SURE™ Double Combustion Increases Capacity at the Tesoro Northwest Company Sulfur Plant (Anacortes, WA)

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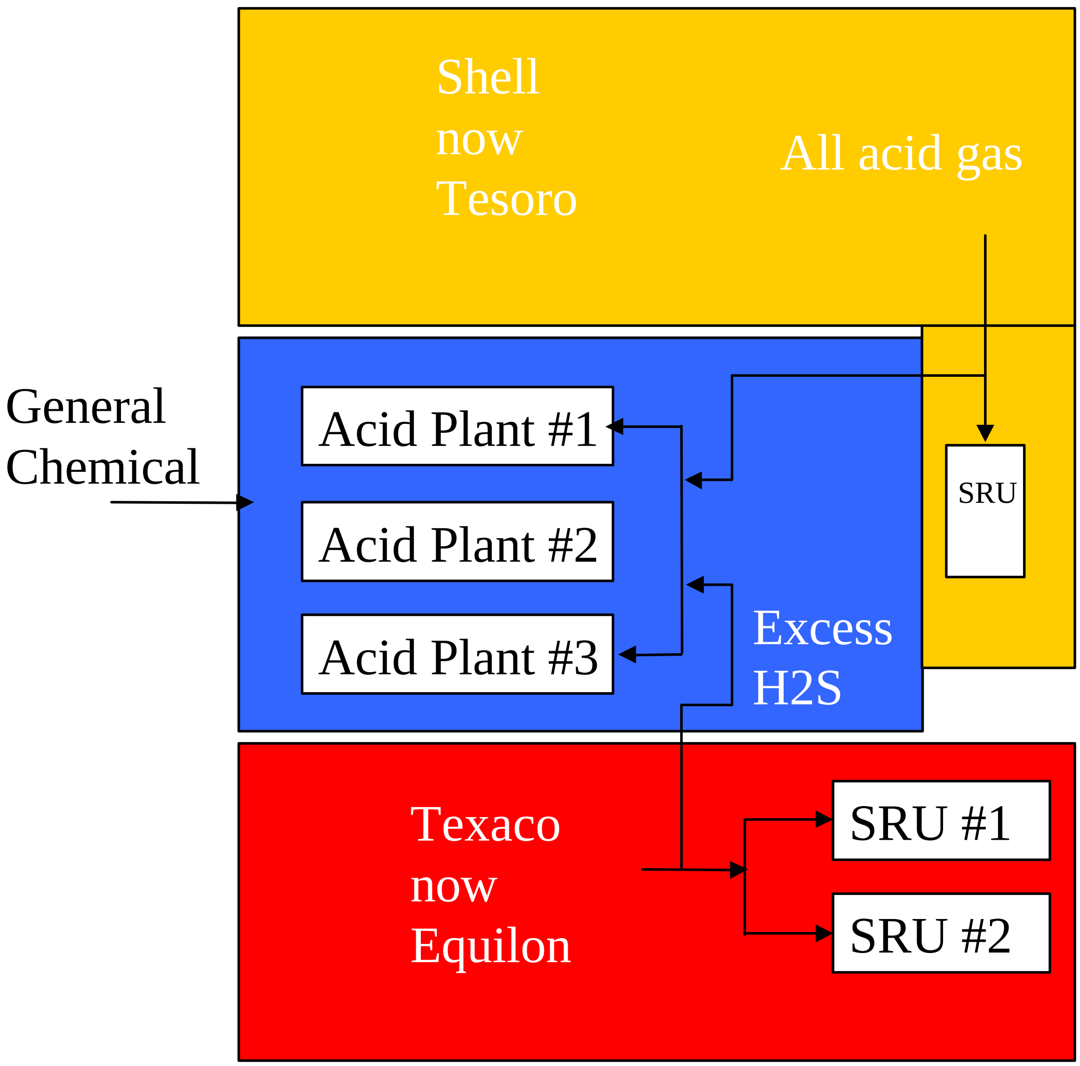
Introduction

This paper describes the project to expand capacity at a sulfur plant operated by General Chemical in the Puget Sound area of the state of Washington. The sulfur plant was owned by Shell Anacortes Refining Company (Shell) at the time of the technology selection process. As part of the formation of Equilon Enterprises, a partnership of Shell and Texaco, Shell was directed to divest itself of the Anacortes refinery. As a result, the refinery including ownership of the sulfur plant was sold to Tesoro. The project continues under Tesoro Northwest Company ownership (Tesoro).

Relationship of the three entities

General Chemical owns and operates 3 sulfuric acid plants strategically located between the two refineries in Anacortes, WA.

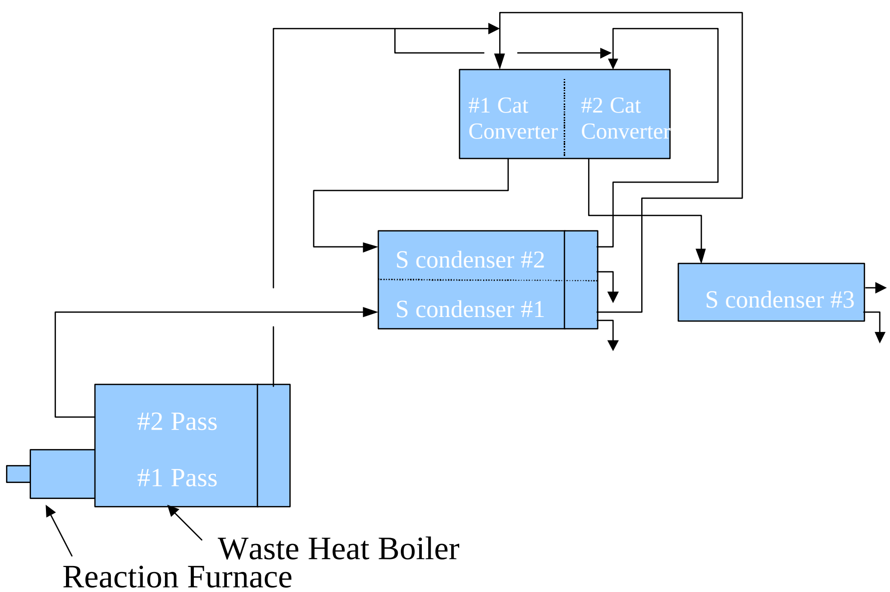


The sulfur plant first owned by Shell Anacortes Refining Company and now owned by Tesoro Northwest Company is located adjacent to General's sulfuric acid plants. All of the amine acid gas from the refinery once owned by Shell is sent to General.
Some is processed in the SRU owned by the refinery and operated by General. The remainder is used as fuel in the sulfuric acid plants.

The other refinery, formerly the Texaco Puget Sound Plant (Texaco), is now part of the Shell, Texaco partnership known as Equilon Enterprises LLC (Equilon). That refinery has two of its own sulfur plants with a total operating capacity, at the time this project was initiated, of 100 LT/D (with oxygen enrichment). Those plants are now also being increased to 175 LT/D in capacity using SURE™ Double Combustion with up to 100% oxygen. Excess amine acid gas which cannot be processed in its own SRU's is sent to General where it is used ONLY as fuel in the acid plants. However, the availability of acid gas from Equilon impacts the feedrate of Tesoro's acid gas to the sulfur plant.

Since the primary purpose of the General facility is to process spent acid, and produce fresh sulfuric acid for its customers, acid gas from Tesoro is first used in the acid plants, and only the remainder used in the sulfur plant. Therefore, a deficiency in acid gas feed from Equilon causes General to use more of the Tesoro acid gas in the acid plants, which results in less feed to the sulfur plant. This proved to be significant in the ability to start up and test the capabilities of the modified unit during the latter part of 1998, and beginning of 1999, as will be discussed later.

Description of existing sulfur plant



The SRU was originally built in 1978 by Black Sivals and Bryson for another client but never used. The unit was then purchased by Shell and relocated in 1987 to Anacortes.

FBD assisted in process design review and upgrades. A FBD burner was also retrofit to the plant. The original capacity was 18.6 LT/D on a 100% H_2S feed basis.The waste heat boiler is a two pass, marine type, configured for hot gas by-pass. Unfortunately, it has had a history of high exit temperatures, and high corrosion. The #1 and #2 sulfur condensers share a common shell.

Basis of Technology Selection

Because General Chemical has the flexibility to process acid gas in both the SRU, and its own acid plants, capacity of the facility is normally adequate to handle needs, but there are brief periods where capacity is not sufficient. The major concern was providing enough capacity to allow for maintenance shutdowns and routine operating problems. Also, a possible change to more sour crude was contemplated.

Oxygen enrichment associated with a burner change would meet immediate needs. However, future needs of the refinery would probably require further increase in capacity at some time. Recognizing that replacement of the WHB was required to increase reliability and operability of the plant, that replacement should be consistent with future expansion needs.

Options Considered

The following technology options were considered.

- COPE™ technology based on burners manufactured by Duiker, and offered by Goar Allison, and Associates (GAA), with possible additional process technology also offered by GAA
- TPA technology based on burners designed, and offered by TPA
- Lurgi burner technology offered in the United States by Black and Veatch Pritchard.
- SURE™ technology based on burners manufactured by BOC Gases, and process technology also developed by BOC Gases, both offered by Parsons Energy & Chemicals Group

All options considered had some relevant commercial experience.

COPE ä

COPE™ I consists primarily of a burners manufactured by Duiker which are designed specifically for the introduction of oxygen. Since the waste heat boiler would be replaced regardless of the technology choice, it would be sized to accommodate the additional flow from a recycle blower (COPE™ II) if added later.

Goar Allison and Associates had done the initial feasibility study for expansion, and General was very satisfied with GAA capability and support.

TPA

The design of the TPA burner is such that oxygen can be introduced by a simple lance inserted directly down the center of the burner. The Texaco refinery (now the Equilon refinery) nearby was using oxygen with the TPA burner / lance, and was satisfied with its operation.

Lurgi

The first installation of a Lurgi burner in the United States was at Shell's Deer Park refinery. The experience there has been good, and Shell is completely satisfied with the technology. Therefore, it was appropriate to consider the technology for application on this project as well.

SURE ä

BOC's burner, and Double Combustion technology was known by General to exist, but since most applications were outside the U.S., there was no first hand experience by General, Shell or well known colleagues. If viable, plant visit(s) would be required.

Prescreening of Options

As stated earlier, Shell has been satisfied with Lurgi burners at Deer Park. However, Lurgi burners are by nature large, and while well suited to larger SRU's, the more complex design also tends to make them more costly to fabricate. At only 18.6 LT/D, the Anacortes SRU was probably not the best possible application for the Lurgi burner. Therefore, Lurgi was not evaluated as thoroughly as the others before being eliminated - in fact, recognizing the difficulty in competing in this size range, Lurgi declined to bid.

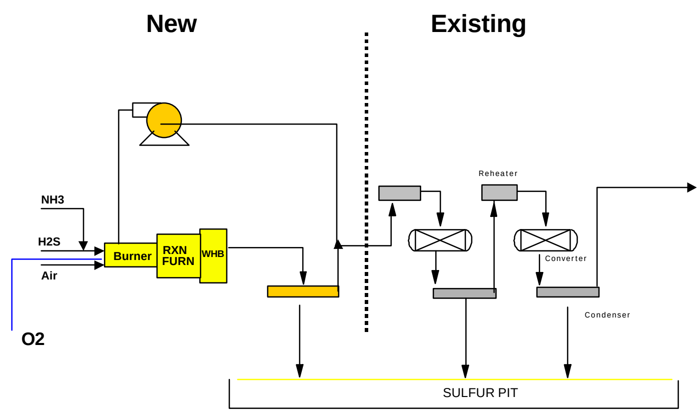
Texaco (now Equilon), located very close to General, uses TPA burners. They are satisfied with operation as well as technical support provided by TPA. However, even at the proposed operation of 2900 ^{o}F, which is higher than industry standard, the sulfur plant would not achieve the same level of oxygen enrichment and capacity increase as either COPE™ II or SURE™. Therefore, TPA was also eliminated from further consideration.

Technology Description - Final Contenders

Both COPE™ II and SURE™ Double Combustion called for process changes, which would mitigate the temperature rise in the reaction furnace, and result in operations with very high concentrations of oxygen.

COPEä II

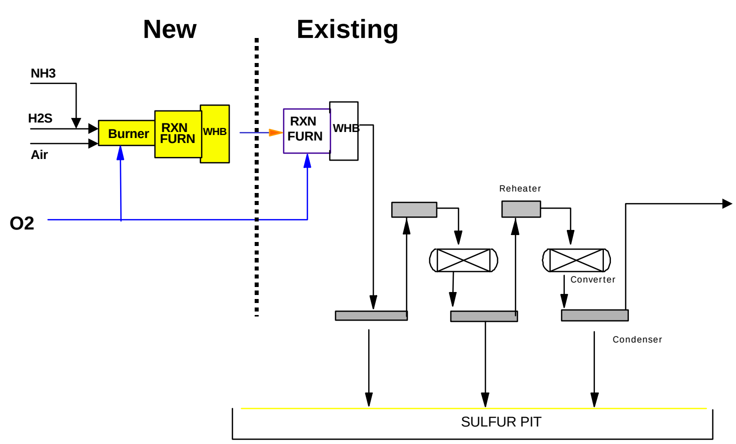
During the initial phase (COPE™ I), a COPE™ burner would be installed to allow moderate oxygen enrichment. However, the waste heat boiler being replaced would be sized to accommodate the recycle gases associated with COPE™ II operation.



In the future, when greater capacity would be required, a recycle blower would be added to take the effluent vapor from the #1 sulfur condenser, and route it back to the reaction furnace, using sensible heat to carry away the heat of reaction. In essence, for oxygen operation, the recycle gas replaces the nitrogen normally entering with air under normal air operation.

SURE™ Double Combustion

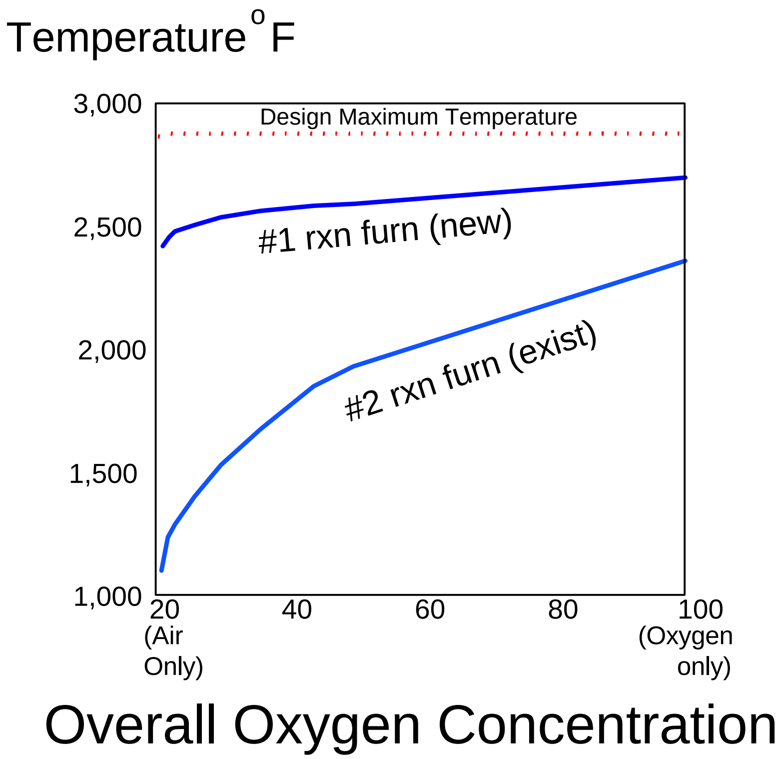
Double Combustion, as the name implies splits the heat release into two separate reactors with cooling in between.



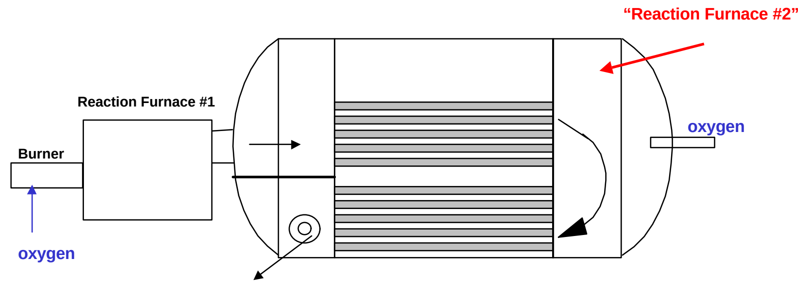
In the first reaction furnace, all amine acid gas, all sour water stripper gas (if any), and all air are fed to the new BOC burner. Only oxygen is split between the first and second reactor. Control is straightforward. The oxygen is split at a constant ratio with about 2/3 going to the first reactor and 1/3 going to the second.

There is no sulfur condenser between the #1 waste heat boiler, and the #2 reaction furnace. Also, there is no burner in the #2 reaction furnace. By design, the gases exiting the #1 waste heat boiler, and entering the #2 reaction furnace, are substantially above the auto-ignition temperature under all normal, and turn down operating conditions. This allows for a low pressure drop system, which is easy to control, and easy to install.

The result of this type of control is a temperature profile ideally suited to the Claus process. Operating temperatures in the first reaction furnace are high enough to destroy ammonia, and hydrocarbons, but low enough that they are well below refractory limitations.



The Double Combustion process has been operating since 1990. However, more recently, in Italy a novel approach seemed to be particularly applicable to the Shell / General project. In that plant, a single multi function heat exchanger provides #1 WHB, #2 WHB, and #2 reaction furnace services. This particular approach has been operational since 1996.



The first pass is the #1 WHB, the second pass is the #2 WHB, and the turn around space is used as the #2 reaction furnace. Thus for very little additional cost to normal replacement of the WHB the plant could be configured to take advantage of high concentrations of oxygen right from the start.

Costs were generated for retaining the existing WHB, and adding new equipment up stream of the reaction furnace in a conventional Double Combustion configuration, as well as using the new multi function WHB approach. The costs were nearly identical, and the decision was taken to use the multi function WHB so that the old WHB, which had been troublesome, could be abandoned.

Overall Evaluation of Competing Technologies

An overall evaluation of the remaining technologies, COPE™ and SURE™ was carried out. The following factors were considered in that evaluation:

- Cost
- Operating Experience
- Technical feasibility
- Ultimate capacity
- Project execution
- Schedule (meet Turn Around window)
- Operability
- Turn Down capability
- Maintainability
- Technical Support
- Risk

While there were minor differences in some of these categories, two issues were identified as having significant impact.

A good relationship had been established with GAA. However, Shell and General did not feel comfortable with the COPE™ II technology which requires a recycle blower to achieve the high levels of oxygen enrichment required for maximum capacity increase. It was noted that this is a particularly harsh service for rotating equipment.

On the other hand, there were some lingering concerns over the ability to introduce oxygen through a lance into the second reaction furnace without oxygen breakthrough or corrosive SO_3 formation. Although equilibrium calculations indicate that there should be no problem. Non equilibrium concentrations possibly due to non-ideal mixing, or temperatures could not be ruled out without some further investigation. Also, because most of the SURE™ experience was outside the U.S., the BOC/Parsons capability to provide adequate Technical support in the U.S. was also unknown.

At the time, the COPE™ technology had more experience with operation at higher levels of oxygen enrichment. However, both technologies had a reasonable level of commercial operating experience worldwide.

Based on the evaluation carried out, General Chemical and Shell decided on the Double Combustion technology as their first choice. The primary motivation for choosing Double Combustion was that it provided the greatest potential for achieving the maximum increase in capacity, in the most cost-effective manner.

The primary issue regarding maximum obtainable oxygen enrichment levels (and therefore, capacity) is the refractory temperature in the reaction furnace. SURE™ Double Combustion represents the most benign approach to the thermal limits of conventional refractory. In addition the SURE™ burners were being well received by clients, and if operating problems necessitated abandoning Double Combustion for burner only operation, Shell and General would still be able to achieve a substantial increase in capacity. While there was some risk associated with the decision, it was considered to be modest. Nonetheless, since Shell and General had no first hand experience with the technology, a final decision would depend on a satisfactory visit to plants using the SURE™ technology.

Plant Visit - API Falconara refinery, Italy

In order to satisfy Shell and General Chemical it was necessary to visit an operating company for observations, operator interviews, and general data gathering. This was primarily to ensure that equipment was standing up well in service, and that there was no evidence of oxygen breakthrough, corrosion of tubes or tubesheet, or refractory damage.

API Falconara has been operating Double Combustion on and off since October of 1996. Therefore, we visited this plant first, and spent a full day talking with the operators and engineers there. API reported complete satisfaction with the technology. Specifically:

- No evidence of oxygen breakthrough
- No refractory damage in #2 rxn furn.
- No evidence of accelerated catalyst sulfation
- Operators satisfied with installation

Visit to AGIP Sannazzaro refinery, Italy

While in Italy we also visited the AGIP Sannazzaro refinery outside of Milan. There, Double Combustion is not being used, but a SURE™ burner has been in operation for 4 years. Also, this refinery is rather unique because AGIP has one sulfur plant with a SURE™ burner installed, and another with a Lurgi burner installed. Even with the Lurgi burner on one plant, AGIP spoke very highly of the SURE™ burner operation.

Shell has had good experience with their Lurgi burners at Deer Park. Since AGIP has both, and reported satisfaction with the SURE™ burner, one could conclude that if Shell is satisfied with Lurgi burners then they will also be satisfied with the operation of SURE™ burners.

Visit to BOC Pilot Plant and Research Facilities

At the research center in Holbrook, England we witnessed a demonstration of the very sophisticated CFD modeling employed to design the burners and lances used in the # 2 reaction furnace. We also visited the pilot plant at the Courtaulds site (carbon di sulfide manufacture) in Stretford, England (outside of Manchester).

The overall impression was that the technology was well thought out, and there was good reason to believe that BOC / Parsons would provide a high level of on going technical support. Based on these visits Shell and General decided that they were ready to proceed with SURE™ for the capacity expansion project.

Project Features

For any project of this nature, the client will demand a credible, experienced engineering contractor to establish confidence in the successful outcome of the project. Engineering for the Double Combustion process, and this project specifically is provided by Parsons Energy and Chemicals Group. For this project, Parsons established a schedule, and provided the initial evaluation of all existing equipment in the sulfur plant and Tail Gas Treating Unit for operation at the increased capacity. They provided specifications for the additional process control requirements necessitated by addition of oxygen into the system, and a complete Front End Engineering Design including Heat and Material balances, PFD's, P&ID's, data sheets for new equipment, and design review of detailed engineering of critical equipment. Detail engineering was completed by a local firm, Anvil Engineering.

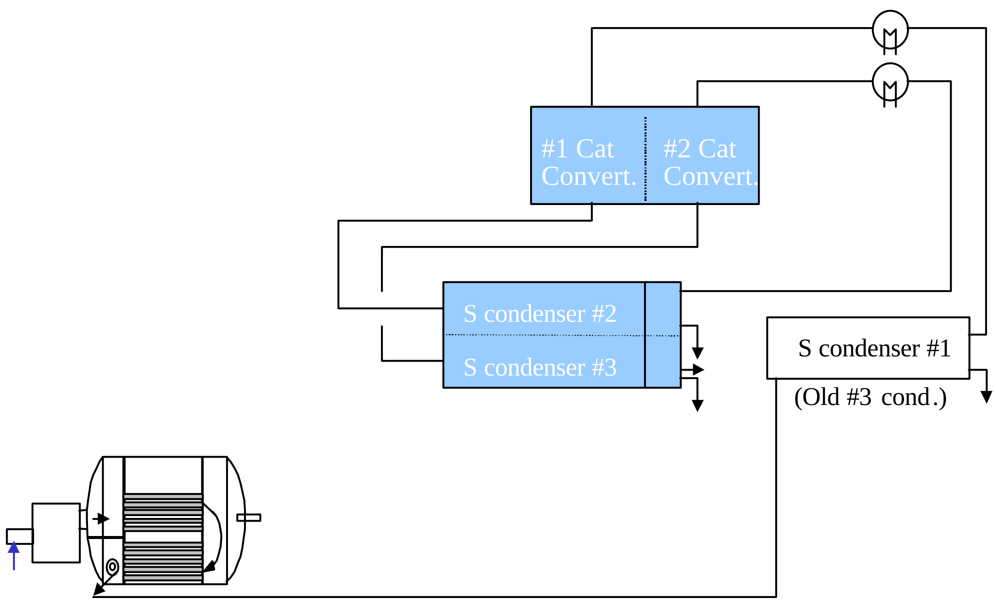
During the selection phase Parsons provided cost estimates for application of Double Combustion, and later provided cost estimates for the two different approaches to employ Double Combustion (retaining the existing waste heat boiler, or replacing both the new and the existing with a multi function heat exchanger).

Some of the key features of this project are listed below:

- Full Flexibility
  (100% air - 100% oxygen)
- 2 1/2 times capacity
  (18 1/2 LT/D to 46 LT/D)
- Turn Down on air retained
- #1&#2 WHB plus #2 Rxn Furn
  in single vessel (like API Falconara)

As part of the overall plant evaluation it was recommended that the service of the condensers be switched. Therefore, the separate #3 condenser is now being used as the new #1 condenser, and the two condensers in a common shell are being used as the #2 and #3 condensers.

The reheat has also been changed from hot gas bypass to electric heat. To the best of our knowledge this plant will be the first sulfur plant to use 100% oxygen on a rich, refinery type acid gas feed. The capacity gained through this project will provide the refinery with much greater flexibility in operations.



Project History

The project was initiated with a kick off meeting at the Parsons offices in Pasadena, CA on August 22, 1997.

The P&ID review meeting was held January 28, 1998.

A Process Hazard Analysis (PHA) was conducted in April 1998, facilitated by Shell, to review the proposed modifications to the SRU, and recommended changes were included in the program.

The SRU was shutdown in June 1998, in conjunction with a Shell (now Tesoro) Refinery shutdown, to increase the size of the H_2S line to the SRU. During this time, the SCOT solvent system was chemically cleaned.

Groundbreaking on the SRU Oxygen Enrichment program began in late July, with construction taking place beside the existing SRU which continued to operate. Major equipment and supporting structural steel and piping was installed whenever possible. On November 11th, 1998, the SRU was shutdown to make the tie-ins for the new process. In addition to modifications in the Claus plant, there were also modifications made to the SCOT tail gas unit.

1. SCOT Reactor System: The design called for removing the "Pre-SCOT Reactor Cooler" (E-401A). The SCOT burner is the Reducing Gas Generator (RGG) for the process, and was originally designed to discharge tail gas at 917°F. The function of E-401A was to cool the process gas from 917°F to 525°F for feed to the reactor bed. The new design called for operating the RGG with an outlet temperature of 525°F, thus eliminating the need for E-401A. However, E-401A was kept in the system, with a bypass added to accommodate the new design. New fuel gas and combustion air valves were added. Both E-401A and E-401, which is the cooler that follows the reactor, operate at 50 psig.
2. SCOT Solvent System: The quench-water cooler, the solvent cooler, and the solvent-stripper-overhead condenser (air cooled units in the same housing) were all increased in size.
3. Sour Water Stripper: The sour water stripper (SWS) had modifications made to allow the unit to process up to 5 GPM, up from 2.5 GPM. At the higher operating rates, the SCOT Quench Tower was expected to increase sour water production. The capacity was increased by adding a sour water feed pre-heater (feed-to-bottoms) and an overhead condenser, to knock out water flow to the incinerator, where the SWS overhead discharges. Additionally, the feed pump and discharge pumps were upgraded, and a cooling water circuit (using quench water) was added to supply the overhead condenser and the product cooler.
4. Utilities: A new, larger steam condenser and deaerator was added to handle the load generated by the new WHB, and the old condenser was kept to supplement the new unit.

While doing loop checks, it was found that the Rosemount 3095MV transmitters were not responding to differential pressure inputs. Nine (9) of these pressure- and temperature-compensated units were installed, for service on the three (3) oxygen lines, three (3) acid gas flows, two (2) air flows, and the natural gas flow. With the exception of the main acid gas meter (which is a calibrated venturi meter), all these flowmeters use an orifice plate as the primary element. The reason that these were not responding properly, after much checking, was that the transmitters had not been pre-programmed by Rosemount. The programming could only be done on a PC with a special modem, and program, neither of which were ordered as part of the original project. A Rosemount technician was called in to service the units, just days before the unit was started up.

Another significant problem realized during the loop checks dealt with solenoid valves used to actuate the automatic block valves. The valves were ordered for 24V, allowing them to be powered directly by the MOORE I/O cards. Because of the low voltage, these solenoids were "pilot-operated" and slightly larger than 110V solenoid we actually received. As a result, the solenoids would not fully open, and the block valves would not respond. Additionally, some wires were damaged. To solve the problem, because the 24V solenoids were a long-lead item, a 110V relay cabinet was quickly fabricated and installed, and the damaged wire bundle was replaced. Later, it was decided to make the relay a permanent modification.

Natural gas was first introduced to the Claus on November 26th, 1998, to begin the refractory cure. There were minor issues with getting the flame scanners to see the pilot, due partially to the nitrogen purges blowing the pilot out their line of sight. The switch to main flame was hindered only by poorly-tuned controllers causing the valves to open slowly. Additionally, the E^2T pyrometer was not acknowledging any temperature change, although the Delta thermocouple did. It turned out to be an issue with the signal isolator, which was remedied. The curing of the front combustion chamber was accomplished during this initial firing with natural gas. However, the second combustion chamber did not rise above 500°F, while operating with clean waste heat boiler tubes, and firing natural gas. The ability to introduce air into the second combustion chamber requires fuel (hydrogen sulfide, and sulfur) plus a temperature well above autoignition. This chamber would not be cured until acid gas was introduced into the system.

On November 23rd, 1998, an unfortunate incident occurred in Equilon's Coker unit, while trying to re-start the unit after a power outage. A result of this incident was the delay of acid gas from the refinery, without which the SRU could not be started, unless an acid plant was taken offline. The SRU was left in "Hot Standby" for the month of December, until acid gas from Equilon began arriving. During this time, the SRU was shutdown twice: once to replace a leaking isolation valve in the steam line to the Claus burner gun; and a second time, unintentionally, when a loss of instrument air and a faulty nitrogen regulator caused the loss of pressure to the block valves, which then went to their fail position.

While only acid gas from Tesoro is used in the SRU, it is important to understand that the primary function of the General Chemical facility is to regenerate sulfuric acid, and the acid plants use hydrogen sulfide as fuel. When there is little or no flow of acid gas from Equilon, more of the acid gas from Tesoro must be fed to the acid plants, which means there is less available for the SRU.

On December 30th, 1998, acid gas was introduced to the Claus. During the initial transition to Acid Gas Combustion with Air, the unit shutdown due to a control system programming error. The program assumed an immediate increase in flow, which did not allow for the transition. This was quickly remedied, and the unit was re-started. There was also some trouble getting the Electric Reheaters started, due to moisture in the element power box. Once the unit was running, it was noted that the tail gas analyzer showed the unit was too far off of ratio. After checking the analyzer, the constant in the ratio equation was adjusted until the unit was in ratio. Several instrumentation modifications were made during this time, as well, including the removal or enlarging of restriction orifices and re-spanning of flow transmitters due to erroneous pressures used in sizing.

After several days of running on acid gas, the unit was running with high emissions. After analysis, it was determined that at some point, the SCOT reactor catalyst had been oxidized. As a result, the tail gas unit was performing poorly. The Claus was put on "Hot Standby," and the SCOT was shutdown on January 12th to change the reactor catalyst. The maximum rates achieved on the unit, up to this point, was 19,000 scfh acid gas, on January 5th, 1999.

There were, and still are, some issues with running on Natural Gas. Keeping the furnace at a moderate temperature requires steam, as expected, and nitrogen. The nitrogen is introduced for two reasons: one, to control the flame temperature without having to go too far into the sub stoichiometric region, with the associated risk of soot formation; two, to meet cooling requirements on the burner gun itself, since the flow of natural gas is much lower than the equivalent flow of acid gas for the same air flow.

With the SCOT catalyst replaced and pre-sulfided, the acid gas was fed into the Claus on January 15th. The emissions dropped, and the unit was pushed to 23,000 scfh H_2S on January 19th. The secondary combustion chamber had still not been fully cured, running at a maximum of 760°F. . Acid gas content in the fresh feed to the sulfur plant is fairly steady at 78 to 80% H_2S. Sulfur throughput on the 19th was approximately 16 LT/D. All figures cited refer to fresh feed to the plant, and do not include SCOT recycle gas.

As a reference point, the sulfur plant prior to replacement of equipment associated with this project had a typical maximum throughput of 23,000 to 24,000 scfh. The highest production year was 1991. In June, the highest month of that year, the plant processed 24,442 scfh of acid gas with a strength of 83% H_2S (approximately 19 LT/D).

After nearly a month's worth of data, it was realized that the main acid gas meter was not measuring accurately, differing from actual production by nearly 20%. Further investigation revealed that the transmitter was setup to use an orifice plate as a primary element, instead of a venturi meter to which it was actually connected. The service technician was called back in (as the programming software had not yet been received) to fix the transmitter on February 10th. Constants within the system were changed to account for the new flow reading, as all flows into the unit are cascaded off this transmitter.

On February 11th, acid gas rates were increased to 23,000 scfh, (77.94% H_2S, 16 LT/D), and the temperature in the secondary combustion chamber reached 696°F. This was still lower than both the design which is based on fouled tubes, and the permissive for introducing either oxygen or air. However, the autoignition temperature of hydrogen sulfide, and sulfur is approximately 550°F. Therefore, the permissive temperature was temporarily lowered to 696°F, and the combustion air introduced. This immediately brought the temperature in the secondary combustion chamber to 750°F.

Oxygen had arrived on site the first week of February, and the tank had been brought up to operating pressure over that week. On February 12th, oxygen was introduced into the burner, with no issues during the transition. The unit was brought up to 30,000 scfh acid gas, (77.94% H_2S, 21 LT/D), at an enrichment level of 40%. The only complication during this run was the oxygen supply pressure regulator, which had to be adjusted. A switch to "Air Only" operation occurred later that day. At that time, a flow of 28,000 scfh acid gas, (20 LT/D) on Air Only operation was established.

Throughout the months of March and April, the unit was run at minimal rates as Equilon was using much of their acid gas to destroy their Sour Water Gases while working down their inventory. As a result, the capacity test was delayed until May 4th and 5th.

Brimstone was present to test the performance of the unit. On the 4th, an attempt was made to run at maximum rates in "Air plus Oxygen" mode. However, an erroneous flow was used to size the main oxygen valve. As a result, the full capacity of the "Air plus Oxygen", and "Oxygen Only" modes went untested. The performance test conducted by Brimstone on air only established the maximum acid gas rate in this mode at 30,000 scfh, (78.89% H_2S, 21 LT/D). This is higher than the maximum achieved with the old equipment. While the increase is modest, especially when compared to the increase now available with oxygen, it is interesting to note that even with the extra waste heat boiler service, there was no loss in capacity. This is due, at least in part, to the low pressure drop design of the SURE™ burner.

During the day, the oxygen tank pressure was raised approximately 50 psig to 150 psig to compensate for line losses, and the smaller valve. This did, however, put the control valves in a poor control range for low flows. On the 5th, the Air and Oxygen test was attempted once again, reaching 58,895 scfh (79.78% H_2S, 43 LT/D) at 53% enrichment. However, the test was quickly terminated as the Boiler Feed Water system could not supply the Waste Heat Boiler fast enough, and nearly hit the low level shut down. At 53%

oxygen the #1 reaction furnace temperature was approximately 2200 ^oF, and the temperature in the #2 reaction furnace (rear chamber of the waste heat boiler) was approximately 1275 ^oF. Sulfur throughput was more than double the maximum current air based capacity established during testing on the previous day (21 LT/D).

After several days of investigation, it was found that a pair of lift-check valves directly after the Boiler Feed Water pumps had an unusually high-pressure drop. As all the boilers began to call for water, the WHB was starved. These check valves were replaced with normal swing-check valves, as were any others in the unit, and the pumps were setup so that they could be isolated in future, if a dedicated circuit for the WHB were desired. Additionally, an orifice plate was put in the feed water line to the auxiliary boiler, which helped to resolve issues with deaerator being drained rapidly. These changes would allow operation with high levels of oxygen. However, once again, the lack of acid gas feed prevented the immediate retesting of the unit.

Additionally, some problems in the SCOT were discovered. The lean-rich solvent heat exchangers were not operating properly, and emissions still seemed high. The whole unit was shutdown on May 24th, when Equilon had to take down their Cat Cracker due to design problems lingering from their recent turnaround. The heat exchangers were heavily fouled on the tube-side. Additionally, it seemed that the SCOT catalyst was not performing properly. An investigation yielded the following:

- The heat exchangers' were too large, allowing the velocity to drop to less than 1 ft/sec. Although we have yet to find out why the exchangers did not foul before, the reason for them fouling this time was apparent.
- The SCOT burner was discovered to be several times too large for the turndown rates.

The unit was re-started, after cleaning the exchangers, on May 27th. It tripped down once on the loss of Combustion Air, and a second time due to especially severe foam in the SCOT unit, causing a high level in the Inlet Separator of the Claus.

It was determined that the original burner in the SCOT unit was oversized to the extent that it was rated at about twice the duty required. The unit was shutdown once again on June 15th. The SCOT burner was modified into a smaller unit, per recommendations by Shell, and the catalyst was changed again.

The Claus was brought on-line on July 12th. The oxygen capability of the SRU has since been put to actual use to allow for repairing a leak in the acid plant TGTU. At that time, 40% enrichment was employed to process 48,000 scfh of acid gas, (78.89% H_2S, 34 LT/D). Today, the SRU with SURE modifications appears to be working properly, with acceptable emissions.

A full performance test up to and including operation at 100% oxygen is anticipated. However, as before, an adequate supply of feedgas is required, and remains the primary constraint.

CONCLUSIONS

Modifications to the Tesoro SRU operated by General Chemical have accomplished project objectives. While the project has had some fits and starts, and lack of feedstock has limited performance testing opportunities, the SURE™ technology seems to operate well under the mild conditions claimed. The ability to use oxygen to achieve greater capacity has already proven useful during an acid plant outage. The operators are very comfortable with control of the unit, whether operating on air or oxygen.