1. INTRODUCTION

Chemical Initiatives’ Umbogintwini plant is the production facility of Chemical Initiatives’ business. Umbogintwini’s J Plant manufactures sulphuric acid. The plant was designed and built by Simon Carves, and was commissioned in 1974.

The plant was designed to produce 500 tons/day of Sulphuric acid (H$_2$SO$_4$) at maximum rates. The Sulphuric acid manufacturing is through the famous contact process whereby liquid Sulphur is injected through dried air in a burner operating at 1000 °C to form sulphur dioxide (10.5% SO$_2$). The SO$_2$ gas is then cooled in waste heat boiler no.1 before being fed to a four pass converter which provides 99.5% SO$_2$ conversion to sulphur trioxide (SO$_3$). The SO$_3$ gas is the absorbed by 98.5% H$_2$SO$_4$ through the inter-pass & final tower to make more concentrated acid and dilute it with water back to 98.5% H$_2$SO$_4$ in acid pump tanks and dispatched to storage tanks.

The manufactured Sulphuric acid is supplied to a variety of industrial manufacturing customers includes Pulp & Paper industry, Mining industry, Chemical manufacturing industry etc.

During the 1st quarter of the year 2007, Chemical Initiatives undertook a study to up rate the sulphuric acid plant output by 10% (i.e. from 500 tpd to 550 tpd).

This was to be achieved by the replacement of the converter fourth pass Monsanto catalyst (LP 110) with Haldo-topsoe cesium based catalyst (VK 69). The simulated analysis yielded an increase from 500 tpd to 547 tpd by the addition of 30,000 litres of HT VK69 in the fourth pass as well as increasing the volume of LP 110 from 20,000 litres to 25,000 litres in the third pass. The simulation study revealed that this setup had a potential to increase the SO$_2$ conversion from 99.5% to 99.79% and therefore providing an extra 47tons/day of Sulphuric acid.

The project proposal included:

- Replacement of the LP110 catalyst with VK69 TOPSOE catalyst from the 4th pass of the converter.
- Increasing the 4th pass VK69 TOPSOE catalyst loading by 26% (from 22 000litres to 30 000 litres)
- Increasing the 3rd pass LP110 catalyst loading by 18.6% (from 20 350 to 25 000litres)
- Running the air blower to maximum rate of 47 500m$^3$/hr (from 45 000m$^3$/hr).

Other process parameters that needed to change in order to achieve desired plant throughput included:

- Increasing sulphur feed rate from 6.8 to 7.4 tons/hr.
2. ADVANTAGES OF SWITCHING TO VK69

VK69 is designed specifically for the final pass(es) of double absorption plants, and the unique VK69 formulation offers unmatched high activity throughout the entire operating temperature range.

VK69 is manufactured in a unique 9 mm Daisy-shape. The high surface area contributes to the high activity in this gas environment and the high void-fraction ensures a low pressure drop and good dust tolerance.

Benefits

The VK69 offers a number of benefits

- 50% reduction in SO2 emission from existing double-absorption plants
- Possibility for significantly increased production without increasing SO2 emissions
- Low ignition temperature for faster and smoother start-ups
- Long lifetime and low screening losses

3. IMPACT ON MAIN PLANT EQUIPMENT

3.1 AIR BLOWER

The design maximum capacity of the blower is 47 500m³/hr at a discharge pressure of 47kPa.

The blower is currently running at discharge pressure of 42kPa, providing a gas flow of 43 000m³/hr.

From the blower curves, it was established that the blower would be able to provide 47 500m³/hr at 46.5 kPa. This could be done by increasing the blower vanes angles to maximum (i.e. 10°). The previous setting of the blower vanes angle was 50° (approximately 50% opening).

3.2 SULPHUR BURNER

Sulphur consumption would have to increase from 6.8tons/hr to 7.4tons/hr and the air flow would also increase as specified above. The burner temperature would also increase from the current 1000°C (10.5% SO₂ content) of 1025°C, generating 11% of SO₂ content.

**SULPHUR Burner Capacity:** GLTA Engineering Company, the original designers of the acid plant was consulted regarding the capacity of the Sulphur burner and it was reported that “the internal volume of the burner is large enough for the acid plant to be increased by 20%.”

**Sulphur Gun:** The current sulphur gun is an atomising type of spray gun which operates with sulphur pressure of 400 – 700kPa. The possibility of sulphur carry over from the
burner to the air inlet duct of the drying tower could arise when increasing the sulphur inlet flow however this could be minimized/eliminated if the burner temp is accurately controlled at permissible level (i.e. 1025 \degree C)

3.3 **WASTE HEAT BOILER NO.1**

The simulated 1\textsuperscript{st} pass converter inlet temp was 430\degree C and prior to the upgrade the 1\textsuperscript{st} passing was operated at 433\degree C. However there is a flexibility of shutting off the boiler by pass completely to enable maximum SO\textsubscript{2} gas cooling from WHB #1. The boiler bypass prior to the upgrade was 25\% open.

Due to the burner temp increase from 1000 to 1025 \degree C, the amount of steam generated from the WHB #1 would increase by 1.8tons/hr.

3.4 **WASTE HEAT BOILER NO.2**

The simulated 3\textsuperscript{rd} pass converter inlet temp was 445\degree C and prior to the upgrade it was running at 461\degree C. The boiler bypass which used to be fully opened would have to be partially shut to enable the boiler to remove the additional extra heat load.

3.5 **HOT & COLD HEAT EXCHANGERS**

The heat exchangers were redesigned for extra heat load and a lower pressure drop during the year 1998. Because of that modification, there’s approximately 2.2kPa allowance in additional pressure drop.

3.6 **CONVERTER**

With the proposed mod of changing the 4\textsuperscript{th} pass type catalyst from LP110 to VK69 and increasing the catalyst loading from a 3\textsuperscript{rd} and a 4\textsuperscript{th} pass, a 99.79\% conversion shall be achieved. The previous conversion was 99.5\%.

**Converter capacity:**

As per GLTA Engineering Company, the 4\textsuperscript{th} pass capacity could accommodate a maximum amount of 30 300litres. As part of the performance upgrade, the catalyst volume of the 4\textsuperscript{th} pass would be increased from 22 000 to 30 000litres.

The 3\textsuperscript{rd} pass catalyst volume would be increased from 20 350 to 25 000 liters and the maximum capacity is 25 100litres.

**Pressure drop:** The predicted/simulated 4\textsuperscript{th} pass pressure drop was 0.79kPa and the pre-upgrade pressure drop was 0.5kPa.

**Thermocouples:** The thermocouples would also be repositioned in the converter shell to accommodate the increased in catalyst depth.

3.7 **DRYING, INTERPASS AND FINAL TOWERS**

GLTA Engineering Company also declared the towers capacity as sufficient to handle a 10\% increase in gas flowrate.
3.8 STRONG ACID COOLERS
The acid temperature to the absorption coolers is allowed to rise to 80°C and prior to the upgrade the acid temperature was running at 71°C, well below the maximum design temp.

4. ECONOMIC BENEFIT
The capital expenditure plant upgrade was R1.735m and the main benefits from the project are the additional 47 ton/day and 43.2 ton/day of sulphuric acid and steam production, respectively.

The payback period for the project was calculated at 2.8 months.

5. RESULTS

The modifications in the converter catalyst were done during the August 07 turnaround shutdown and prior to the upgrade the production rate was averaging 477 tpd. After the upgrade, the plant production rate increased to an average of 533 tpd. The reason for not constantly producing at 547 tpd is the failure of maintaining the 4th pass inlet temperature below 405°C without compromising the desired export steam temperature at the boiler station. Plans are in place to reduce heat losses on the export steam line.

6. CONCLUSION

Average production prior to implementation :

Target production after implementation :

Average production achieved after implementation :