



Use a Cansolve SO₂ scrubbing system to better link your batch-operated furnace with its by-product sulphuric acid plant

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Synopsis

Smelting or converting of sulphide concentrates and mattes in a batch operation presents a challenge when directing the off-gas to a conventional acid plant. The Hindustan Zinc Ltd. (a division of the Vedanta Group of companies) Chanderia Lead Zinc smelter was presented with such a challenge that was met with the adoption of the Cansolv® SO₂ Scrubbing System.

The Ausmelt top submerged lance technology used at Hindustan Zinc generates a furnace gas stream that contains between 0.1 vol% and 12 vol% SO₂ during the three stages of batch smelting. Cansolv® SO₂ Scrubbing Technology captures the SO₂ to ensure that treated flue gas exits the facility at a concentration below 100 ppmv SO₂ and it releases SO₂ in a controlled fashion, to more closely match the needs of the existing acid plant.

The application of a regenerable scrubbing system to capture SO₂ from a batch-operated furnace and convert it to acid in a conventional acid plant was a first of its kind in the world. This paper provides an update on the design and operation of the Hindustan Zinc SO₂ recovery system and suggests two improvements to the basic flow sheet that optimize the cost of SO₂ scrubbing further.

Introduction

Batch smelting of lead, copper or zinc ores cycle between smelting, reducing and cleaning cycles. In addition, a hold cycle may also be incorporated. Each cycle is accompanied by different gas flow rates and SO₂ concentrations that can make operation of a sulphuric acid plant difficult. Hindustan Zinc recently completed the construction of a batch lead smelter, which used the Cansolv SO₂ Scrubbing System to smooth out the cyclic flow rates of SO₂ and reduce the impact of the feed gas SO₂ concentration on the acid plant.

Hindustan Zinc Limited (HZL) is a member company of the Vedanta Resources group (London, UK) and is a major base metal producer in India. Its operations encompass a full range of activities from mining, to smelting and refining of various metals, including zinc, lead, copper and precious metals. HZL has implemented an aggressive expansion strategy at its Chanderia Lead Zinc Smelter by doubling its hydrometallurgical zinc processing capacity and by building a new lead smelter.

The new lead smelter was commissioned in December 2005 and uses Ausmelt's top submerged lance technology to process the lead sulphide concentrate in a batch-wise fashion. The total batch time lasts between 10 and 12 hours and includes a smelting, reduction and cleaning stage. During the smelting part of the batch, which lasts approximately 6 hours, the SO₂ concentration in the off-gas can reach as high as 15%. The SO₂ concentration drops to between 3 and 4% during the reduction phase and to less than 1% during the cleaning phase of the batch. The amount of SO₂ produced in the off-gas is considerable, amounting to an equivalent of approximately 150 Mt per day of sulphuric acid.

The large amount of SO₂ emitted by the smelter made it impractical to sequester the SO₂ with a non-regenerable scrubbing agent such as lime or zinc oxide. Also the variable SO₂ concentration and the large volume of gas flowing from the smelter exceeded the hydraulic limit of the existing acid plant. A Cansolv® SO₂ scrubbing unit was installed to capture and concentrate the SO₂ gas, to allow the existing acid plant to absorb the additional load.

The Cansolv® SO₂ Scrubbing System uses a regenerable amine-based solvent, which is highly selective for SO₂ and produces a concentrated water-saturated stream of SO₂ (97% SO₂/ 3% water).

The acid plant was already facing some problems of low SO₂ concentration when processing the sinter plant gases, which required the preheater to be run intermittently to maintain thermal balance. The new, concentrated, SO₂ gas stream from the Cansolv® unit removed the need for supplemental heat and the operation of the acid plant has been improved.

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Process description

Furnace operation

Ausmelt's top submerged lance technology for lead smelting uses a vertically suspended lance submerged in a molten slag bath. As process gases are injected through the lance, the slag in the bath remains well mixed. Fuel is also injected through the lance and is combusted at the lance tip to heat the furnace. Controlled cooling inside the lance promotes the formation of a layer of slag around the outer surface of the lance, which protects the lance from the highly aggressive environment in the smelter bath.

The feed material to the furnace is delivered from the top of the furnace and dropped directly into the molten bath. At all times, the ratio of fuel to oxygen supplied to the lance is controlled, to ensure that proper oxidizing environments and bath chemistries are maintained. Reduction is controlled by the quantity and rate of reductant coal or concentrate that is fed to the system.

A batch mode of operation in this application allows the use of one furnace for all stages of production (smelting, reduction, cleaning), by allowing the operation to be switched from strongly oxidizing to strongly reducing conditions.

Heat recovery and dust removal

The furnace operates at a temperature of approximately 1 100°C. Hot gas is passed through a waste heat boiler in order to recover as much heat as possible as high pressure steam. Enough steam is generated in the waste heat boiler to provide approximately 75–80% of the steam required for the regeneration of the Cansolv® solvent. Dust is collected in the waste heat boiler and discharged by a drag chain conveyor. Gas exits the waste heat boiler at a temperature of approximately 350°C and is directed to a three-field hot electrostatic precipitator to complete the de-dusting of the gas. In the hot electrostatic precipitator, the dust particles are charged and collected on the electrodes. Dust, from both the waste heat boiler and the hot electrostatic precipitator is recycled to the furnace. Dust that is captured during the cleaning stage is collected and recycled to the existing sinter plant.

Gas cooling and mist elimination

Clean gas leaving the hot ESPs must be further conditioned before it is sent to the SO₂ Scrubbing System. First, it is cooled in a series of direct contact cooling towers and then it is treated in a wet ESP (WESP) for further particulate and acid mist removal. Appendix I illustrates the process operations used for the gas cleaning systems at Hindustan Zinc.

The gas is initially cooled to its saturation temperature in the quench tower. The tower is a brick-lined, open spray vessel and water is circulated through the tower both to quench it and also to remove additional dust. The quench tower cools gas from approximately 350°C to between 65 and 70°C. The water make-up to the quench tower is provided by the condensed water from the packed cooling tower, which follows it. A constant water purge is sent to the water stripper where SO₂ is air stripped from the water and sent back to the process. Stripped excess water is purged to the effluent treatment plant.

Gas leaves the quench tower at its saturation temperature and then enters the packed cooling tower where it is sub-cooled to a temperature of approximately 45°C. Cool water flows countercurrently to the warm gas over a packed bed. The circulating water is cooled in a water-cooled plate and frame heat exchanger.

The final step in gas conditioning prior to SO₂ recovery is to treat the gas in a two stage, wet electrostatic precipitator (WESP). The two WESPs, installed in series, are designed to remove the remaining fine dust and most of the acid mist present in the gas. It is crucial to remove this acid mist in order to prevent the strong acid from saturating the SO₂ scrubbing solvent and eventually rendering it inactive.

Sulphur dioxide capture and regeneration

The Cansolv® SO₂ Scrubbing System is used to recover the SO₂ and send it as a concentrated stream to the acid plant. The CANSOLV System is a wet scrubbing process that uses a regenerable aqueous amine solvent to remove SO₂ from the smelter off gas.

The CANSOLV Solvent is highly selective to SO₂. All the other compounds in the gas are not absorbed and are discharged directly to atmosphere through the stack. SO₂-containing solvent leaves the absorber and is regenerated using steam to produce a concentrated SO₂ stream whose small volume can easily be accommodated in the existing acid plant. Appendix II shows a typical flow diagram of the Cansolv unit.

The cleaned and cooled gas is contacted in the absorption tower with the lean amine solvent in a countercurrent arrangement in which liquid flows down and the gas flows up. The absorption tower uses structured packing in order to maximize the area of contact between the gas and liquid and to minimize the gas-side pressure drop. Since the amine solution is a chemical equilibrium solvent, the concentration of SO₂ in the solvent increases as it reaches the bottom part of the absorption tower where it contacts the gas with the highest SO₂ concentration where it enters the tower. The temperature of the lean amine fed to the tower is controlled to match the temperature of the incoming gas in order to avoid condensing or evaporating water into the gas. The cooling of the amine is achieved by a water-cooled plate and frame heat exchanger. The flow of the lean amine to the absorption column is also varied depending on the SO₂ content of the gas at each stage of the batch in the smelting cycle. The rich amine is then collected in the absorption tower sump and is pumped to a rich amine storage tank.

The rich amine solvent from the rich amine storage tank is pumped to the regeneration tower to recover the SO₂ from the solvent. Before entering the tower, cool, rich amine solution is cross heat exchanged with hot, lean solution in a lean/rich heat exchanger. This heat recovery reduces both the amount of steam necessary to regenerate the solvent and the amount of cooling water needed to cool the lean solution to absorber conditions.

The rich amine enters the regeneration column and flows down the structured packing bed against upwardly flowing steam. The higher temperature environment of the regenerator and the flow of steam remove SO₂ from the rich solvent and carry it out of the column. Amine solution that is depleted of SO₂ enters the reboiler, where part of the water

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contained in the solution is vapourized by 3–5 bar(g) steam that is introduced into the tube side of the kettle reboiler. The vapourized portion of the amine solution serves as the source of steam in the regenerator tower that regenerates the incoming rich amine. Once regenerated, the lean amine leaves the reboiler and is pumped from the regeneration tower to the lean amine storage tank via the lean/rich heat exchanger.

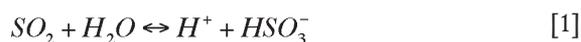
The SO₂ released from the rich amine solution exits the top of the regeneration tower along with water vapour and flows to the condenser where the water fraction of the gas is condensed and returned to the tower. The non-condensable, water saturated SO₂ gas stream is sent to the acid plant for conversion to sulphuric acid. A short section of structured packing is installed above the rich solution feed point. Water from the reflux drum is introduced to the tower above this section of packing to remove entrained amine solution that may be carried upwards from the rich amine feed point.

The regeneration section of the Cansolv® SO₂ Scrubbing system is designed to operate at a constant rich amine flow rate in order to moderate the variability of the SO₂ flow rate from the regenerator. Since the flow of lean amine to the absorption tower varies with the incoming gas SO₂ concentration, the rich and lean amine storage tanks are designed to act as buffers to accommodate the different amine flow rates required for the various stages of the conversion process.

Any strong acid that comes in with the gas accumulates in the amine solvent as a heat stable salt (HSS) and cannot be regenerated using steam. Minor amounts of HSS are also formed by a disproportionation reaction of SO₂, which converts it to SO₄ at elevated temperatures. If the HSS are allowed to accumulate, they will eventually neutralize the amine and the solvent will lose its SO₂ absorption capacity. In order to maintain the concentration of HSS constant in the solution, a slipstream of the cool, lean amine is directed to an amine purification unit (APU). The HSS are anions, consisting mainly of sulphates and can be removed either by an electrodialysis or an ion exchange process. Hindustan Zinc has successfully used both HSS removal methods, in a complementary fashion.

Cansolv® process chemistry

The Cansolv® SO₂ Scrubbing System is based on a unique class of diamine absorbents that optimally balance the ability to absorb and regenerate sulphur dioxide. Removal of SO₂ from a feed gas stream first requires mass transfer of the SO₂ from the gas into the solvent, which typically operates at 25–30% amine concentration. In solution, dissolved SO₂ undergoes reversible hydration and ionization according to the following equations:

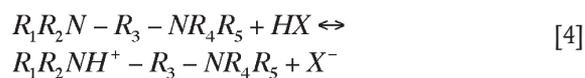


Reactions [1] and [2] are half completed at pH values of 1.81 and 6.91, respectively, at 18°C. The presence of the amine buffer in the solution, increases the quantity of SO₂ which can be dissolved. The buffer drives the above equilibria to the right by reacting with the hydrogen ions to form amine salts:

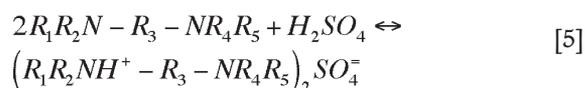


In order for the process to be regenerable, the buffering agent should operate in a pH region sufficiently low so as to present a desirable value of SO₂ vapour pressure over the solution at the regeneration temperature. Steam stripping of the vapour phase SO₂ in a multiple stage column will then reverse reactions [1]–[3], regenerating the absorbent.

One of the amine functionalities of the diamine absorbent is formulated to be strongly basic such that it is essentially non-thermally regenerable under the Cansolv® System process conditions. Therefore, once reacted into a salt by SO₂ or any stronger acid, this strongly basic amine functionality will remain permanently as a salt while in process. This is illustrated in Equation [4], for the case of virgin diamine reacting for the first time in process with an acid HX, where X⁻ is any anion of a relatively strong acid, such as SO₄²⁻, Cl⁻, NO₃⁻, etc.

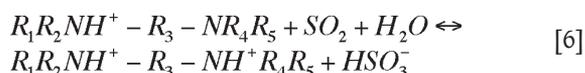


A strong dibasic acid such as sulphuric acid would protonate two amines and yield SO₄²⁻ as the anion X⁻.



The monoprotonated amine on the right-hand side of Equations [4] or [5] is the in-process lean amine, which is used to scrub SO₂. Because the solvent is now a salt, it is essentially non-volatile and since it is non-heat regenerable, it will stay in salt form throughout the process.

The second amine functionality (the 'sorbing nitrogen') is less basic and it buffers in the desired range for regenerability of SO₂, which in practice is about pH 4–5 for the rich amine and pH 5–6 for the lean. This buffering range provides the proper balance of absorption and regenerability and is the essence of the Cansolv® SO₂ Scrubbing System. This reaction is shown in Equation [6].



In Equation [6], the anion X⁻ is not shown as it does not participate in the SO₂ reaction with the sorbing nitrogen. However, if X⁻ is the anion of a strong acid and is allowed to accumulate to more than 1 equivalent per mole of amine, it will eventually neutralize the sorbing nitrogen and thereby decrease the SO₂ scrubbing capacity of the solvent. Thus, the level of these 'heat stable salts' (HSS) must be controlled by treating a slipstream in the purification unit.

Plant operation

The variation of SO₂ concentration in the gas being treated by the Cansolv unit is depicted in Figure 1 of Appendix IV. The Figure shows data for a 24-hour period, which incorporates all stages of a full batch cycle and the smelting and reduction stages of a second batch cycle. The initial smelting stage lasts for five hours. During this stage, the SO₂ content of the raw gas hits its maximum level of 12 vol%. The reduction stage is next and lasts two and a half hours. During this time, the SO₂

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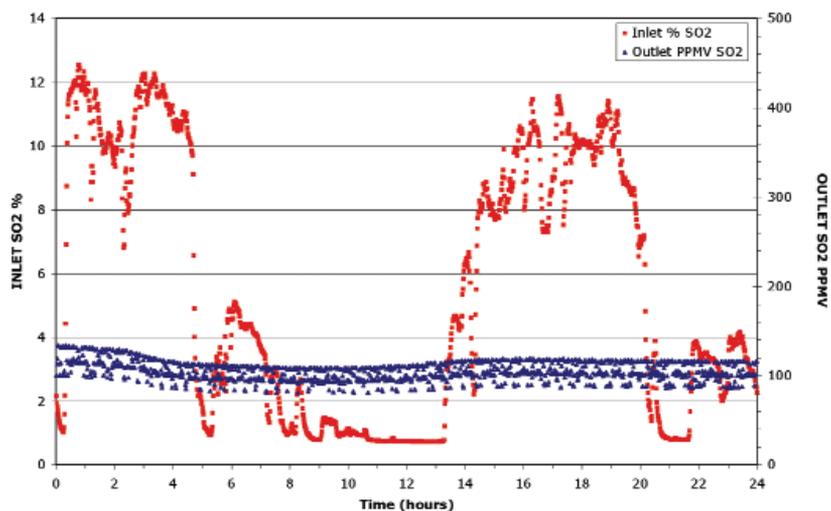


Figure 1—Inlet and outlet SO₂ concentration

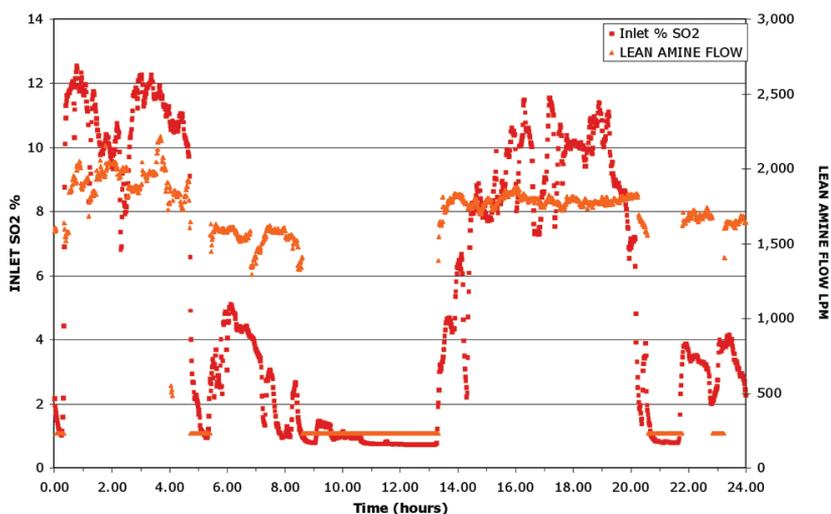


Figure 2—Lean amine flow and inlet SO₂ concentration

concentration drops to between 3 vol% and 4% SO₂. The cleaning stage, lasting approximately five hours, follows the reduction stage and during this period, the SO₂ concentration in the absorber inlet gas drops to less than 1%. During the cleaning stage, the metal tap and the slag tapping are performed.

Figure 1 of Appendix IV illustrates that the SO₂ concentration of the gas going to the stack is maintained at approximately 80–130 ppmv throughout the whole batch, regardless of the inlet concentration of SO₂. During the batch, the amine flow to the absorption tower is adjusted depending on the SO₂ concentration and gas flow. Figure 2, in Appendix IV, shows that adjustments to the amine flow rate are made to match the changes to the inlet SO₂ concentration.

Figure 3 of Appendix IV shows the variability of the SO₂ production rate over a twenty-four hour period. When the inlet gas contains a high concentration of SO₂, the rich solution is highly loaded with SO₂ and the regenerator SO₂ flow rate is high. During the reduction and cleaning cycles,

the SO₂ flow rate gradually drops off because inventory in the rich tank is being diluted in SO₂ from the weakly loaded amine solution that flows from the absorber. Figure 3 also shows that the SO₂ flow rate reaches a maximum of 1500 Nm³/h during smelting periods and gradually falls to 500 Nm³/h during the cleaning phase.

A constant minimum inventory in the rich solution tank also provides a buffer for the SO₂ flow rate fed to the acid plant during the final stages of the smelting cycle. If the residual inventory in the rich tank is low, then weakly loaded rich solution, generated during the final stages of the batch, has a greater tendency to dilute the rich solution inventory, resulting in reduced SO₂ flow rates at the end of the cycle. Higher rich inventories overcome this dilution effect and dampen the variability of the SO₂ flow rate.

These maximum and minimum flow rates of SO₂, occurring during each batch, could have been dampened out had the SO₂ production profiles been accurately identified during the detailed design phase of the project. Initially, it

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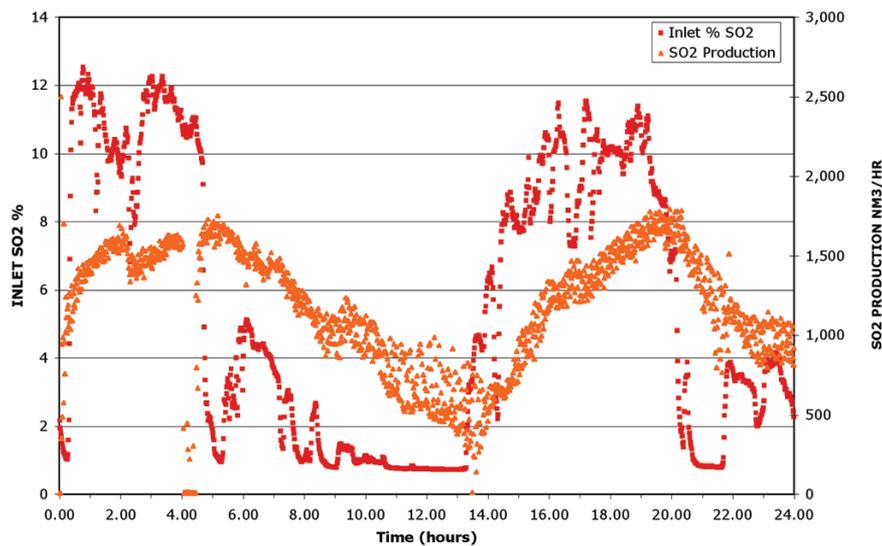


Figure 3—SO₂ production and inlet SO₂ concentration

had been planned to use coal as the reductant during the reducing phase and a higher quantity of SO₂ would have been produced. Late in the design phase, it was decided to use concentrate as the reductant. This reduced the amount of SO₂ that would be generated by the furnace and a more optimally sized regenerator could have been selected. The hydraulic design turndown limits of the absorber and regenerator had been frozen by this stage of the design and equipment had already been purchased.

The change in design basis did not affect the project, however, because the existing acid plant was able to accommodate the minimum and maximum flow rates of SO₂ received from the Cansolv System for the actual operating conditions.

Steam that is consumed in the regenerator is the single greatest consumable in the Cansolv SO₂ System. Approximately 75 to 80% of the steam necessary for the solvent regeneration is produced in the waste heat boiler at the outlet of the furnace. The remaining steam is taken from the plant steam systems. The unit was designed to operate at 0.24 tons of steam per ton of rich amine and has been operating at 95% of this value. This design corresponds to a specific steam consumption of 4.5 tons of steam/ton of SO₂ produced. The plant has demonstrated specific steam consumption rates of 5.6 ton/ton. The higher steam consumption rates relative to design are partly due to the inefficient use of solvent during the reduction phase and to a fouled lean/rich heat exchanger. Fouling occurred because the solids load entering the unit was initially higher than design.

Process development—greenfield applications

Hindustan Zinc operated an existing sulphuric acid unit before the new lead smelter was installed. A Cansolv SO₂ Scrubbing system was chosen to allow the SO₂ load from the new smelter to be incorporated into the existing acid plant. The project's goal was to convert a high flow rate of smelter

off-gas, containing low concentrations of SO₂ into a small flow rate of pure SO₂. To that end, the Cansolv SO₂ Absorber was sized for the full flow of smelter off gas.

In a greenfield application, a new acid plant is required to convert smelter SO₂ to sulphuric acid. Its only feed stream would be SO₂ from the batch smelter. In this case, additional design considerations come into play.

A designer would like to achieve the following for his facility:

- Minimize the cost of the acid plant
- Minimize the cost of the SO₂ capture facility
- Ensure that the acid plant operates autothermally or exothermally at all times.

Acid plant cost

Space velocity defines the amount of catalyst and the absorber and the reactor size of an acid plant. If the volumetric flow rate fed to the acid plant is reduced, then the cost of the acid plant can be reduced.

The SO₂ concentration of the acid plant feed gas determines whether it can be operated in a net positive or negative energy mode. If the SO₂ concentration of the feed gas can be held between specific minimum and maximum levels, then the size and cost of cross exchange and steam generation systems can be optimized. Feed gas preheat can be avoided if the SO₂ concentration exceeds a specific minimum concentration in the acid plant feed.

SO₂ capture plant cost

SO₂ absorber

The superficial velocity of gas flowing to the SO₂ absorber tower sets the absorber diameter. The cost of the absorber section of the SO₂ capture system is thus directly proportional to the feed gas flow. If the gas volume is reduced, then the cost of the SO₂ absorber is reduced.

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SO₂ regenerator

The amount of SO₂ that is captured and regenerated by the SO₂ regenerator determines the size of the regeneration system. If the SO₂ rate is reduced, then the cost of the regeneration system is reduced.

Integrating Cansolv SO₂ scrubbing into a smelter/acid system

A Cansolv SO₂ Scrubbing System can be integrated into the batch smelter system in a way that meets the objectives cited above. Table I illustrates the feed conditions that might apply to a Cansolv SO₂ Scrubbing System for a hypothetical 100 000 t/year batch lead smelter.

In this case, if all of the smelter off-gas is fed to the acid plant, then the unit would require external heat for nearly 30% of the cycle time because the SO₂ concentrations of the gas are insufficient to maintain an exothermic condition.

All of this gas could be fed to the Cansolv SO₂ Scrubbing System, however, and a load leveling strategy could be implemented that feeds a stream containing 100% SO₂ to the acid plant. The Cansolv System unit would need to be designed to treat all of the smelter off-gas and regenerate all of the SO₂, which maximizes the cost of the Cansolv System.

A compromise between the two extremes highlighted above can lead to a more optimum investment strategy. A more balanced solution is shown in Table II.

This example illustrates how design compromises can be achieved.

- The clean smelter gas is split on a 60%/40% basis to the Cansolv absorber and the acid plant, respectively. The Cansolv absorber is designed to handle the variable gas flow rates from the smelter
- The concentration of SO₂ in the acid gas feed is increased to nearly 10 vol% during the smelting and reduction stages and not permitted to drop below 5 vol% during the fuming and hold stages.

Cansolv system design considerations

As in the HZL system, the Cansolv SO₂ Scrubbing System must still accommodate the variable gas and SO₂ flow rates

fed it by the batch smelter. In this case, the maximum and minimum lean solvent flow rates fed to the SO₂ absorber amount to 190 m³/h and 30 m³/h, respectively. In order to satisfy the solvent inventory requirements, a rich solution flow rate to the regenerator of 133 m³/h must be maintained. The rich and lean solvent tanks must both be sized for a maximum inventory of 400 m³. An inventory of 100 m³ of rich is assumed to be available at the start of the smelting cycle to satisfy the needs of the batch.

Table III summarizes both the demand for lean solvent and the associated demand for steam to regenerate this solvent. The design calls for the consumption of nearly 0.24 tons of steam per cubic metre of solvent fed to the regenerator. This consumption rate can be reduced to nearly 0.17 tons of steam per cubic metre of circulated solvent by introducing a steam saving feature into the design of the Cansolv solvent regeneration system.

Sulphuric acid tail gas treatment

The scenario considered above assumes that the acid plant may discharge tail gas directly to atmosphere. Should this not be the case, the designer can consider incorporating the tail gas into the feed stream entering the Cansolv SO₂ absorber as suggested by Figure 1 of Appendix III. Alternatively, a separate acid plant tail gas absorber can be considered that treats the tail gas alone. In either case, a continuous flow of lean and rich amine solution would be used to capture SO₂ and treat it to the necessary levels mandated by environmental considerations. The Cansolv SO₂ regenerator would be

Table I

Hypothetical batch smelter case

Parameters	Units	Smelting	Reduction	Cleaning	Hold
Duration	hours	4.5	1	2	0.5
Gas flow rate	Nm ³ /h	75 000	68 000	83 000	79 000
SO ₂	vol %	6.0	4.0	0.1	0.1

Table II

Integrated flow scheme for Cansolv SO₂ smelter acid plant

Parameters	Units	Smelting	Reduction	Cleaning	Hold
Duration	hours	4.5	1	2	0.5
Gas flow rate	Nm ³ /h	75 000	68 000	83 000	79 000
SO ₂	%	6.0	4.0	0.1	0.1
Gas to acid plant	Nm ³ /h	31 000	31 000	31 000	31 000
Gas to Cansolv	Nm ³ /h	44 000	37 000	52 000	48 000
SO ₂ in acid plant feed	Nm ³ /h	1 900	1 400	31	31
SO ₂ from Cansolv	Nm ³ /h	1 750	1 800	1 600	1 600
Acid plant feed SO ₂	% (dry)	11.0	9.0	5.0	5.0

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Table III

Cansolv SO₂ scrubbing system design parameters

Cycle	Smelting	Reduction	Cleaning	Hold
Time—hours	4.5	1	2	0.5
Flow—Nm ³ /hour to Cansolv N m ³ /hour	44 000	37 000	52 000	48 000
SO ₂ content—vol%	6.0	5.0	0.1	0.1
Lean solvent flow—m ³ /hr	190	107	30	28
Regen rich flow—m ³ /hr	133	133	133	133
Regen steam flow—t/hr	32	32	32	32
Lean flow to Abs—m ³ /cycle	860	100	60	20
Rich to regen—m ³ /cycle	575	133	266	66
Accumulation during cycle—m ³	285	-33	-206	-46

incrementally increased in size to handle this additional SO₂ stream and the recycle SO₂ flow rates would increase slightly over the numbers shown in Table III. Incorporating an acid plant tail gas absorber may allow the designer to take more latitude with his acid plant design and consider, for example, the economic benefits of using single absorption vs. double absorption configurations, or to increase the permissible gap between start of run and end of run catalyst conditions.

Cansolv single effect vs. double effect solvent regeneration

Multiple effect energy recovery/reuse flow sheets are well known in many industries where aqueous solutions containing small concentrations of a desired material must be concentrated into nearly pure streams of the desired material. These distillation systems are applied when the simple distillation technique is energy intensive, and where an overhead product of one distillation system can be used to reheat or reboil the bottom section of another distillation system. Double effect evaporation has been demonstrated in the past by the regenerable Wellman Lord SO₂ scrubbing system. This energy intensive process reduced its energy consumption for a given SO₂ scrubbing duty by a significant amount when a secondary evaporator was incorporated, which used the overhead vapour from the primary regeneration tower to regenerate the solvent.

The Cansolv SO₂ scrubbing system lends itself well to a double effect regeneration flow sheet. A flow diagram of the Double Effect Solvent Regeneration system is shown in Figure 2 of Appendix III. In this concept, two, nearly identical regeneration towers are provided. The hot rich solution exiting the lean/rich heat exchanger is split into two streams and fed to each regeneration tower. The two regenerator towers are operated at different pressure levels and the overhead stream from the high pressure regenerator is used as a heat source in the reboiler of the low pressure regenerator. The process gas entering the low pressure regenerator reboiler enters as a dilute stream of SO₂ and water vapour. The material leaving this reboiler is a partially condensed, more concentrated, stream of SO₂ and water vapour and liquid. Referring to Figure 2 of Appendix III, it

can be seen that the gas from the reboiler enters the low pressure regenerator overhead condenser, where the balance of the water is condensed and removed and the SO₂ is directed back to the acid plant.

Overhead product from the low pressure regenerator is cooled and the SO₂ is separated from the condensed water. The wet SO₂ product of the low pressure regenerator is directed to an SO₂ product blower and the SO₂ product from the blower is combined with the SO₂ stream from the high pressure regenerator system and sent to the acid plant.

The use of a double effect system increases the total capital cost of the Cansolv SO₂ scrubbing system by nearly 40% and additional rotating equipment is needed to maintain the necessary differential pressure between the high and low pressure regenerator towers. But, nearly 30% of the steam that would be used in an equivalent single effect regenerator is saved, which cuts the operating cost of the unit significantly and brings the steam consumption rate of the SO₂ capture system more in line with the steam generation rate of the sulphuric acid plant.

Conclusion

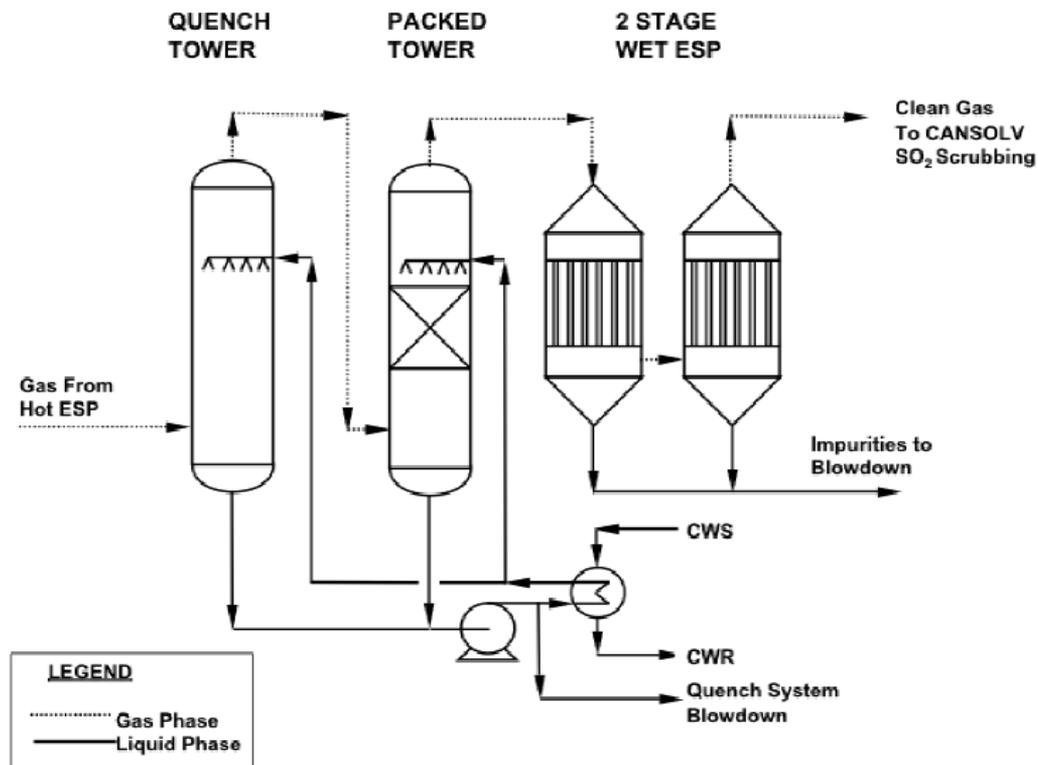
The Cansolv SO₂ Scrubbing System has been demonstrated successfully in a large scale batch lead smelter and has allowed Hindustan Zinc to process its entire load of SO₂ generated by the smelter in existing sulphuric acid facilities. Improvements to how the smelter flue gas is managed in a greenfield facility can lead to considerable savings in both the acid and SO₂ capture systems, while ensuring that the acid plant operates in an autothermal or exothermic mode.

Acknowledgement

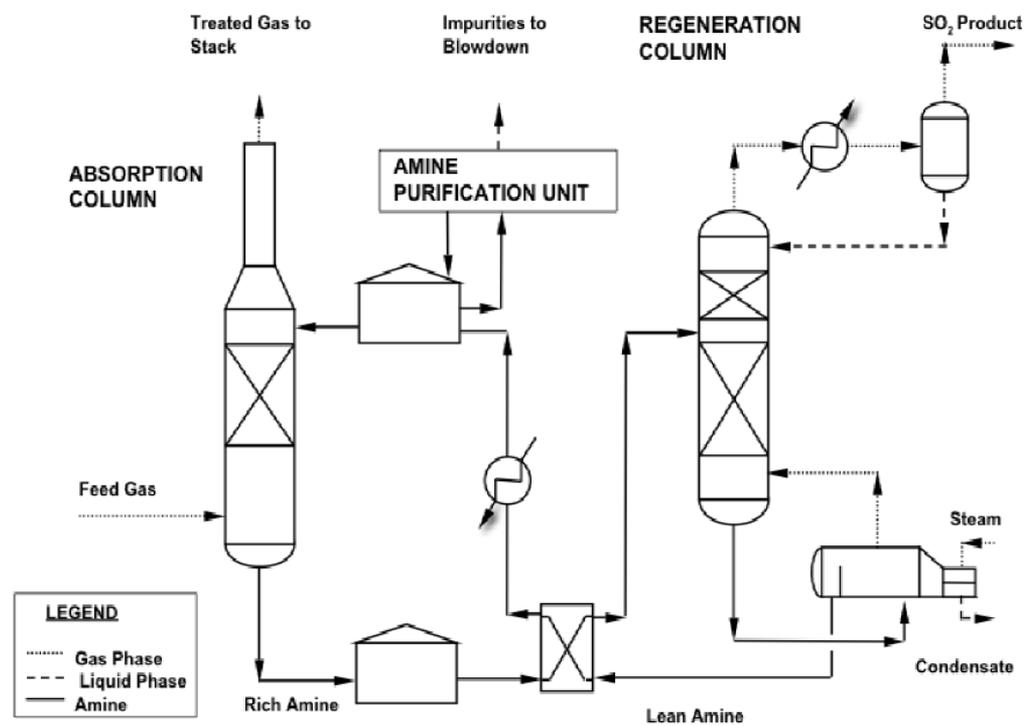
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Use a Cansolve SO₂ scrubbing system to better link your batch-operated furnace

Appendix I
Gas cleaning system process flow diagram



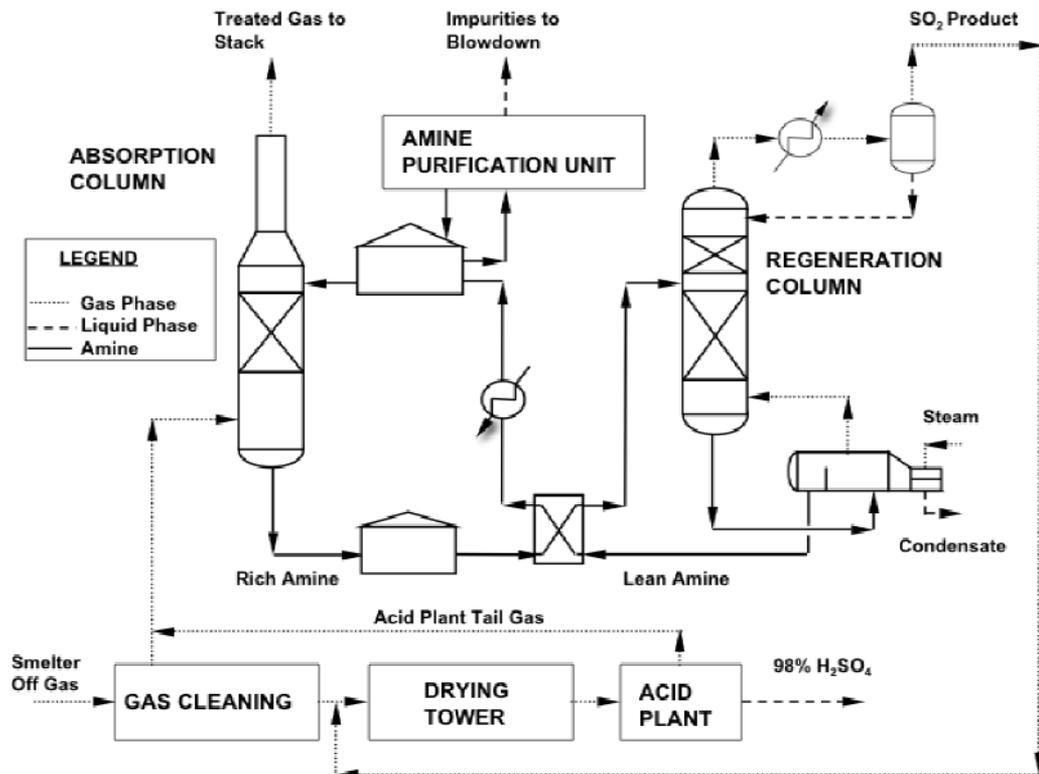
Appendix II
Cansolv® SO₂ scrubbing system process flow diagram



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Appendix III

Integration of Cansolv® SO₂ scrubbing system into a smelter acid system



Appendix IV

Hindustan zinc plant data

