburg and be lifted into position.

Ducting and acid piping installation and insulation tasks were quickly completed and the plant turned over to Sasol 21 days after sulphur off, to allow for plant heat up to commence.

Since restarting the plant, production rates have exceeded 2000 MTPD with sustained production above 1950 MTPD. As can be seen in Table 1, the sustained high production rates have been achieved at an equivalent clean blower discharge pressure to the 1750 rate, which is a direct consequence of the combined efficiency of Chemetics proprietary Heat Exchanger and Acid Tower designs.

Table 1

Production Rate MTPD	**Gas Flow Nm^3 /hr**	**Δ P Clean mm WC**	**Δ P Dirty mm WC**
1600	160,300	5,590	6,475
1750	168,600	5,000	5,210 *
2000	189,400	4,950	-

* after 2 years continuous operation

The success of this project is a combination of several factors. During the execution phases, frequent and open communication between Client and Contractor and Contractor and Subcontractor were essential, as was total commitment and support from the Subcontractor and selected Vendors. Today's instant electronic communications made life easier for review and approval of drawings and data. Planning, pre-manufacturing and scheduling were also key to an almost flawless execution.

Finally, the Clients participation in the project and his forethought have resulted in Sasol now having a plant which can reliably meet today's increased standards of low emissions; greater flexibility and operability; and low maintenance and operating costs which together have help position Sasol to meet the challenges of market globalization which is sure to set our course for the years ahead.

References:

(i) Grant Harding, Chemetics:

Developments in Sulphuric Acid Resistant Metal, "Saramet® Technology".
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