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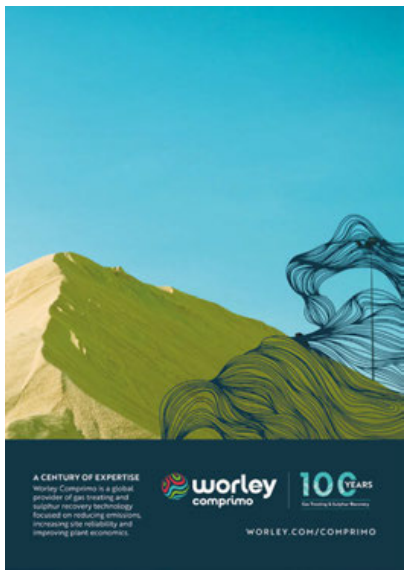

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China's acid exports

Concentrate shortage affecting smelters

Pyrite roasting

Extracting the sulphur from mine tailings

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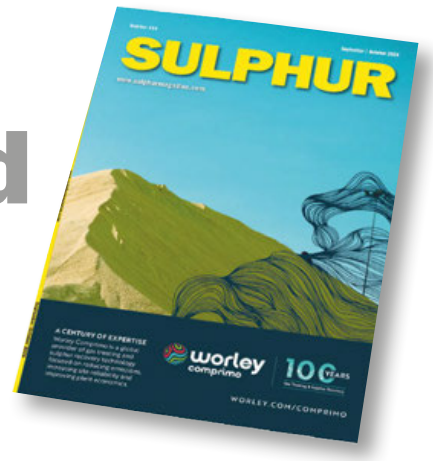


The effect has been equally dramatic on the sulphur and sulphuric acid industries...

One of the biggest areas for new sulphuric acid demand in the past few years has been in nickel processing plants, particularly in Indonesia. A decade ago, incoming president Joko Widodo took a strategic decision that the country needed to try and capture more of the value chain from its mining and mineral industry, which was focused at the time on exports of aluminium, copper and nickel ores and concentrates, mainly to China. Over the past 10 years, the export of raw ores has been progressively restricted and companies instead compelled to build downstream processing plants for the metals. With China the main recipient of Indonesian ores, much of the investment in metals processing in Indonesia has been via Chinese companies.

The results are now beginning to bear fruit, with the completion of projects like PT Freeport's major new copper smelter at Gresik (see Sulphuric Acid News, this issue). On the nickel side, several major plants for recovery of nickel using high pressure acid leaching (HPAL) have now been completed, and Indonesian refined nickel output is rising sharply. Recent figures show that by Q2 2024 global nickel supply rose by 8% year on year, with Indonesia the main driver of this. Indonesian nickel output rose 11% in the past year.

The effect has been equally dramatic on the sulphur and sulphuric acid industries, as acid demand for HPAL is considerable. While this initially drove an increase in sulphuric acid imports to Indonesia, rising sulphur burning acid capacity in Indonesia is now leading to a switch away from acid imports to sulphur imports. Indonesia's imports of sulphuric acid for July declined to 64,000 tonnes, down 64% year on year, while sulphur imports were 425,000 tonnes for the month, up more than 400% from the same period in 2023. Indonesian sulphur imports in the first seven months of the year increased 39% to 1.92 million t/a, up from 1.38 million t/a in the same period a year earlier. Global sulphur consumption for nickel production has climbed from 1.7 million t/a in 2020 to 3.5 million t/a in 2023, with most of the increase coming from Indonesia. Meanwhile Indonesian acid imports are likely to fall later this year, with increased domestic production expected from smelters such as the new Gresik copper smelter.

At the moment, there seems no sign of this stopping, in spite of a slowdown in the Chinese economy and a fall in world nickel prices. Indonesia's nickel capacity is fairly low on the cost curve, at around $14-16,000/t. While nickel prices have dropped from highs of $30,000/t in 2023 to $15,700/t at time of writing, this is below the cost of production for a lot of global nickel capacity, which has been struggling. Outside of China and Indonesia, nickel output has actually been falling, dropping 9% year on year to 219,000 t/a in Q2 2024, and 37% down on the level of 2015. Ferronickel capacity has been closing, such as at Koniambo in New Caledonia, and some HPAL capacity is also struggling. Sumitomo's Ambatovy project in Madagascar has been running at low operating rates due to technical issues and has recently filed a debt restructuring plan.

Meanwhile, the cost-advantaged position of Indonesian nickel projects, along with the longer-term strategic objectives of Chinese owners to secure the nickel units, is expected to mean that project activity will continue. Tsingshan is in the process of commissioning another 50,000 t/a of nickel cathode capacity. Global sulphur demand for nickel processing is expected to rise to 6.7 million t/a in 2028, with much fo the increase continuing to come from the ramp up of new HPAL capacity in Indonesia.

Richard Hands, Editor

Price Trends

SULPHUR

At the end of August, the Qatar Chemical and Petrochemical Marketing and Distribution Company (Muntajat) tendered for 35,000 tonnes of sulphur for September loading from Ras Laffan, with offer prices reported at or around $130s/t f.o.b., according to market sources. Bids were received at multiple levels, with market participants initially anticipating awards around the mid-$120s/t f.o.b. The tender result was higher than market expectations and would equate to delivered prices to key Asian markets at $150-155/t c.fr. But prices in China and Indonesia remained lower this week at around $140-145/t c.fr, with India at $145-150/t c.fr. Prices have increased steeply since Muntajat's 25 June session, which was indicated awarded in the mid-$80s/t f.o.b.. and Muntajat posted its Qatar Sulphur Price (QSP) for September at $125/t f.o.b., up $19/t from $106/t f.o.b. in August. This represents the highest QSP since March 2023 at $133/t f.o.b., and reflects delivered levels to China nearing $150/t c.fr at current freight rates. Tight supply and strong downstream demand have pushed tender prices higher. Muntajat tenders were previously awarded at $92/t f.o.b. in April, up from $88/t in March and the low $80s/t f.o.b. in February.

Overall the Middle East spot sulphur assessment remained flat at $120-125/t f.o.b. this week even though prices in recent tenders were higher. In addition to Muntajat's tender. Kuwait's KPC closed two sales tenders over the past two weeks, both of which were indicated awarded in the high $120s/t f.o.b., up 58% over the past two months.

Spot prices for sulphur exports from the US Gulf were assessed up at $100-110/t f.o.b. at the end of Augst, up from $95-100/t f.o.b. despite limited trading activity based on strengthening global prices. Offers as high as $120/t f.o.b. were heard in the market but some sources indicated the lower end at $105/t f.o.b. in the US spot market. However, spot deals remain scarce, while market participants expect activity to pick up momentum following the CMOC tender in Brazil. In the first half of this year, US exports of sulphur decreased slightly to 815,447 tonnes, down slightly from 844,430 tonnes during the same period last year, according to Global Trade Tracker data. Spot prices for seaborne sulphur exports from Canada rose slightly to $102-106/t f.o.b. Vancouver, up from $100-105/t f.o.b., as market participants remain concerned over the supply chain and prompt export availability despite rail strikes being called off. Trading activity was still limited, and some market participants expect activity to pick up as the logistics systems are back up fully and running as normal. Latest business in China, including a cargo of Canadian sulphur sold around $145/t c.fr, suggests netbacks potentially higher than the current assessed f.o.b. range, but activity in Canada remained lacklustre.

The price for PT Lygend's latest tender for 50,000 tonnes of sulphur for October arrival was heard in the $140s/t c.fr, according to market sources. The session closed on 26 August amid firm f.o.b. prices in the spot market. Lygend was reported to have scrapped its 30 July session for 50,000 tonnes for September delivery after getting only one offer in the high $140s/t c.fr. Following this tender, both Lygend and another buyer Huayue purchased spot volumes in the low-to-mid-$140s/t c.fr, according to sources, with around seven to eight cargoes bought between them. The spot price assessment for sulphur cargoes to Indonesia was unchanged at $140-145/t c.fr.

SULPHURIC ACID

The price range for sulphuric acid sales into Chile narrowed to $165-170/t c.fr at the end of August, rising by $5/t from the lower end of last week's range of $160-170/t c.fr, on the back of tight supply globally and strong Chinese export prices. AMSA closed a tender for 40,000 tonnes of acid at no higher than $167/t c.fr, while another forward deal was indicated at low $170s/t c.fr for December, with no further details given at the time of writing. Spot offers were heard at $173/t c.fr in the region. Sellers have increased their offers on any new transactions in Chile based on current freight rates and Far East export prices. At the current freights and lack of spot supply availability, deals would be concluded near $170/t c.fr, traders said. The average Chilean spot price has reached their highest level since August 2022, when the assessed price was at $160-180/t c.fr on 22 August 2022, according to CRU data

Elsewhere, BHP was last week able to resolve a six-day strike at its Escondida, the world's largest copper mine and a major acid consumer, easing concerns of a negative acid demand impact. Exports from Peru to Chile rose in July to 100,551 tonnes, up from the previous month of 84,155 t, according to Global Trade Tracker data. However, in the year-to-date period, Peruvian exports declined 13% to around 666,000 tonnes from 770,000 tonnes in the same period in 2023. Quarterly prices for Q2 supply were reportedly agreed in the upper $120s/t c.fr, while the annual contract range is published at $125-135/t c.fr. Sources indicated that quarterly agreements for Q3 were also concluded in the $150s/t c.fr. Spot prices for sulphuric acid sales into Brazil were assessed steady at $145-155/t c.fr, though market sources expect prices to edge higher amid tight supply. Most recent business was concluded around the mid-to-high-$150s/t c.fr, with rumours of one deal concluded in the low $160s/t c.fr, but no details could be confirmed at the time of writing. Still, given current Europe f.o.b. prices in the $80s/t f.o.b., and NW Europe-Brazil freight rates in the low-to-mid-$50s/t, delivered prices in the $140s/t c.fr should in theory be achievable. One trader indicated that at current freights it would be more favourable to sell into Brazil than Chile, although buyers have generally remained on the sidelines.

Overall, spot activity has been limited, though Brazil imports for January-July were up 16% from last year, according to data via Global Trade Tracker. The latest purchase tender from Argentina's Bunge was indicated in the mid-$160s/t c.fr, which equates to a Brazil c.fr around the low-to-mid-$150s/t c.fr.

Spot prices for sulphuric acid exports from northwest Europe were assessed unchanged at $80-90/t f.o.b. on balanced supply/demand fundamentals. New deals have been scarce in recent months, with buying appetite from Morocco slowing down while spot availability remained tight. Most market sources expect the supply situation to limit any price declines in the short-term, though availability is widely expected to improve in the coming months. Supply is likely to increase despite some further smelter maintenances planned for Q3 as the acid output reduction is lower than the previous quarter.

A strong maintenance slate in Europe curtailed spot availability for Q2, with some post-maintenance restart issues leaving

the recent market tighter than expected. Aurubis is now returning to full production after a two-month maintenance planned at its Hamburg smelter through May and June. Issues with the restart last month led the producer to purchase acid from other producers. The smelter has acid capacity of around 1.3 million t/a.

Nyrstar and Boliden completed maintenance earlier this year, while KGHM in Poland and Atlantic Copper in Spain have maintenance shutdowns in Q3. Tight molten sulphur availability in Europe has added additional merchant acid demand from European buyers and is limiting acid production from sulphur burners, further tightening the market.

Spot prices for full cargoes of sulphuric acid to India were unchanged at $95-105/t c.fr, with buyers unwilling to accept higher offer levels present in the market. Although buyers are looking to purchase acid, lower offers were no longer available because of increased export prices in the Far East and elevated freight rates. MCFL is said to be looking for one to two cargoes of acid in a tender for October delivery, according to market sources. Offers were indicated around $105-110/t c.fr. Some traders signalled that while some cargoes might be available at the lower end of the range, securing any vessel below $105/t c.fr is unlikely. Earlier in August, Wilson International secured a 20,000 tonne cargo of acid at $100/t c.fr, scheduled for delivery to Tuticorin between late September and early October. Greenstar is believed to be the buyer, though the importer has not confirmed.

Indian acid demand should be decreasing this year due to new domestic supply, while sulphur is a more attractive alternative as current prices. CIL started new sulphur-burner capacity as of late August 2023, according to sources. The plant, which was announced in November 2021, is set to increase the company's acid production by around 500,000 t/a. IFFCO in Paradip inaugurated its new acid plant, with capacity around 2,000 t/d on 20 February. The company indicated in July that it had commenced operations at the new acid plant, leading to a reduction in merchant acid demand. In addition, Adani Group in late March commenced operations at its new refinery, with smelter production expected to start within Q3. The smelter has 1.5 million t/a of sulphuric acid capacity.

Prices for sulphuric acid exports from China were unchanged for the fifth consecutive week at $50-55/t f.o.b. amid tight supply and low buying activity. The average price of $52.50/t f.o.b. represents the highest level since August 2022 and is up from -$5/t f.o.b. in early August 2023, though it is still well below its mid-June 2022 level of $150/t f.o.b., according to CRU data. Some market sources see prices higher following the incident in southern China, which curtailed spot supply, whereas others argued that netbacks in the $50s/t f.o.b. were not achievable given current freight rates and c.fr prices in key import markets. A furnace incident in mid-August at Shandong Humon Smelting, a subsidiary of Jiangxi Copper, led to three deaths and fourteen injuries, according to press reports. Sources suggested this would lead to a loss or delay of around 100,000-120,000 tonnes of acid supply committed to various traders.

Phosphate sentiment in China has improved over the past couple of months, with some increases in downstream production adding support to domestic acid markets, though there are signs that phosphate production may be softening slightly due to concerns over export restrictions. In the copper market, persistently low TC/RCs have put pressure on copper smelters, with reducing copper concentrate feed and using more blister and anode to maintain refined copper production, which is expected to reduce acid output as well. Tightening mine supply in the zinc and lead industry has also constrained smelter acid by-product output. With zinc TCs falling significantly in recent months, Chinese smelters are still at high risk of production cuts in Q3. Additionally, a few smelters brought forward their routine maintenances from late Q3 to July. Resistance from producers to lower export prices emerged partly because of relatively higher prices available on domestic sales. Domestic prices continue to offer a premium over achievable f.o.b. for most producers.

Price Indications

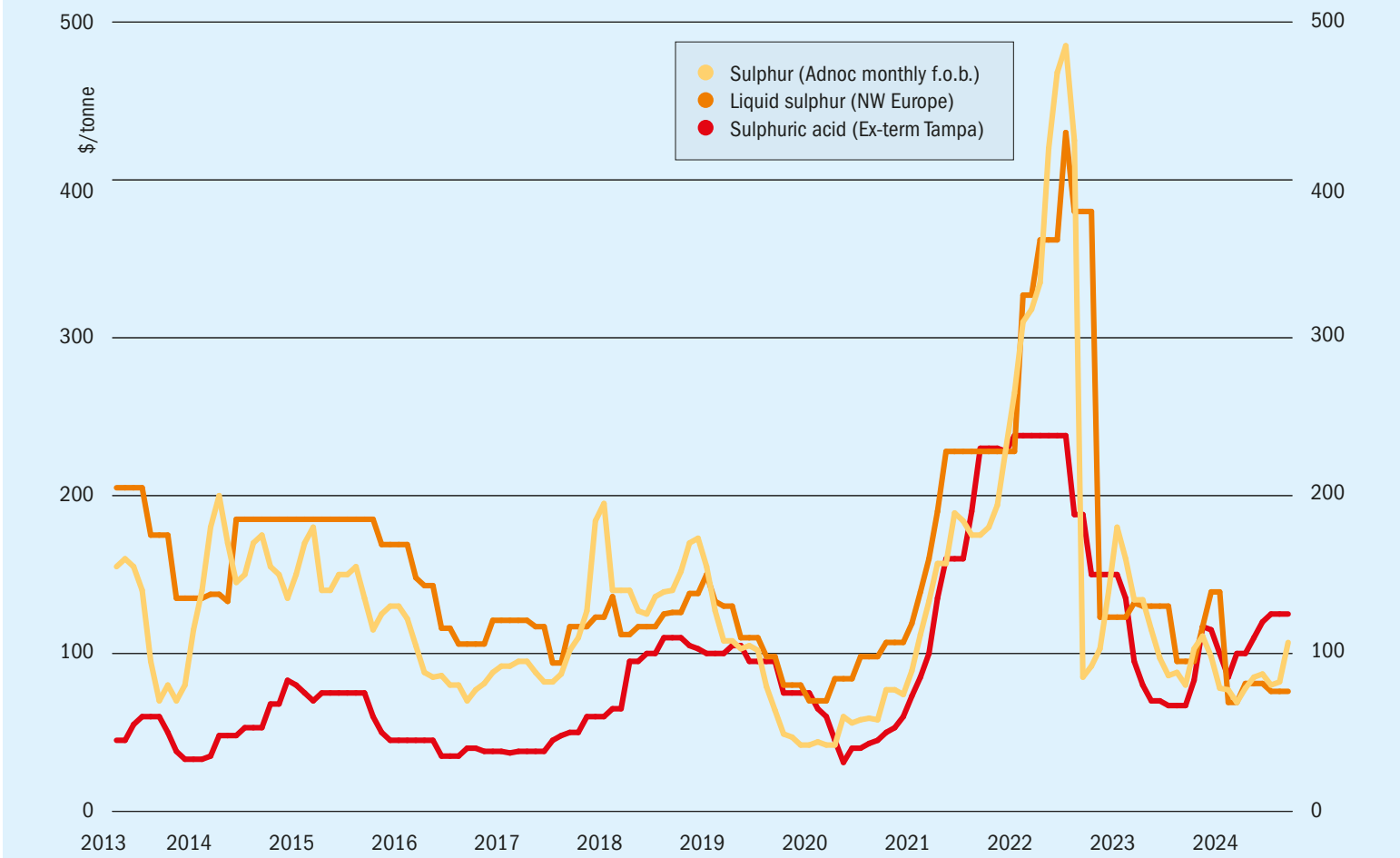
Table 1: **Recent sulphur prices, major markets**

Cash equivalent	April	May	June	July	August
Sulphur, bulk ($/t)					
Adnoc monthly contract	85	87	80	82	107
China c.fr spot	110	103	103	125	143
Liquid sulphur ($/t)					
Tampa f.o.b. contract	81	81	76	76	76
NW Europe c.fr	158	158	158	163	163
Sulphuric acid ($/t)					
US Gulf spot	110	120	125	125	125

Source: CRU

Market Outlook

Historical price trends $/tonne



Source: CRU

SULPHUR

- Muntajat announced its QSP for September at $125/t f.o.b., an increase of $19/t from its August price. This was following its tender earlier this week, which market sources indicated to have achieved at or around $130s/t f.o.b. Over the past two weeks, KPC in Kuwait closed two sales tenders, with both indicated awarded in the high $120s/t f.o.b. Middle East spot f.o.b. prices are at their highest level since March 2023 and have climbed 58% over the past two months.
- At the same time, Chinese delivered prices climbed slightly higher to $140-145/t c.fr amid latest indications, while Indonesian prices remained unchanged in the range of $140-145/t c.fr this week.
- Most traders remain confident of further price increases across the globe over the coming weeks due to strong downstream markets driving increasing demand, particularly given good affordability as phosphates prices continue to climb.
- Nevertheless. good overall availability should limit the upside to prices, particularly as China stocks remain high, even though a rail strike in Canada as well as refinery maintenance in Kazakhstan may tighten availability a little.

SULPHURIC ACID

- Global spot prices are likely to remain relatively firm over the coming weeks. Strong Moroccan offtake has added support to some benchmarks, with further support coming from Chile's recent return and persistently strong offtake for Saudi Arabia. Domestic acid production is set to increase in some key import markets, though this is more weighted to later in the year. Affordability relative to downstream markets is broadly acceptable, but looks particularly bad when compared with upstream sulphur.
- Chinese sulphur burners are setting prices in the traded market, while the lack of domestic smelter acid supply due to raw material shortages is also reducing export availability and pushing up prices. China requires high acid prices to draw out more volume, as domestic sales offer favourable pricing, thereby limiting the potential downside for spot business.
- Production issues at smelters in Japan and South Korea has restricted spot tonnes. This has allowed sellers to resist lower bids. However, high freight rates, rising supply in other Asian countries and concerns over phosphate markets may weigh on prices.
- In the longer term, growth in smelter acid production is being limited by a shortage of copper concentrate. new smelter capacity in Asia is expected to be commissioned, but tightness in the copper concentrate market will limit its operations in 2024. Increased competition and declining acid import requirements are expected to cut Chinese acid exports in 2025. Consistent traded demand and weaker European exports have maintained market tightness, which will delay price declines to 2025.

Sulphur Industry News

GERMANY

Shell to build green hydrogen plant for refinery

Shell Deutschland has taken a final investment decision (FID) to progress REFHYNE II, a 100 MW renewable proton-exchange membrane (PEM) hydrogen electrolyser at the Shell Energy and Chemicals Park Rheinland in Germany. Using renewable electricity, REFHYNE II is expected to produce up to 44 t/d of renewable hydrogen to partially decarbonise site operations. The electrolyser is scheduled to begin operating in 2027. Renewable hydrogen from REFHYNE II will be used at the Shell Energy and Chemicals Park to produce energy products such as transport fuels with a lower carbon intensity. Using renewable hydrogen at Shell Rheinland will help to further reduce Scope 1 and 2 emissions at the facility. In the longer term, renewable hydrogen from REFHYNE II could be directly supplied to help lower industrial emissions in the region as customer demand evolves.

Shell says that the REFHYNE II project has been enabled by supportive policies, including the European Union's (EU) binding targets for the use of renewable hydrogen, and the German Federal Government's regulatory framework. The project has also received funding from the EU's Horizon 2020 research and innovation programme.

"Today's announcement marks an important milestone in delivering our strategy of more value with less emissions. Investing in REFHYNE II is a visible demonstration of our commitment to the hydrogen economy, which will play an important role in helping to decarbonise Shell's operations and customer products," said Shell's Downstream, Renewables and Energy Solutions Director Huibert Vigeveno. "Our decision to invest illustrates what can be achieved with the right enabling conditions to deliver competitive projects."

Shell plans to invest $10-$15 billion across 2023-2025 to support the development of low-carbon energy solutions including e-mobility, low-carbon fuels, renewable power generation, hydrogen, and carbon capture and storage. In the Netherlands, Shell is currently constructing Holland Hydrogen I with a capacity of 200 MW, one of Europe's largest renewable hydrogen plants.

SAUDI ARABIA

Aramco to acquire majority stake in Petro Rabigh

Aramco has signed a definitive agreement to acquire an additional stake of approximately 22.5% in the Rabigh Refining and Petrochemical Company, the refining and petrochemical complex located on Saudi Arabia's west coast, from Sumitomo Chemical for $702 million. Aramco and Sumitomo Chemical currently each own 37.5% of shares in Petro Rabigh, which was listed on the Saudi Exchange in 2008. Upon completion of the transaction, which is priced at 7 riyals per share, Aramco will become Petro Rabigh's largest shareholder with an equity stake of approximately 60%, while Sumitomo Chemical will retain an equity stake of 15%.

Under the terms of the agreement, all proceeds received by Sumitomo Chemical from the sale will be injected into Petro Rabigh, through a mechanism to be agreed with Petro Rabigh. Aramco will also provide additional funds to Petro Rabigh, via a mechanism also to be agreed, matching the $702 million from Sumitomo Chemical, to improve Petro Rabigh's financial position and support the company's future strategy. In addition, Aramco and Sumitomo Chemical have agreed to a phased waiver of shareholder loans of $750 million each, which will result in a $1.5 billion direct reduction in Petro Rabigh's liabilities. The move will keep Rabigh afloat after it had accumulated a reported 8.87 billion riyals ($2.36 billion) in accumulated losses according to a statement issued in June this year. Aramco and Sumitomo also plan to upgrade the refinery with the aim of helping improve the profitability of the business.

BAHRAIN

BAPCO funding for oil and gas expansions

Bahrain's state-owned BAPCO Energies has secured $500 million from the United States Export-Import Bank (US EXIM) to develop its energy resources. The funding will be used to expand operations at the Bahrain Field Expansion and Development Programme in the southern part of the country, the company said in a statement. The medium-term development programme comprises several oil and gas projects to maximise onshore oil and gas production as well as recovery. The programme includes the drilling and commissioning of new gas wells and appraisal of the newly discovered resources. It also involves drilling and commissioning new oil wells and developing additional oil production facility enhancements.

ARGENTINA

Low sulphur fuel programme

Argentina's state owned oil company Yacimentos Petroliferos Fiscales (YPF) is reportedly moving ahead with a modernisation programme for its Luján de Cuyo refinery in Mendoza province. The refinery currently produces 100,000 bbl/d of fuels, but increased deliveries of light crude to the refinery from the Neuquén basin following expansions of the Puesto Hernández-Luján de Cuyo and Vaca Muerta Norte pipelines have prompted the site's proposed capacity expansion. The $600 million modernisation programme includes construction of a hydrogen plant and a 20,000 bbl/d diesel hydrotreater at the Luján de Cuyo industrial complex, aligning the refinery with Argentina's fuel specifications by reducing the sulphur content of the fuel from 50 ppm to 10 ppm.

NIGERIA

Dangote in row over sulphur content of fuel

Aliko Dangote, the president of Dangote Industries Limited (DIL) has found himself in a row with the Nigerian Midstream and Downstream Petroleum Regulatory Agency (NMDPRA) over the sulphur content of fuels produced by the new Dangote refinery in Nigeria. Africa has long lagged the rest of the world on regulations for sulphur content of fuels, and until March Nigeria permitted imported fuels to contain up to 3,000 ppm of sulphur. Even then, some fuels were reportedly higher still at up to 7,000 ppm, and Africa had become something of a 'dumping ground' for refiners unable to sell high sulphur fuel into other markets. However, Nigeria moved to a 200 ppm domestic sulphur limit in March 2024. The NMDPRA had said that Dangote was, like

other Nigerian refineries, producing fuels with between 650-1200 ppm sulphur, but Aliko Dangote was able to prove that a sample from the Dangote refinery clocked in at 87 ppm sulphur, and said that as sections of the refinery continued to come on stream, he expected to move to 50 ppm in the near future and down to 10 ppm by 4Q 2024.

KAZAKHSTAN

Chevron says Tengiz growth project is on track

Chevron CEO Mike Wirth said in the company's 2Q conference call that commissioning continues for the $47 billion upgrade projects at the Tengiz oilfield, the largest in Kazakhstan. Chevron has a 50% stake in the Tengizchevroil (TCO) joint venture, along with partners ExxonMobil (25%), KazMunayGas (20%) and Lukoil (5%), and is leading the development. Commissioning of the two-phase expansion started with high-to-low pressure conversions at the field's facilities under the Wellhead Pressure Management Project (WPMP), with the second phase, the Future Growth Project (FGP), due to begin later in 3Q 2024. FGP will boost the field's crude production by 260,000 bbl/d to a target of 1 million bbl/d. The current production sharing agreement runs to 2033, but there is as yet no news of an extension.

KPO achieves gas reinjection

Meanwhile, at the Karachaganak field, the Karachaganak Petroleum Operating company, (KPO), a joint venture between Shell (29.25%), Eni (29.25%), Chevron (18.0%), Lukoil (13.5%) and KazMunayGas (10.0%), says that it has achieved first acid gas reinjection at the KEP-1A Project, enabling gas from the Karachaganak Processing Complex (KPC) to be reinjected into the reservoir through the new KEP-1A gas reinjection system for the first time. This milestone, the most critical in the KEP-1A Project, was safely completed one month ahead of schedule. The compressor is set to significantly boost gas reinjection volumes, maintaining reservoir pressure and extending the field's liquid production plateau. The project has progressed successfully despite external challenges such as geopolitical tensions, logistical restrictions, and supply chain crisis.

It is also reported that KPO is preparing an engineering, procurement and construction (EPC) contract award for constructing a gas processing facility at Karachaganak which would feed about 3.6 billion cubic metres per annum of dry gas to the Kazakhstan and exterior markets.

ANGOLA

Cabinda refinery aiming for end of year

Commissioning for the first phase of the new Cabinda refinery is expected to begin by the end of 2024, according to Gemcorp Holdings, the developer and 90% majority shareholder in the project (the remining stake is held by state oil producer Sonangol). The 30,000 bbl/d facility is expected to reach full capacity by July 2025. The first $473 million phase of the modular refinery will produce naphtha, jet fuel, diesel and heavy fuel oil (HFO), with the naphtha and HFO destined for export markets. Overall, the refinery will supply around 10% of Angola's domestic fuel market.

Sulphuric Acid News

UNITED STATES

Veolia sells its acid regeneration business

Veolia says that its subsidiary Veolia North America has signed an agreement for the divestment of Veolia North America Regeneration Services, which includes its sulphuric acid and hydrofluoric acid regeneration activities for refineries, to private equity firm American Industrial Partners for $620 million. These activities represented revenues of around $350 million in 2023. The financial closure of the transaction is expected soon. Veolia's Sulphuric Acid Regeneration Business includes its sulphuric acid and potassium hydroxide regeneration, as well as sulphur gas recovery, and sulphur-based products production businesses.

"This disposal is in line with our policy of continuously reshaping our portfolio of assets in line with the strategic priorities of our GreenUp plan whilst maintaining a strict balance sheet discipline," said Estelle Brachlianoff, Veolia's Chief Executive Officer. "The sulphuric acid regeneration business in the United States is not one of our key priorities and does not offer synergies with our core activities. Their disposal will enable us to create value and concentrate our investments on the 'boosters' of the GreenUp strategic plan ."

AIP has renamed the acquired unit Nexpera. Alex Schukin, Partner at AIP, said, "Nexpera's business units align with strong market drivers related to clean fuel production, emission reduction, and reshoring of industrial activities in the US. We look forward to partnering with the Nexpera team as they enable their customers to meet the world's growing demand for clean-burning fuel components with sustainable, efficient and environmentally conscious regeneration services. As an industry leader, the company serves a vital role in our nation's energy infrastructure while also addressing diverse, growing, and high-value applications across the industrial economy."

Electronic grade phosphoric acid plant for Texas

South Korea-based Soulbrain is planning to build a new $175 million electronic grade phosphoric acid plant in Taylor, Texas, about 30 miles northeast of state capital Austin. The plant, which is due to begin construction in January 2025, will supply electronic giant Samsung's new $17 billion semiconductor facility which is being built in the town. Electronic grade phosphoric acid is used as an etching agent in semiconductor manufacturing. The first phase of the plant will be built at the RCR Taylor Rail Logistics Park according to Soulbrain, which is also considering investing $400 million in a second construction phase.

"Adding Soulbrain to our community adds yet another diverse, international company that will expand our tax base and create new jobs for our citizens," said Betty Day, chairperson of the Taylor Economic Development Corp. "Ever since Taylor landed Samsung, we have been working hard to recruit their top suppliers."

EGYPT

US investor considering new phosphoric acid plant

US-based Lionsbridge, a subsidiary of the construction services firm Wesson Group, is planning to set up a phosphoric acid production factory at Egypt's Abu Tartour port in Safaga, with investments of up to $3 billion, according to a press statement. The project aims to meet the demand of the local market and export abroad. The company says that the project will be implemented in several phases, with the first phase targeting a production capacity of 350,000 t/a of phosphoric acid, with $395 million worth of investments. The project's production capacity would be doubled in the second phase, in addition to producing 500,000 t/a of sulphuric acid annually. Other potential expansions include mono- and di-ammonium phosphate, and plans to use green electricity to produce hydrogen for ammonia production to increase the project's environmental sustainability.

Egypt's Deputy Prime Minister for Industrial Development and Minister of Industry and Transport met with Lionsbridge in July to discuss the project proposal, as well as a system of Free Zones in the Abu Tartour region, in coordination with the General Authority for Investment and Free Zones.

RUSSIA

Agreement on new phosphate plant

An agreement was signed in July to build a new phosphorus production and processing plant in the Alabuga Special Economic Zone in the republic of Tatarstan. Rikoflot plans to build yellow phosphorus production facilities with 25,000 t/a year, with a subsequent expansion of phosphoric acid production of 100,000 t/a according to the company. It is the first plant for production of phosphorus and complex fertilizers in the region. Tatarstan has an existing ammonia plant. Raw materials will most likely have to be sourced from the Kirov or Murmansk regions, since there are no phosphorus deposits in the Republic of Tatarstan. The project is in the initial stages of development and is initially designed for the domestic market, with no talk of exports yet.

MOROCCO

OCP selects Chemetics sulphuric acid technology

OCP says that it will award Worley Chemetics the contract for three new sulphuric acid plants at the company's Mzinda Phosphate Hub (MPH) in Morocco. The notice of award is conditional on the subsequent signing of a contract. Under the contract, Worley Chemetics will agree to supply proprietary sulphuric acid technology and equipment alongside detailed engineering, procurement and advisory services. The company will deliver the contract from Canada through its offices in Vancouver and specialised fabrication plant near Toronto.

Worley says that its Chemetics' sulphuric acid technology offers increased electrical power which is CO_2 emission-free and results in lower stack emissions. Air cooling is also used to conserve and reduce the plant water usage. Additionally, the company's proprietary CES-ALPHA™ System recovers low-grade heat as steam for maximum heat recovery.

"We are pleased to continue to support OCP with our proprietary sulphuric acid technology, consistent with our purpose of delivering a more sustainable world," said Chris Ashton, Worley's CEO.

The MPH project is a part of the OCP's Green Investment program. This is aiming to increase the company's annual fertilizer production capacity from 12 million tonnes currently to 20 million tonnes by 2027 using clean energy and non-conventional water sources.

AUSTRALIA

Nickel shutdown poses risk to rare earths plant

Lynas Rare Earths says that it is working on contingencies with BHP to ensure a continued supply of sulphuric acid to its Kalgoorlie facility after BHP made the decision to suspend its nickel operations at Nickel West in Western Australia from October. BHP has said the Nickel West operations and West Musgrave project will be suspended from October 2024, with the decision to be reviewed by February 2027. The shutdown, which BHP says has been necessitated by a global oversupply in nickel, removes supply of sulphuric acid from BHP's Kalgoorlie nickel smelter which is crucial for Lynas' rare earths processing operations. BHP is contracted to supply nickel to Lynas until June 2027 under the current contract.

In a message to shareholders, Lynas said that BHP had affirmed its commitment to "using reasonable efforts" to supply imported acid to Lynas in line with the terms of the supply contract, via purchasing acid on global markets.

Lynas' Kalgoorlie plant processes rare earth concentrate extracted from its Mount Weld mine. This concentrate undergoes a high-temperature process in a 110 m rotating kiln to convert rare earth phosphate minerals into rare earth sulphate. Following this, a leaching process with added water removes impurities such as iron phosphate, ultimately yielding a mixed rare earth carbonate (MREC). The MREC produced in Kalgoorlie is subsequently refined further at Lynas' advanced materials plants, such as the facility in Gebeng, Malaysia, or potentially at its upcoming rare earths separation facility in the US. Lynas has also said that it is considering producing its own acid to supply the rare earths plant, and is looking to Federal government assistance.

NEW ZEALAND

Ravensdown to stop making superphosphate

Ravensdown is proposing to stop manufacturing superphosphate fertiliser at its Ravensbourne plant, in Dunedin. The company has three manufacturing sites, at Napier, Christchurch, and Dunedin, with a combined capacity of 700-800,000 t/a, but in recent years has only been operating 400,000 t/a of that. Factors affecting the decision are that Christchurch is closer to the market for the product, and Ravensbourne would need capital spending to keep operating and a renewal of operating permits was also coming up. The shutdown is likely to be decided at the end of September, with closure coming in December or January 2025, according to the company. Ravensdown includes a vintage 240 t/d sulphuric acid plant built by Lurgi Chemie which dates back to 1967.

INDIA

Coromandel to restart sulphuric and phosphoric acid plants

Coromandel International Ltd says that that the Tamil Nadu Pollution Control Board (TNPCB) has approved the partial resumption of operations at its Ennore facility, nearly eight months after the plant was closed down following an ammonia leak from its pipeline. The unit has received approval from the TNPCB to resume operations of

the phosphoric acid plant and the sulphuric acid plant, but not the ammonia storage facility, whose restart remains subject to conditions recommended by a technical committee, include replacing the existing offshore pipeline with a new pipeline and providing an adequate number of ammonia sensors all around the plant.

Mangalore and Paradeep to merge

The Competition Commission of India (CCI) has approved the proposed merger of Mangalore Chemicals and Fertilizers Ltd (MCFL) with Paradeep Phosphates Ltd and the proposed acquisition of equity shares of MCFL by Zuari Maroc Phosphates Private Ltd. Paradeep Phosphates Limited (PPL) is part of the Adventz group of companies, with its majority shareholding held by Zuari Maroc Phosphates, itself a 50:50 joint venture between Zuari Agro Chemicals Ltd and Moroccon phosphate giant OCP. MCFL is also part of the Adventz group, with Zuari holding a 54% majority stake.

INDONESIA

Freeport officially opens new copper smelter

Indonesia's Minister of the Economy Airlangga Hartarto and Investment Coordination Agency BKPM head Bahlil Lahadalia were present at an opening ceremony for PT Freeport Indonesia's new $3.7 billion copper smelter, along with Freeport Indonesia's president director Tony Wenas, at the Java Integrated Industrial and Port Estate Special Economic Zone (SEZ) in Gresik, East Java.

Minister Hararto noted that construction had been completed in only 30 months, on-time in spite of the covid pandemic, with production beginning in August 2024 and full capacity due to be achieved in December 2024. He said Freeport's smelter development is part of an agreement reached with the company over the special mining operation permit awarded to the company.

PTFI president director Tony Wenas said development of this new smelter was a consequence of PT Freeport Indonesia's commitment to support the copper mineral downstream development policy launched by the government. He said going ahead, copper will be in high demand globally to supply the energy transition. PTFI's new smelter can refine copper concentrate at a capacity of 1.7 million t/a to produce around 600-700,000 t/a of copper cathode. The smelter will also produce anode slime that will subsequently undergo refining in the precious metals refinery to produce gold and silver bullion, as well as platinum group metals (PGMs). Sulphuric acid capacity at the site is 750,000 t/a.

Harita reports rising HPAL output

PT Trimegah Bangun Persada Tbk (NCKL), also known as Harita Nickel, recorded a 25% increase in sales of 25% in its results for the first half of 2024. The company made sales of 12.8 trillion rupiah over the period ($823 million), up from 10.2 trillion rupiah for 1H 2023. The company says that this growth has been driven by increased production output and higher sales volume across its mining and processing operations. Production capacity continues to grow in line with the rising capacity of the RKEF smelter and HPAL purification facilities. Sales of nickel ore in the first half of 2024 reached 8.37 million wet tonnes, an increase of 29%, with mixed hydroxide precipitate output from the HPAL plant rising by 28%, reaching 38,334 tonnes.

WORLD

Report warns of gap in copper supply chain

Diversification away from China and its supply of critical minerals such as copper would put the global energy transition goals in jeopardy, according to a recent report by WoodMackenzie. The firm puts the potential gap in the world's copper supply chain at $85 billion. Copper is a crucial component of electrification, with demand set to rise by as much as 75% to 56 million tonnes by 2050. Existing mines and projects under construction are expected to meet only 80% of copper needs by 2030, the International Energy Agency has said. Downstream processing (smelting and refining) and semi-manufacturing/fabricating are also major parts of the copper supply chain. Since 2000, China has accounted for 75% of global smelter capacity growth and currently controls nearly all of global smelting and refining capacity (97%), contributing over 3 million t/a of production and nearly $25 billion in investment. The country has also added nearly 11 million t/a of copper and alloy capacity since 2019, representing around 80% of global additions. Approximately two-thirds of these facilities produce wire rods, giving China half of the world's fabrication capacity, with further expansion underway.

The report estimates that there will be around 8.6 million t/a of additional copper demand ex-China over the next decade, driven by growth in transport, power and electrical networks. This equates to 70% of smelter capability and 55% of fabricator capacity in the rest of the world, in spite of capacity outside China barely changing over the last 20 years, raising the question of whether such a shift is achievable.

MOROCCO

US raises duty on Moroccan phosphates

The US Department of Commerce (DoC) has announced an increase on import duties for fertilizers from Morocco. The move relates to a request from US fertilizer producer Mosaic received in May 2023. In June last year the DoC published a notice of initiation of an administrative review of the countervailing duty (CVD) order on phosphate fertilizers from Morocco, and it has twice extended the deadline for the preliminary results of this review, which was finally completed in April 2024. The determination is backdated to imports from January-December 2022, and increases import duties on Moroccan fertilizers from 2.12% to 14.21%, while lowering duties on Russian phosphate fertilizers to 18.83% from 28.5%.

FINLAND

Metso technology for quenching of off-gas

Metso is reintroducing the OtoVentTM off-gas treatment technology for the quenching of various types of off-gases in non-ferrous and ferrous metallurgical processes and in oil, gas and chemical plants. OtoVent technology is used, for example, at the most modern copper smelters. It incorporates high quenching and pre-dedusting capability, and the design ensures lower maintenance effort. Metso says that its compact size also makes it suitable for both greenfield and brownfield installations and it is an exceptional replacement for existing quenchers

BRAZIL

Metso order for Galvani fertilizer plant

Galvani Fertilizante has awarded Metso an order to deliver a lime calcination kiln and cooler package for its fertilizer plant in Irecê, Brazil. Metso says that he total value of the order is over euro 10 million. The Irecê project is a significant step for Galvani in introducing sustainable technological innovations at its industrial plants.

The new unit is expected to annually produce 350,000 t/a of phosphate concentrate and 600,000 t/a of agricultural limestone. Metso will supply a rotary kiln, a rotary cooler and ancillary equipment for the project. The kiln and the cooler system are a critical part in the process to remove limestone from the phosphate concentrate. The kiln will be the largest lime calciner Metso has ever delivered, measuring almost six meters in diameter and over 140 meters in length. Metso has installed over 200 lime calcining systems globally.

"The partnership with Metso will bring strategic benefits to Galvani, allowing gains in mineral processing at our new unit in the municipality of Irecê, in Bahia. The laying of the foundation stone for this unit, which took place in May of this year, reinforces the importance of this project for the development of the economy of the state of Bahia, in Brazil, and for the generation of jobs and income. This milestone represents our commitment to innovation and development, boosting our ability to meet the demands of the fertilizer market," says Galvani's CEO, Marcelo Silvestre.

"We are proud to partner with Galvani in this project. With Metso's vast experience in lime calcining and rotary kiln technology and Galvani's rich history and expertise in phosphate fertilizers, we're certain the project will be a landmark success for both parties," says Chris Urban, Vice President, Heat Transfer at Metso.

SAUDI ARABIA

Acid imports down 50% in Q1

Saudi Arabia imported 96,141 tonnes of sulphuric acid during January-March 2024, down 50% from the equivalent period in 2023, according to Global Trade Tracker (GTT). Imports from Japan climbed from nothing to 40,400 tonnes, while the volume from South Korea was down 38% at 25,846 tonnes. The volume from China was down 84% at 19,394 tonnes, while acid received from Taiwan, China was roughly stable at 10,501 tonnes.

Saudi phosphates producer Ma'aden first purchased spot acid in November 2020, buying a cargo from Chinese sulphur burner Two Lions via a trader. The buyer then made a range of acid purchases through 2021 and 2022. Saudi imports for January-December 2023 were up 14% year on year at 565,488 tonnes, according to GTT, while annual imports for 2022 were up 53% at 493,954 tonnes. The company typically bases its production off its own acid output, produced using Saudi sulphur from Aramco. Ma'aden enquired about acid purchases several times throughout 2020, but no deal was concluded until the November purchase.

CHILE

Copper output down at Codelco

Copper production at Chilean miner Codelco was reportedly 484,500 tonnes in the first five months of the year, 6.1% under the company's target. May's output of 103,100 tonnes was 8.6% below the goal, according to Reuters, while April production of 95,100 tonnes was the first time a month's output was below 100,000 tonnes in at least 18 years. The state-owned company lost production when it suspended activity at Radomiro Tomic to enable an inspection following a fatal accident in March. A workers' strike at the mine added to the company's woes. As lower ore grades across all operations is the underlying reason for reduced output, Codelco has embarked on a multi-billion dollar investment programme to return production to the historic level of around 1.7 million t/a..

People

SGS Sulphur Experts has appointed **Patrick Beck** as the new CEO. Beck brings over two decades of leadership experience in the oil and gas industry and what Sulphur Experts describe as "a wealth of strategic insight and operational excellence to the team, steering the company towards continued innovation and engineering excellence."

Beck commented: "I'm thrilled to guide Sulphur Experts towards a performance-driven culture, surpassing ambitious targets and delivering exceptional value to our clients worldwide."

Coromandel International Ltd (CIL) has announced the appointment of **S Sankarasubramanian** as the company's new managing director and chief executive officer (CEO). Sankarasubramanianwas previously the executive director of Coromandel's Nutrient Business, and brings a background in both finance and business management, including a stint as chief financial officer. A mathematics graduate from the University of Madras, he is also a member of the Institute of Cost and Management Accountants of India and an alumnus of the Advanced Management Program (AMP) at Harvard Business School, which he completed in 2009. As the head of the Nutrient segment at Coromandel, Sankarasubramanian played a pivotal role in solidifying the company's industry position. In addition to his new role, Sankarasubramanian holds board positions with the Fertiliser Association of India, Tunisian Indian Fertiliser SA, and Foskor (Pty) Ltd., South Africa, along with several subsidiaries of Coromandel International.

Nutrien has announced the appointment of **Mark Thompson** as executive vice president and chief financial officer, effective from 26 August 2024. Thompson succeeds Pedro Farah, who will remain with Nutrien in an advisory capacity until his departure on 31 December 2024.

Ken Seitz, Nutrien's president and CEO said: "Mark's impressive track record of execution, along with his proven financial and strategic acumen provides the unique ability to succeed in this position on day one. He brings in-depth knowledge of our business that will support the advancement of our strategic actions to enhance quality of earnings and cash flow. On behalf of the Nutrien team, I would also like to thank Pedro for his service and commitment to Nutrien over the last five years."

"I've had the privilege to serve in leadership roles across the company and firmly believe in the opportunities afforded by Nutrien's strong competitive advantages and world-class asset base to deliver long-term shareholder value," said Thompson. "I look forward to continuing to partner with Ken and our executive leadership team on the disciplined execution of our strategy and drive a focused approach to capital allocation."

Thompson has been with the company since 2011, currently serving as executive vice president and chief commercial officer. Prior to his current position he held numerous executive and senior leadership roles across the company, including chief strategy & sustainability officer, chief corporate development & strategy officer, and vice president of business development for Nutrien's Retail business. He earned his Bachelor of Commerce (Finance) and Bachelor of Arts degrees from the University of Saskatchewan is a Chartered Financial Analyst (CFA).

Calendar 2024

SEPTEMBER

1-5

Sulphuric Acid Plants Round Table, PUERTO VARAS, Chile
Contact: Hotlec ltda, San Felipe, Chile
Tel: +56 34 251 5557
Web: https://mesaredondachile.com/en/holtec-round-table-2024-welcome

9-13

31st Annual Brimstone Sulphur Symposium, VAIL, Colorado, USA
Contact: Mike Anderson, Brimstone STS,
Tel: +1 909 597 3249
Email: mike.anderson@brimstone-sts.com

9-13

Sulphur Experts' Amine Treating and Sulphur Recovery Technical Training Course, KANANASKIS, Alberta, Canada
Contact: Jamielynn Russell, Sulphur Experts
Tel: +1 403 215 8400
Email: Jamielynn.Russell@SulphurExperts.com
Web: SulphurExperts.com/Courses

11-12

Oil Sands Conference & Trade Show, CALGARY, Alberta, Canada
Contact: Bruce Carew, EventWorx
Tel: +1 403 971 3227
Email: marketing@eventworx.ca

16-20

Sulphur Experts' Sulphur Recovery Technical Training Course, KANANASKIS, Alberta, Canada
Contact: Jamielynn Russell, Sulphur Experts
Tel: +1 403 215 8400
Email: Jamielynn.Russell@SulphurExperts.com
Web: SulphurExperts.com/Courses

30-Oct 4

Sulphur Experts' Amine Treating and Sour Water Stripping Technical Training Course, NOORDWIJK, Netherlands
Contact: Jamielynn Russell, Sulphur Experts
Tel: +1 403 215 8400
Email: Jamielynn.Russell@SulphurExperts.com
Web: SulphurExperts.com/Courses

OCTOBER

7-11

Sulphur Experts' Sulphur Recovery Technical Training Course, NOORDWIJK, Netherlands
Contact: Jamielynn Russell, Sulphur Experts
Tel: +1 403 215 8400
Email: Jamielynn.Russell@SulphurExperts.com
Web: SulphurExperts.com/Courses

8-9

TiO2 2024, VIENNA, Austria
Contact: Smithers
Tel: +44 (0) 1372 802000
Email: eventseu@smithers.com
Web: https://www.smithers.com/services/events/2024-conferences/tio2-europe-2024

15-17

AFPM Annual Summit, NEW ORLEANS, United States
Contact: American Federation of Petroleum Manufacturers
Web: https://summit.afpm.org/about-summit

21-25

Sulphur Experts' Advanced Amine Treating and Sulphur Recovery Technical Training Course, KEMAH, Texas, USA
Contact: Jamielynn Russell, Sulphur Experts
Tel: +1 403 215 8400
Email: Jamielynn.Russell@SulphurExperts.com
Web: SulphurExperts.com/Courses

Chinese sulphuric acid production and exports

China's acid production continues to grow as new smelters come on-stream. But high domestic demand from phosphate production as export restrictions are lifted and a shortage of copper concentrate may limit the potential for acid exports.

While China's growth has slowed after the breakneck growth of the first two decades of the 21st century, it remains a mainstay of global manufacturing, and growth continues, albeit at a slower rate. GDP grew by 5.2% in 2023 and is forecast to rise by only 4.7% this year, as the economy continues to be dogged by a downturn in the property sector, high levels of indebtedness, especially among regional governments, elevated youth unemployment and deflationary pressures, as well as a demographic shift to an older population with more retirees. Nevertheless, these are still significant increases, especially in a country responsible for almost half of all global demand of some key raw materials like copper and nickel.

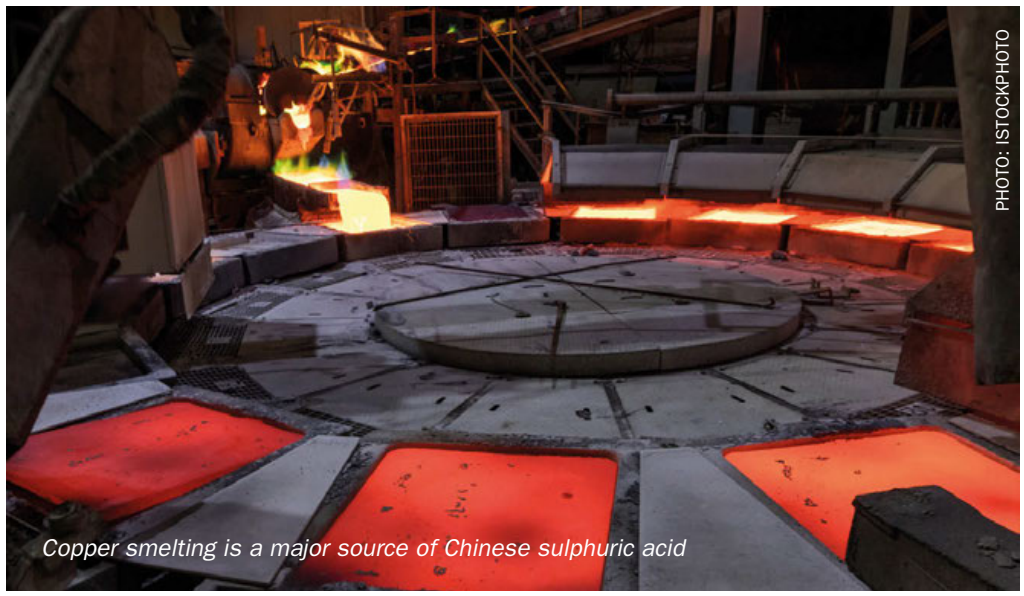


PHOTO: ISTOCKPHOTO

Copper smelting is a major source of Chinese sulphuric acid

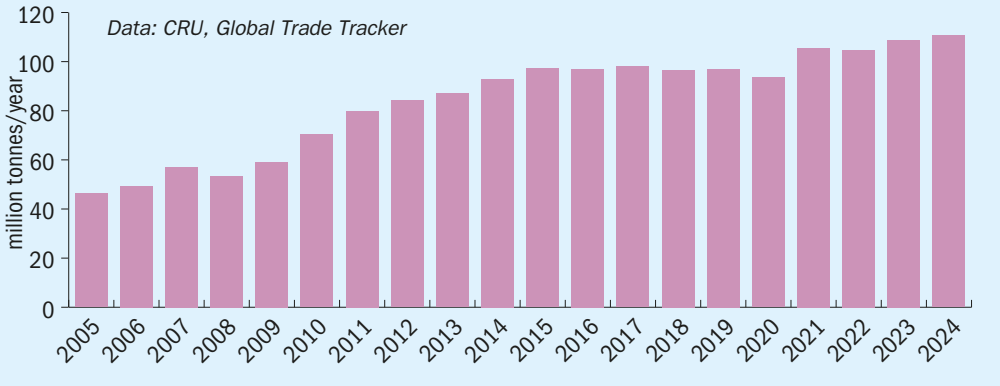
Phosphates

China's sulphuric acid consumption has long been dominated by its phosphate fertilizer industry. China has the world's second largest phosphate reserves after Morocco, and has been a major consumer of phosphate fertilizer to feed its huge population. Around the turn of the century, China was actually one of the largest importers of phosphates, but from 2000 up to 2015 embarked upon a massive expansion of domestic mono- and di-ammonium phosphate (MAP/DAP) capacity, with processed phosphate capacity more than doubling from 2008-2015.

Indeed, China overbuilt capacity to a considerable degree, and although much was able to find its way onto export markets, much was not, as China faced stiff competition from lower cost capacity in North Africa and the Middle East. Consequently the end of the 2010s led to something of a shakeout in the Chinese phosphate industry, with higher cost, less efficient capacity closing at the same time that government policy pivoted towards capping use of fertilizer to over-application and encouraging more efficient use of fertilizer; and clamping down on air and water pollution by closing factories that breach new emissions targets or which were within 1km of the Yangtse River. This led to a significant fall in Chinese MAP/DAP consumption and production, which was exacerbated in 2020 by the covid pandemic.

After a rebound in production and particularly demand in 2021, the Chinese government began to impose periodic restrictions on exports of MAP/DAP to try and keep domestic prices lower during peak application periods, including longer inspection times at ports and restrictions on availability of export licenses. In 2022, Chinese DAP exports shrank from 6.3 million t/a to 3.6 million t/a. These restrictions were eased around April 2023, leading to a rush of exports until curtailments were reimposed in October 2023. DAP exports reached 5 million t/a in 2023. A similar pattern has been seen this year, with a relaxing of restrictions in March-April, and a reimposition now in progress. Nevertheless, although Chinese export quotas for MAP and DAP are actually lower this year than last, China's January-July DAP/MAP production actually increased 14% year on year to roughly 17.7 million tonnes, up from 15.5 million tonnes for the same period of 2023. China's full-year 2023 DAP/

Fig. 1: **Chinese sulphuric acid production, 2005-2024**



MAP production reached roughly 27.5 million tonnes, a 9% increase from 25.3 million tonnes in 2022, according to official statistics. This is higher than the figure for 2021, and approaching the peak figure of 28,8 million t/a seen in 2018. This has served to boost Chinese domestic demand for sulphuric acid for phosphate production back towards its level of a few years ago.

Batteries

At the same time, there has been a rapid expansion in production of batteries for electric vehicles, many of them based on lithium iron phosphate (LFP) cathodes. China dominates the supply and consumption of LFP and has invested heavily in capacity – indeed, as has been typical of China in recent decades, there has been an overbuilding of capacity and some rationalisation. LFP now represents one third of all purified phosphoric acid demand in China. CRU estimates that in 2023, country-wide LFP capacity exceeded 2.5 million t/a of cathode active material (CAM) and production surpassed 1.5 million t/a CAM. Production has risen rapidly but is expected to level off from 2025.

Industrial consumers

In addition to phosphates and battery production, Chinese demand for acid continues to rise from the industrial sector. Caprolactam production is a major user, as is titanium dioxide production, which accounts for around 30% of industrial demand, hydrofluoric acid production, animal feed calcium, viscose fibre manufacture and so on. Industrial demand is likely to see some of the main gains in Chinese acid consumption over the next few years, although ammonium sulphate is also leading to increased demand, as noted in our article elsewhere in this issue.

Overall Chinese sulphuric acid consumption dropped to 92.6 million t/a in 2020, but has since risen back to 107.3 million t/a in 2023 (100% acid basis), up 6% on the figure for 2022, and this year it may rise to 110.7 million t/a on the back of increased industrial demand, as well as the boost in phosphate production mentioned earlier.

Acid production

Chinese sulphuric acid capacity has been growing rapidly, mainly due to the rapid expansion of non-ferrous metal smelting, which represents around 28% of Chinese acid capacity and 41% of production. Smelter acid production has risen by 55% in the past decade, reaching 45 million t/a as last year. Sulphur burning acid production was almost the same at 42% of production (46.2 million t/a) in 2023, and the remainder came from China's pyrite roasting acid production, which reached 15.2 million t/a in 2023. China represents 90% of all global pyrite based acid production, although production has declined by about one quarter in the past decade. While pyrite roasting remains in relative decline in the long term, credits from the iron component of iron pyrites, with the metal slag being sold into the steel industry, have kept it afloat through times of lower acid prices.

Geographically, much of China's sulphuric acid output is concentrated in Hubei and Yunnan provinces, with significant production also in Guizhou, Sichuan, Shandong and Anhui. Yunnan, Hubei, Guizhou and Sichuan are major fertilizer producing regions and capacity there is dominated by sulphur burning plants, while Shandong is a coastal chemical producing region, and Anhui has a lot of smelter capacity.

Acid production continues to rise, as Figure 1 shows, running just ahead of demand. In 2022, net acid exports peaked at 3.6 million tonnes, as reduced phosphate production left more acid available. This fell to 2.5 million t/a in 2023, and is expected to fall further to 2.25 million t/a this year because of the rebound in phosphate production.

Smelter acid

China's investment in smelter acid capacity has mainly been based on rapidly increasing copper demand in China. China already represents half of all copper consumption, and its status as the main manufacturing centre for domestic appliances as well as a need for new electric power cabling is driving new demand. The involuntary nature of smelter acid production means that it tends to be produced provided that metal prices justify it. In spite of a dip in 2022, global copper prices have been at historically high levels for the past few years, continuing to drive new investment.

However, a shortage of copper concentrate this year has forced a few smelters in China to cut output, and more curtailments could follow next year when the raw material supply is expected to tighten further. CRU predicts a shortage of concentrate feed globally in 2025 at 1.1 million t/a of copper-in-concentrate. This will likely lead to capacity closures, and an 800,000 t/a reduction in demand from Chinese smelters, lowering their utilisation rates as well as delaying some new smelter projects. While large smelters reliant on yearly contract purchases are less affected by the concentrate shortage, smaller producers are under pressure to cut production as spot treatment charges fall along with concentrate supply.

Overall, however, in spite of the fall in smelter acid production, total Chinese acid production is expected to reach 112.8 million t/a this year, with sulphur burning acid capacity for phosphate production making up most of the increase.

Sulphur production

The profitability of the 42% of Chinese sulphuric acid capacity that depends upon sulphur burning depends very much upon Chinese sulphur prices and in turn domestic sulphur production. Over the first two decades of the 21st century, the rapid growth in Chinese sulphur-burning acid capacity to feed the equally large increase in processed phosphates capacity led to a rapid ramp-up in the country's sulphur consumption, and a corresponding increase

in imports of sulphur, peaking at 12.2 million t/a in 2016, at which time Chinese imports represented over one third of all globally traded sulphur.

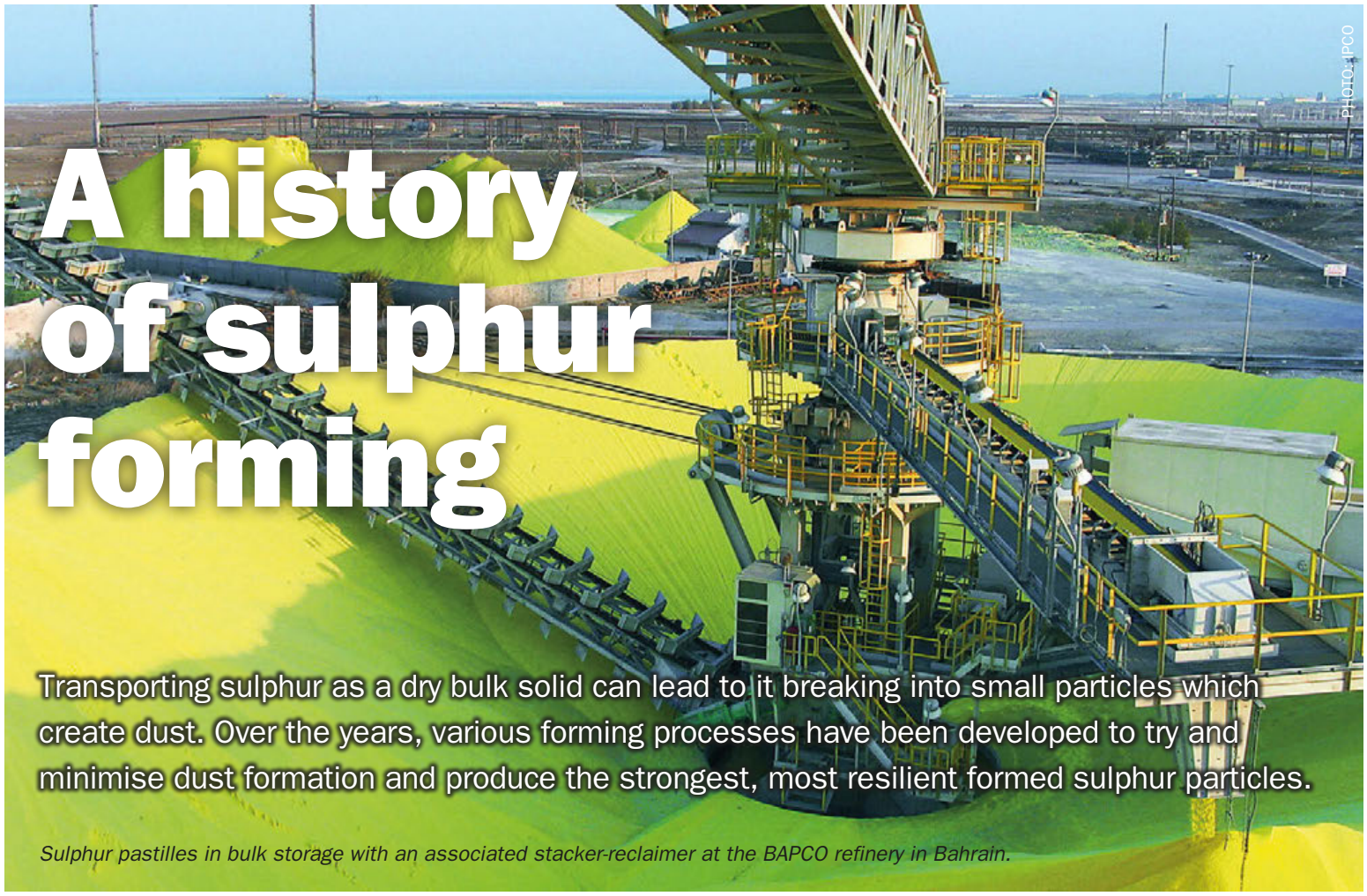
However, domestic sulphur production has also been rising steadily, albeit from a low base. There was an initial spurt from sour gas processing, mainly in the south-central Sichuan province, beginning with the large Puguang gas field in 2011, and then followed by Yuanba in 2014 and Chuandongbei in 2016. More recently, major refinery expansions have also been driving new sulphur production in China. Chinese refining capacity rose to 936 million t/a (18.7 million bbl/d) in 2023, making it the largest refining sector in the world in terms of capacity, according to official figures, while actual crude oil processing was 738 million t/a (14.8 million bbl/d), a record high. China's refining capacity is expected to rise by 2.7% this year to 961 million t/a (19.2 million bbl/d), but this continues to run significantly in excess of demand, and overcapacity continues to dog the industry. Overall Chinese refinery throughput is expected to reach 752 million t/a (15.1 million bbl/d) this year, up 1.8% year on year, and equivalent to a capacity utilisation rate of 78%.

Between refining and sour gas production, Chinese sulphur production is expected to rise to 10.6 million t/a this year, and 11.7 million t/a in 2025. This is set against demand of 18.8 million t/a this year and a forecast 18.3 million t/a next, meaning that the deficit is set to fall from 8.2 million t/a to 6.6 million t/a. China's sulphur deficit and hence imports are both forecast to continue to fall over the coming years as more sulphur capacity comes into play. Additionally, Chinese port stocks of sulphur remain at historically high levels, having peaked at around 3 million tonnes in April and declined slightly to 2.7 million tonnes in June. The decline has been driven by drawdown at river ports, typically belonging to traders, while southern stocks, mainly belonging to phosphate producers, have actually slightly increased since March. DAP prices have declined since January 2024, while sulphur prices have increased, meaning that sulphur affordability to phosphates consumers has slightly worsened. Nevertheless, sulphur's price as a share of the DAP price remains at a relatively favourable level of around 25%, well below the long-run affordability average range of 35-42%, and Chinese sulphur burning acid capacity seems capable of weathering a surge in phosphate production.

Acid exports

At the moment, in spite of higher prices for acid which typically encourage Chinese exports, Chinese net exports of acid seem set to decline as price differentials widen the domestic premium for Chinese producers. Chinese domestic prices for acid remain relatively high on the back of increased demand for phosphate production, making supplying that more attractive, and the price differential between exporting and non-exporting regions has been narrowing.

It is expected that sulphur-burnt supply will continue to play a minor role in exports and smelter volumes will dominate in the long term, especially in the export market, but the current shortage of copper concentrate is affecting smelter acid production, meaning that exports are likely to be down this year. Chinese acid exports were 2.5 million t/a in 20223 and expected to be 2.2 million t/a for the full year 2024, dropping to 1.75 million t/a next year.



A history of sulphur forming

Transporting sulphur as a dry bulk solid can lead to it breaking into small particles which create dust. Over the years, various forming processes have been developed to try and minimise dust formation and produce the strongest, most resilient formed sulphur particles.

Sulphur pastilles in bulk storage with an associated stacker-reclaimer at the BAPCO refinery in Bahrain.

While sulphur emerges from a Claus plant as a liquid, and a sizeable minority of sulphur is still consequently stored and transported as a liquid, keeping large volumes of sulphur at high temperatures creates challenges for transportation, and these days most of it is transported long distances as a bulk solid. However, this in turn can create its own problems, and this has led to a number of different alternatives for forming solid sulphur.

In the early days of the industry, molten sulphur was simply poured into large open air vats, sometimes up to hundreds of thousands of tonnes in size, and left to solidify, then recovered mechanically as large crushed lumps of sulphur. However, sulphur is extremely brittle, and this process created a large amount of sulphur dust, which can be a fire and explosion hazard, as well as allowing wind-blown sulphur dust to be carried to neighbouring sites and properties, eventually breaking down and acidifying. One of the reasons for a move to storing and shipping sulphur as a liquid was to avoid these problems, and by the 1980s, around 50% of all sulphur transported internationally was as a liquid, with that figure reaching 95% in North America.

But receiving cargoes of sulphur as a liquid requires specialised equipment, including heated lines and tanks, which not all customers had available, and this restricted the client base for those producing sulphur. A better way of transporting solid sulphur over longer distances needed to be found.

Slate

Although the first sulphur forming processes were based on both wet and dry prilling (see below), sulphur forming on a large scale really began with the slating system developed in Canada in 1969 by Vennard & Ellithorpe, later part of Procor Ltd, and eventually Enersul. Slate sulphur is formed by pouring molten sulphur onto a moving belt, where it is solidified into a continuous slab with a thickness of around 5 mm by indirect water sprays. After quenching in water, the sulphur is discharged from the end of the belt and breaks into smaller pieces. Slating appeared to solve the dust problem of crushed bulk sulphur, and in 1972 the port of Vancouver banned the export of all sulphur not formed into slate. However, the product remained in irregularly shaped pieces with sharp edges which tended to break during storage and transport, and eventually deteriorate to produce fine sulphur dust, necessitating water sprays to keep dust levels down, in turn leading to corrosion inside e.g. ship vessel holds. In 1974, the Canadian Industry Sulphur Forming Committee therefore commissioned the Sulphur Development Institute of Canada (SUDIC) to evaluate forming processes and recommend one for the Canadian sulphur industry. A number of forming processes were available, as detailed below;

Prilling

Prilling or pelletising could take two forms, wet or dry. Wet pelletising, such as the Sulpet process commercialised by Humphreys & Glasgow, involved allowing molten droplets of sulphur to fall through a body of water, leading to solid pellets which are recovered on a screen and dried. Other wet prilling processes force liquid sulphur in narrow streams into an agitated water bath. The low thermal conductivity, high

specific heat, and long transformation time of sulphur make it necessary to maintain the pellets in suspension for as long as possible, allowing them to harden. This process produces spherical, uniformly sized pellets.

Taking a cue from fertilizer prilling processes, air/dry prilling allows droplets of molten sulphur to be sprayed into the top of a tower and fall under gravity against an upward flow of cooling air, with the length of drop calculated so that the sulphur is solid enough to survive the impact at the bottom. The first air prilling process was developed by Outokumpu (now Outotec) in 1962, but the technique was refined by Siarkopol in Poland and became known as the 'Polish Prill' process. It was first installed in Tarnobrzeg in Poland in 1966, and later spread across Alberta, including Shell's Waterton site, and at Aramco's al Jubail site in Saudi Arabia. However, a series of fires at air prilling towers in the 1980s caused by electrostatic discharges igniting sulphur dust in the towers led to the process being largely discarded and superseded by other methods. More recently, Dutch based prilling developers Kreber have modified the sulphur air prilling process, with a closed loop of circulating nitrogen gas to remove the danger of fire, better integrated heat recovery and a wet scrubbing system to remove fugitive dust.

'Popcorn' sulphur

Union Oil Co of California developed the so-called 'popcorn' process, where molten sulphur and water are sprayed together into the open air from a specially designed jet. The product lands on a stockpile as small solid particles. Although the company installed it at their own sites in the US, however, it was not sold on the open market.

Pastillation

Pastillation took the belt driven slate process and refined it by dropping liquid sulphur from a distributor onto a moving metal belt to form small hemispherical pastilles. As with slating, the belt is cooled from below by jets of water. The temperature of the cooling belt is controlled by regulating the flow and temperature of the cooling water sprayed onto the underside of the belt. The cooling water is collected and re-circulated through a cooling system. Control of the heat transfer rate from the molten sulphur droplets to the metal belt and from the metal belt to the cooling water not only optimises production capacity, but also ensures the production of a high quality product. The process was developed by Sandvik Process Systems (now IPCO) in the 1980s and is marketed as Rotoform. A claimed advantage for the system is that the formed sulphur is low in moisture content, although debate continues to rage over the optimum water content for dry bulk sulphur.

Granulation

The final development of sulphur forming processes was as dedicated granulation technologies. These use a size enlargement process to gradually build seeds layer by layer into dense spherical solid granules. Small particles of sulphur (seed) are introduced at the feed end of the drum and are sprayed and coated with molten sulphur as the product moves toward the drum discharge. Each applied layer is cooled to solidification before another coat of molten sulphur is applied. With repeated application, bonding and then cooling of successive coats, the seeds increase in volume and weight until they reach the desired granule size.

An early example of this was the Procor (now Enersul) GX process, which was first commercialised in 1979. Over the years, the GX process has become a family of granulators, from the GXM1 to the large scale GXM1 Nexgen and the smaller scale modular GXM3. Other granulation processes include the Devco wet granulation process, developed by Devco USA in 1980 and eventually updated as the Devco II process, which was bought by Matrix PDM Engineering in 2016. There is also the Brimrock process, developed by Brimrock and Martin Sulphur Systems in 2010, and acquired by IPCO in 2014. Kaltenbach-Thuring, acquired by Yara in 2003, also modified its own fluidised drum granulation (FDG) system in the 1990s for sulphur granulation.

Blocking

Finally, of course, where long term storage is required rather than sale and transport of sulphur product, sulphur can be poured to block. Generally this is done by spraying a thin layer of molten sulphur onto a block pad or existing sulphur block, then allowing it to cool and solidify before adding another layer.

How does inventory change impact sulphur availability and pricing?

In the last two years there have been significant changes to the level and location of sulphur inventory, which has caused swings in short-term supply availability. Inventory plays a necessary role in balancing the sulphur market but exactly when, where, how, and why inventory enters the market can trigger a diverse range of price responses. In this insight article, CRU's **Peter Harrisson** looks at how inventory change influences sulphur availability and pricing.

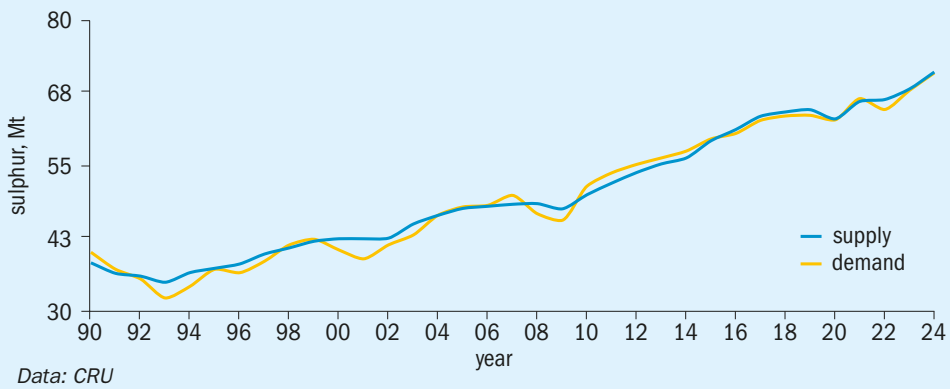
The sulphur market is in a constant state of structural imbalance as supply and demand movements are driven by different economic drivers. This drives a frequent flip-flop between surplus and deficit driving the necessity for inventory to manage this volatility in availability.

How has the sulphur market balance varied throughout history?

Most sulphur supply originates as a by-product of oil and gas production with the volume of sulphur produced being independent of the demand for the product. Sulphur demand is driven by a diverse range of industries with the dominant sectors focused on fertilizer, metals and industrial markets. There is an underlying link between sulphur supply/demand and overall economic activity but the exact influence that this has on each sector is not identical.

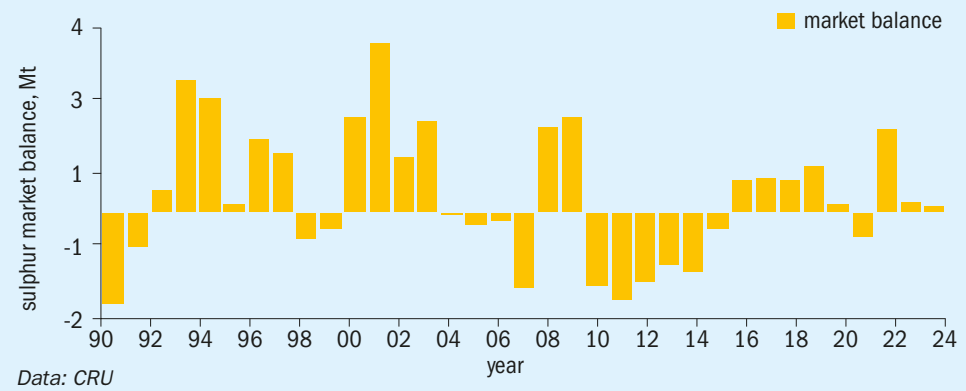
Given the inherent disconnect between supply and demand the sulphur market is in a constant state of flux between surplus and deficit (see Fig. 1). According to CRU data (see Fig. 2), since 1990, the sulphur market has been in a deficit for 15 years with 20 years of surplus and an average balance of 0.37 Mt. The range of supply imbalance has been between a

Fig. 1: **Global sulphur supply/demand is guided by economic activity but to different degrees**



Data: CRU

Fig. 2: **The swing from surplus to deficit is a fundamental feature of the sulphur market**



Data: CRU

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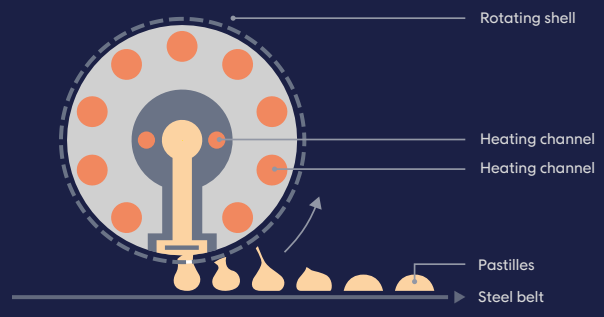
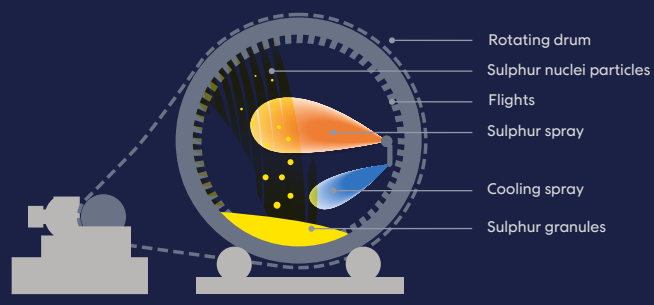


KEY FEATURES

- Solidification capacity up to 280 mtpd.
- Duplex steel belts alloyed for maximum lifetime.
- Pastilles according to SUDIC premium quality spec.

SG DRUM GRANULATION
Where higher capacity is required, our SG rotating drum system is a fully automated, 'once through', sulphur granulation process based on a size enlargement process by continued coating of seed material.



KEY FEATURES

- Capacity up to 2,000 mtpd.
- Single pass, no need for screens.
- Process simulation to suit all conditions.
- Simple operation, precise control.

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peak surplus of 4 Mt and a deficit of 2 Mt with the annual market balance as share of market size averaging 1%. The state of physical surplus and deficit necessitates that inventory be built and drawn down to allow supply to meet demand.

Where and why is inventory built?

Historically sulphur inventory has been built at production sites with remote geographical location and insufficient access to logistics. The largest accumulation of sulphur in long-term storage is in Alberta, Canada at oil sands operations. There has also been stock accumulated in Kazakhstan, at the Kashagan operation, and in Saudi Arabia at the Berri gas plant. Canada's stocks have been built over many years but the accumulation of volumes at Kashagan and Berri has been a more recent trend. There are also other locations with inventory throughout the Middle East and Central Asia.

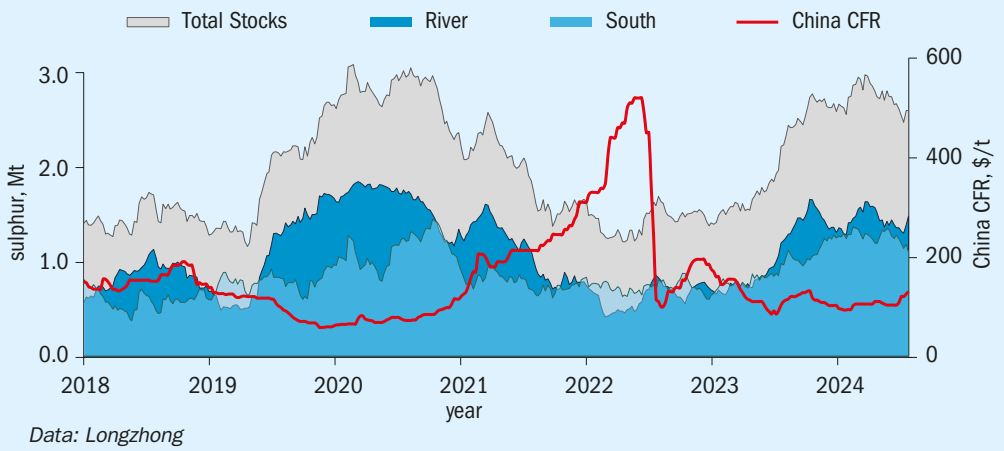
Prior to 2020, most of the inventory management happened at production sites with increased sales in times of deficit and increased stock build in times of surplus. However, China has begun to play a more active role in inventory management. China has operated a system of port inventory for many years but this stock would typically not exceed 1.5 Mt, equivalent to 10-15 % of annual imports. However, since 2020 China has twice accumulated over 3.0 Mt of inventory, equivalent to 30-35% of annual imports (see Fig. 3).

How has the behaviour of stockholders changed?

The upswing in the level of inventory held in China is partly the cause and partly a symptom of a wider shift in stockholder activity. Throughout 2020 the steep increase in stocks was in response to falling prices, concerns over logistics and speculative buyer behaviour. The fall and subsequent rebound in stock levels followed the upswing and retreat in sulphur pricing, but also continued to incorporate an element of speculative purchasing behaviour.

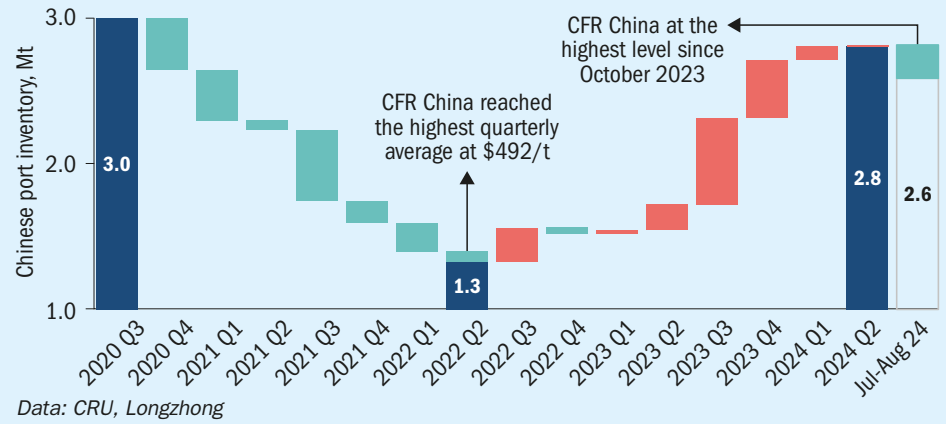
Since April 2024, stocks have fallen with inventory currently assessed at 2.68 Mt, the same level as the beginning of the year. The decline has been mainly driven by drawdown at river ports, typically belonging to traders, whose inventory has fallen by 0.2 Mt, and the southern stocks (phosphate producers' stock) have dropped by 0.1 Mt.

Fig. 3: **China port inventory levels reach new highs in 2020 and 2024**



Data: Longzhong

Fig. 4: **Chinese port inventory build-up or drawdown has been correlated with sulphur prices**

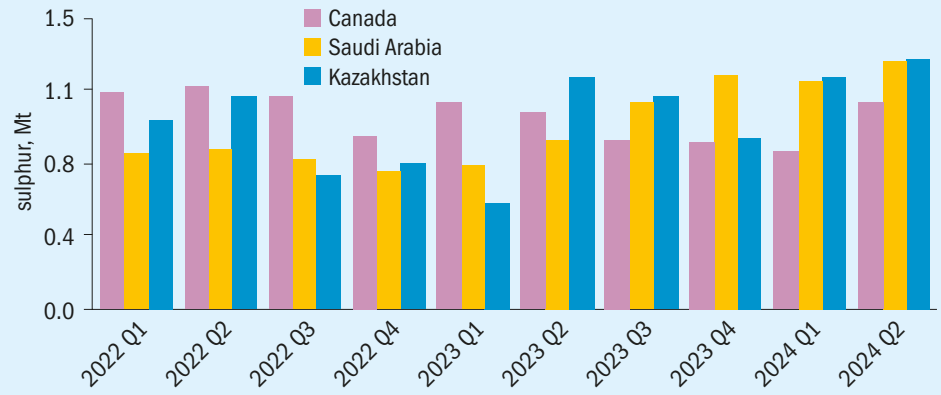


Data: CRU, Longzhong

The increase or decrease in stocks has responded inversely to the trajectory of sulphur prices. The last time a programme of consistent stock drawdown occurred was from 2020 to 2022 when stocks declined from a high of 3.0 Mt to 1.3 Mt (see Fig. 4). In total, port inventory dropped by 1.7 Mt in around two years. This time frame coincides with a significant jump in China CFR prices from an average of $76/ t in 2020 Q3 to $492/ t in 2022 Q2. After the stock peak, prices reversed their upward trajectory and were depressed throughout 2023, which triggered stock build-up up to April 2024. Strong demand from China has pushed sulphur prices up since July, and port inventory levels have started to fall again.

Since late 2022, there has been a shift in the overall market dynamic as the market has entered a period of global surplus and lower prices. However, this period has also coincided with an increase in voluntary stock drawdown in Kazakhstan and Saudi Arabia (see Fig. 5). Although it is typical for a global net-surplus to be composed of supply locations which are building inventory and other in the process of drawing down stocks. However, this is typically still price driven. Canada's stock drawdown behaviour has followed the price trend with periods of high prices driving increase drawdown and low prices slowing additional sales. By contrast, Kazakhstan and Saudi Arabia export increases since 2023 Q2 have coincided with a period of lower pricing. The objective in both locations has been to decrease the volume of supply held in inventory. In Saudi Arabia, this has been due to current stock location nearing capacity and therefore the strategic benefit to manage logistics outages had been diminished. Saudi Arabia has added around 0.15 Mt /q to its export programme from stock drawdown. In Kazakhstan, the trigger of stock decline has been regulatory risk. Stock at Kashagan was accumulated in the early years of operation, when export logistics were yet to be completed. Kazakhstan has a long-held aversion to the long-term storage of sulphur with regulatory pressure triggering the sale of 9.5 Mt of sulphur inventory from 2005-2015.

Fig. 5: **Export surge driven by increased stock drawdown**



Data: CRU, Global Trade Tracker

The most recent pressure on Kashagan's sulphur inventory came in the form of the announcement of a significant fine from the Kazakh government due to the accumulation of 1.7 Mt of stock at the site.

This has triggered a concerted effort from the operators of Kashagan to start a programme to remove the accumulated inventory. The programme of stock removal has increased exports from Kazakhstan by around 0.25 Mt /q with the total inventory expected to be depleted by mid-2025.

How will stock change influence the market in 2025?

The presence of high inventory in China and the programme of proactive stock drawdown in Saudi Arabia and Kazakhstan will continue to place a negative pressure on prices. However, the current rally in sulphur prices, driven by resurgent demand, illustrates the difference between short-term sentiment and overall trend. The other point that the recent price increases show is that proactive stock drawdown and price increases can coincide with each other. The determinant of this relationship is the overall market balance trend. The global market has entered a period of resurgent demand growth and slowing supply increases with the global balance expected to move into deficit in 2025. The result is that proactive stock drawdown will be a necessary feature of the market and will not put downwards pressure on prices as was the case in 2024 H1. The status of China's inventory will continue to hang over the market as the current 2.6 Mt is equivalent to 2-4 months of imports and this gives Chinese consumers and traders more choice over if, when and how much they enter the international traded market.

About the author

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The Sulphur Conference at 40

This year will be the 40th Sulphur – now Sulphur + Sulphuric Acid – Conference to be held. From its beginnings in Canada to this year's meeting at the Hyatt Regency hotel in Barcelona, much has changed, but its mission – to be an essential annual forum for the global sulphur and acid community – remains the same.

Beginnings – SUDIC

The history of the Sulphur Conference goes back to 1981, when it was originally held in partnership between the British Sulphur Corporation, the Sulphur Development Institute of Canada (SUDIC), and the provincial government of Alberta. But the impetus for and the organisation behind the conference was largely down to British Sulphur, particularly publisher John French and technical editor Alex More. The first conference, held in Calgary in 1981, included keynote papers by British Sulphur's founder John Lancaster as well as sulphur industry stalwart Jim Hyne, who was then head of Alberta Sulphur Research Ltd (ASRL), and a paper by Robert Phillips of Cansulex.

Canada, and specifically Alberta, was at the time the centre of the world sulphur industry, and these three organisations were testament to that growth, with Cansulex – Canadian Sulphur Exporters – coming first in 1962 as a consortium of sulphur producers to jointly handle overseas sales of their product, and later in 1991 to become renamed as the PRISM Sulphur Corporation. ASRL was a similar industry sponsored body formed in 1964 to handle research into sulphur technology with funding from all members, and SUDIC followed later in 1973, with a brief to develop and expand uses for sulphur and to provide technical assistance on industry problems. In 1976 a fourth company, Sultran, headed by Kevin Doyle, was added to manage the transportation of Alberta sulphur to Vancouver and other western British Columbian ports. The 1960s and 70s had been a time of rapid growth in sulphur production as sour gas sources were tapped in Canada, the US and Europe. Canada in particular had benefited from this growth and was producing far more sulphur than it could sell, leading to a steady build of inventories in Alberta. Even so, by 1983, Canada was exporting 5.7 million t/a of sulphur, making it the largest exporter by some way, and responsible for 40% of all global solid sulphur trade, which at the time stood at 11.5 million t/a. Liquid sulphur at the time added another 4.1 million t/a, with Canada taking a back seat to Poland – which produced mainly from its Frasch mines – in terms of exports.

The success of a conference focusing specifically on this vital industry to Canada and the world led to another SUDIC-sponsored conference following in 1982, co-sponsored by The Sulphur Institute from the US, and held on the British Sulphur Corporation's home turf in London, UK. The conference then skipped a year – several missing years over the early decades of the conference are why 2024 is the 40th conference, and not 2021. It was run again in Canada in 1984, again with SUDIC co-sponsorship - before the first Sulphur conference held entirely under the auspices of the British Sulphur Corporation was run, once again back in London, in 1985.

Sulphur 1985

One of the innovations in terms of the programme at the 1985 conference was to have a large section on sulphuric acid, representing almost half of the 34 papers presented. This was something which the previous SUDIC-sponsored conferences had not really covered in any depth, and were something of a first for the industry. Indeed, that mix of sulphur and sulphuric acid has been a hallmark of all subsequent Sulphur conferences, and the reasoning behind the more recent change of name to fully represent it. The SUDIC runs of the conference had very much focused on producers, and as well as sulphur production technology, they had covered some specifically Canadian producer problems such as trade and transportation, and new uses for sulphur to use up the huge stockpiles – up to 20 million tonnes – that they were at the time sitting on. But by the 1980s the sulphur market was starting to move into deficit, at least as regards the western world, and there was an increasing reliance on importing sulphur from what was then still called the 'eastern bloc' – mainly Poland, the USSR and China. Declining Frasch mines in the US and elsewhere were seeing the increasing importance of 'involuntary' production from oil refineries and gas plants. Patterns of demand were also changing, with phosphate demand emerging in North Africa, Brazil and other new locations.

Technical standards were also looming large. Before the 1980s, sulphur had almost exclusively been exported as bulk 'slate', but Canadian exporters had faced issues with fugitive dust emissions, while the 'Polish prill' process had seen sulphur dust fires at facilities. In Canada the industry had seen legislation forcing it to move to fully formed product. This in turn was responsible for the development of the SUDIC premium standard for sulphur in 1978, which remains a mainstay of the industry. The Sandvik Rotoform process for producing sulphur pastilles was developed in 1985 and first presented at the Sulphur conference in Vienna in 1988. Indeed, after another missing year (1986), the Sulphur conferences of the late 1980s; Houston in 1987 and Vienna in 1988 were showcases for a number of technologies which the industry still relies upon, from Topsoe's WSA wet sulphuric acid process

to Goar Allison's COPE oxygen enrichment scheme for Claus plants and Comprimo's SUPERCLAUS process.

The 1990s

The start of the 1990s brought some major changes to the sulphur market with the collapse of the Soviet Union and the political changes sweeping through eastern Europe, where Poland and the USSR represented over one quarter of all sulphur production/ This period also saw the Iraqi invasion of Kuwait and subsequent US-led international coalition which removed it, which temporarily removed 2 million t/a of sulphur from the market.

The Sulphur Conference itself began to range wider afield, visiting Cancun in Mexico in 1990 and Abu Dhabi in 1995, a foretaste of the inexorable rise of the Middle East as a producing region. It also had a change of ownership – though not personnel – when CRU bought the British Sulphur Corporation in 1986. CRU has organised and run the Sulphur conference ever since that date.

Meanwhile, while Frasch sulphur continued to decline and involuntary production increased, reaching 80% of elemental sulphur production in 1995, there was nevertheless a paper on the new Main Pass sulphur mine in the US, which began production in 1992. Formed sulphur continued to spread across the market, with forming facilities installed in Kazakhstan and Orenburg in Russia, as well as Germany, Rotterdam, Abi Dhabi, and Thailand, and there was also an increased focus on sulphur degassing to improve safety in sulphur production.

On the acid side, the late 1990s also saw the rapid increase of sulphuric acid demand for metal leaching, particularly in the Chilean copper industry, as well as the advent of the second generation of high pressure acid leach plants for nickel extraction from lower grade laterite ores, in Australia, the Philippines, Papua New Guinea and New Caledonia.

The 2000s

At the turn of the millennium, Sulphur was held in San Francisco in 2000, before moving to Marrakesh in Morocco for 2001. While this conference had intended to capitalise on the new demand for sulphur coming from OCP's rapidly expanding phosphate processing operations at Jorf Lasfar, it was unfortunately held only two months after the terrible events of September 11th, and bans on flights and international travel for many delegates made it only sparsely attended. The meeting in Vienna in 2002 was fortunately held under much happier circumstances.

Major trends of the 2000s reflected in the conference programme were the continuing rise in sulphuric acid leaching for metals extraction. Involuntary sulphuric acid output from metal smelting was also leading to a rise in acid production as emissions standards tightened on release of SO_2 into the atmosphere. Southern Peru Copper Corporation described how this had led to the installation of a 3,700 t/d acid plant at their Ilo smelter at Sulphur 2009 in Vancouver. Larger sizes for acid plants required new technologies, such as Chemetics (then owned by Aker Solutions) modularised gas-gas exchanger, designed to make large plants easier to ship from fabricators.

Meanwhile, there was continuing rapid growth of sulphur production in the Middle East and now, increasingly the Caspian Sea region, with Tengizchevroil (TCO) describing their use of acid gas reinjection at Sulphur 2005 in Moscow. But in spite of TCO's sulphur output rising rapidly to 2.4 million t/a in the late 2000s, booming demand in India and China also sent prices to what were then record levels of $220/t in 2007, before supply issues in both Vancouver and Russia let to an unprecedented peak at over $800/t in early 2008. This was followed by the global financial crisis, leading to an equally rapid crash in prices back to earth. Nevertheless, Chinese imports soared to 9-10 million t/a by the end of the decade, with that sulphur increasingly coming from the Middle East as well as Canada.

The 2010s

The 2010s were an era of mega-projects like Shah in Abu Dhabi, Qatar's North Field and Common Sulphur Project, Kashagan in Kazakhstan and some of the large sour gas plants in Saudi Arabia, all of which were the subject of conference presentations, particularly the technical and contracting innovations needed to manage such large and complex projects. Indeed, so much sulphur was predicted to emerge from sour gas processing that much of the conference programme found itself focused towards looking for new uses for sulphur, with papers looking at

John French, organiser of the first Sulphur conference, speaking at Sulphur 2008 in Rome.

sulphur asphalt, sulphur concrete, sulphur polymers, and techniques for long term storage; Angie Slavens even proposed a process for combining H_2S and SO_2 back to sulphur and water to 're-deposit' sulphur in depleted gas reservoirs. Kazakhstan became so concerned about its sulphur stockpile that it generated an entire uranium extraction industry to try and use it up. But in the end the surplus never quite arrived due to equally large increases in demand from phosphates and metals processing. Even so, changing flows of sulphur product as North American and European sour gas production declines and the refining and sour gas industries move to the Middle East and Asia have also led to a relative decline in liquid sulphur and the installation of large sulphur melters to allow more flexibility in receiving product. Mosaic's 1 million t/a melter at New Wales in Florida was presented by Mark Gilbreath of Devco at Sulphur 2015 in Toronto.

Technology continued to advance, and ever-cheaper and more powerful computers led to the spread of distributed control systems, as well as greater use of computation fluid dynamics to improve the interior flow of Claus reactors via innovations such as Blasch's Vectorwall.

The 2020s

This decade saw the unwelcome outbreak of covid in 2020, which forced the Conference for a couple of years to become a 'virtual' meeting. While the quality of the presentations remained the same, I hope that you agree with me that there is no substitute for face to face meetings, which the conference fortunately was able to return to in 2022 at The Hague in the Netherlands, New Orleans in 2023, and Barcelona this year.

Sulphur + Sulphuric Acid 2024 Conference

Join us at the CRU Sulphur + Sulphuric Acid 2024 Conference and Exhibition in Barcelona, 4-6 November, for a global gathering of the sulphur and sulphuric acid community. Meet leading market and technology experts and producers, network, share knowledge, and learn about market trends and the latest developments in operations, process technology and equipment.

The Sulphur + Sulphuric Acid 2024 Conference and Exhibition takes place at the Hyatt Regency Barcelona Tower in Barcelona 4-6 November. This year marks the 40th year of the Sulphur conference and features the most comprehensive agenda yet.

The opening session of the main agenda brings together industry leaders to discuss sustainability initiatives and strategies for decarbonising the sector. Focusing on the integration of digitalisation, strategic advancements in production, and global collaboration, this session aims to shape a more sustainable and efficient sulphur and sulphuric acid supply chain, crucial for the evolving green economy.

The market outlooks agenda has been extended with expert insights from CRU's analysis teams on major supply and demand markets, including sulphur and sulphuric acid, plus additional industry updates from key players from across the supply chain.

On the agenda this year, leading producers from around the globe, alongside technology and technical experts will be sharing operational best practices and insights to improve plant operations. The comprehensive technical programme is split into two parallel streams, a sulphur track and a sulphuric acid track, and will provide updates on the production and processing of sulphur and sulphuric acid, with presentations covering new innovations in processes, technology, materials and equipment developments, as well as practical case studies highlighting operational experience and improvements. Sulphur and sulphuric acid troubleshooting clinics, panel discussions and technical showcases will extend the opportunities to learn about best practices, lessons learned and the latest technologies and innovations.

This year's conference will once again be co-located with RefComm Europe.

Preliminary Agenda

Monday, 4 November

SULPHUR TRACK – 10:00-13:45

10:00-12:00 – Sulphur Troubleshooting Clinic
Presenter: Elmo Nasato, *Nasato Consulting Ltd*

12:30-13:45 – Technical Showcases

- **Rejuvenation of a vintage SRU to meet hanging refinery requirements** – Claudio Pupatti, *Wood*
- **Two big advancements in Claus instrumentation** – Bob Poteet, *WIKA*
- **Eliminating nitrogen purging in SRU furnaces: Daily ImpermaWell™ and its benefits for process optimisation and safety** – Deniz Keles, *Daily Thermetics*
- **Technological solution for designing customised products from liquid and powdered raw materials** – Johannes Buchheim, *Glatt Ingenieurtechnik GmbH*
- **Flexible mechanical drives for fans and compressors** – Cornelia Liebmann, *Howden*

SULPHURIC ACID TRACK – 10:00-13:45

10:00-12:00 – Sulphuric Acid Troubleshooting Clinic
Presenters: Stuart Hinze, *J.R. Simplot Company*; Hanno Hintze, *Aurubis AG*; Hannes Storch, *Metso*; Steve Puricelli, *EXP*

12:30-13:45 – Technical Showcases

- **Spray solutions for sulphur and sulphuric acid** – Sebastian Rohacz, *Lechler GmbH*
- **Practice of technical reformation of dry absorption and water addition of sulphuric acid plant** – Jae Shi, *Wylton (China) Chemical Co., Ltd*
- **Leak detection and dew point measurement in sulphuric acid plants** – Cal Lockert, *Ohio Lumex Co., Inc.*
- **Optimising wear life and performance in sulphuric acid production** – Dr. Carsten Düchting, *DÜCHTING Pumpen Maschinenfabrik GmbH & Co. KG*
- **Gain and retain talent with our proven on-line courses for sulphuric acid plant operators** – Dirk van der Werff, *Academia.Holtec*

COMMERCIAL AND MARKETS SESSION –14:00-17:30

- **Welcome address**
- **Special guest key note address** – Prof. Dr. rer. nat Christian Sattler, *German Aerospace Center*
- **Panel discussion: Sulphur and sulphuric acid industry – At the heart of the future green economy** – Chair: Hannes Storch, *Metso Outotec* – Speakers: Khalid Hamed Al-Ahmadi, *Ma'aden*; Lucretia Löscher, *thyssenkrupp Uhde*; Dr Sascha Vukojevic, *BASF*; Francesca Ortolan, *CEFIC*; Graeme Cousland, *Begg Cousland Envirotec Ltd*
- **Focus on sulphur and sulphuric acid** – Peter Harrisson, *CRU*
- **Panel discussion: Sulphur and sulphuric acid industry economics – Future strategy, production, markets and global trading** Chair: Peter Harrisson, *CRU* – Panellists: Craig Jorgenson, *The Sulphur Institute*; Viviana Alvarado, *CRU*; Jérôme Villaumie, *Sojitz-Solvadis*; Janne Lovén, *Boliden Smelters*

WELCOME RECEPTION –17:30-19:00

Tuesday, 5 November

SULPHUR TRACK – 09:00-12:30

Sulphur plant reliability, availability, maintenance & economics

- **Initiatives at sulphur recovery unit (SRU) to reduce and eliminate hotspots due to refractory failures** – Mukhriz Badaruddin, *Petronas*
- **European SRU incinerators - Optimising to simultaneously save money and reduce CO_2 emissions** – Leah Goettler, *Sulphur Experts*
- **Considerations for reliability, safety, and operations responsibilities during extended downtime** – Baylee Thompson, *Wood*
- **How enhanced reality technology increases operator competency and reduces human error** – Susanna Voges, Bas Janssen, *Voovio*
- **You can't always get what you want (but you can get what you need!)** – Steve Puricelli, *EXP*
- **Panel discussion: Sulphur plant reliability, availability, maintenance & economics** – Panellists: Mukhriz Badaruddin, *Petronas*; Leah Goettler, *Sulphur Experts*; Baylee Thompson, *Wood*; Susanna Voges and Bas Janssen, *Voovio*; Steve Puricelli, *EXP*

SULPHUR TRACK – 13:30-17:30

Sulphur plant operational best practices

- **Minimising amine carryover from a regenerator** – Ben Spooner, *Amine Experts*
- **Alkanolamines in the thermal reactor as a possible source of ammonia** – Rob Marriott, *ASRL*
- **Kuwait Oil Company's approach to sustainable oil recovery: Addressing sulphur-induced iron sulphide formation in effluent water treatment** – Mahdi Ashkanani, *Kuwait Oil Company*
- **Advanced feed gas control by detecting the BTEX concentration in sulphur recovery units (SRUs)** – Michael Gaura, *Ametek*
- **Risk of accumulated sulphur in sulphur recovery unit** – Ganesh Gujar, *Bharat Petroleum Corp. Ltd*
- **Thermodynamic simulation and case study for 3rd generation SRU incinerator** – Mason Lee, *Aecometric Corp.*
- **Low temperature activation of 934 catalyst at Motiva Port Arthur: Assessment of staged addition of H_2S and H_2** – Ron Pitman, *Motiva*

SULPHURIC ACID TRACK – 09:00-12:30

Sulphuric acid industry innovation: Digitalisation, energy transition, circular economy

- **Using AI-powered infrared imaging for real-time sulphur dioxide leak detection and quantification** – Francisco Cortez, *SENSIA Solutions*
- **Implementation of low CO_2 district heating usage of copper smelter's sulphuric acid plant** – Hanno Hintze, *Aurubis AG* and Torsten Weber, *Smart SCOPE GmbH*
- **Utilisation of non-condensable gases from pulp and paper process** – Robert Kahr, *Kanzler Verfahrenstechnik GmbH*
- **Supporting decarbonisation with new approaches in the sulphuric acid industry** – Dimitrios Dimitrakis, *Deutsches Zentrum für Luft und Raumfahrt (DLR)* and Martin Kürten, *Grillo Chemicals GmbH*
- **Advances in NOx removal in a metallurgical DCDA/Petersen Fattinger process** – Anthony McHendrie, *Anglo American Platinum*
- **Panel discussion: Sulphuric acid industry innovation: Digitalisation, energy transition, circular econom** – Panellists: Dimitrios Dimitrakis, *Deutsches Zentrum für Luft und Raumfahrt (DLR)*; Martin Kürten, *Grillo Chemicals GmbH*; Anthony McHendrie, *Anglo American Platinum*

SULPHURIC ACID TRACK – 13:30-15:00

Sulphuric acid plant performance: Catalysts and emissions

- **Staying ahead of todays and future SO_2 emission limits – Why superior catalyst shape and composition is so important** – Jochen Willersinn, *BASF SE*
- **Understanding the sulphuric acid catalyst properties and reaction resistance in the SO_2 oxidation - and their implications for catalyst design and selection** – Martin Alvarez, Anders Theilgaard Madsen, *Topsoe A/S*
- **Platinum promoted honeycomb catalysts for sulphuric acid making - A novel approach for CAPEX and OPEX reduction in acid plants** – Johannes Hofer, *P&P Industries AG*
- **Panel Session: Sulphuric acid plant performance: Catalysts and emissions** – Panellists: Jochen Willersinn, *BASF SE*; Martin Alvarez, Anders Theilgaard Madsen, *Topsoe A/S*; Johannes Hofer, *P&P Industries AG*

SULPHURIC ACID TRACK – 15:30-17:30

Sulphuric acid plant operations: Debottlenecking, reliability & availability

- **How to successfully run a four-year acid plant campaign** – Trevor Mwanza, *Kansanshi Mining Plc*
- **Digital solutions to improve operational KPI's and increase plant availability for gas cleaning and sulphuric acid plants** – Steffen Haus, *Metso*
- **Increase plant No. 7 reliability and stability** – Ayman Abdelhafeiz, *Abu Zaabal Fertilizer & Chemical Company*
- **Capacity and uptime boost: Optimising sulphuric acid plant from 2200 to 3000 MTPD** – Florian Kistl, *CS Combustion Solutions GmbH*

DRINKS RECEPTION –17:30-18:30

Wednesday, 6 November

SULPHUR TRACK – 09:00-13:00

Innovation, digitalisation & energy optimisation in the sulphur plant

- **H_2S splitting industrial units** – Giovanni Manenti, *ITT SpA*
- **Energy and cost optimisation opportunities in an SRU** – Jan Willem Hennipman, *Worley Comprimo*
- **The Digital Process Monitor (DPM): Digitalisation aiming to process and environmental excellence** – Daniela Boni, *Nextchem Tech*
- **A step-by-step approach to reducing CO_2 through SRUs** – Samuel Scherman Johansson, *Topsoe A/S*
- **Probabilistic, time-based economic analysis of sulphur recovery technologies** – Alberto Martinez, *Worley Comprimo*; Harry Matthews, *Indicatura*
- **Panel Session: Innovation, digitalisation & energy optimisation** – Panellists: Giovanni Manenti, *ITT SpA*; Jan Willem Hennipman, *Worley Comprimo*; Daniela Boni, *Nextchem Tech*; Samuel Scherman Johansson, *Topsoe A/S*; Alberto Martinez, *Worley Comprimo*; Harry Matthews, *Indicatura*
- **Open Forum Q&A / War Stories**

SULPHUR TRACK – 14:00-16:00

Sulphur product handling safety, innovation & best practices

- **Safety in design of sulphur forming and handling** – David Savage, *Matrix Service Company*
- **Exploring other sulphur sources and ways of purification** – Jan Hermans, *Sulphurnet*
- **Sulphur degassing for large scale sulphur recovery units** – Marcus Weber, *Fluor*
- **Panel Session: Sulphur product handling safety, innovation & best practices** – Panellists: David Savage, *Matrix Service Company*; Jan Hermans, *Sulphurnet*; Marcus Weber, *Fluor*

SULPHURIC ACID TRACK – 09:00-11:00

Sulphuric acid plant design: Process technologies

- **Enhancing sulphur burning acid plants with oxygen-enriched air: LUREC-S** – Stefan Bräuner, *Metso*
- **The CORE-FGD™ process in action - Producing sulphuric acid from gas streams with low SO_2 concentrations** – Boris Nesic, *Worley Chemetics*
- **Oxygen plant compressor electricity savings and CO_2 reduction using new technology actuators on compressor inlet guide vanes** – Mark Ferra, *REXA Inc.*
- **Production of liquid SO_2 via condensation – synergies with sulfuric acid manufacturing and challenges of energetic optimisation** – Dr. Daniel Fickinger, *HUGO PETERSEN GmbH*
- **Panel Session: Sulphuric acid plant design: Process technologies** – Panellists: Stefan Bräuner, *Metso*; Boris Nesic, *Worley Chemetics*; Mark Ferra, *REXA Inc.*; Dr. Daniel Fickinger, *HUGO PETERSEN GmbH*

SULPHURIC ACID TRACK – 11:30-13:00

Sulphuric acid plant design: Equipment

- **Steuler quickfit brick-lined equipment delivered ready for fast installation** – Rolf Rockenmayer, *Steuler Tecnica s.l.u.*
- **Outstanding accuracy and no acid-runaway: Inline concentration monitoring of sulfuric acid with LiquiSonic®** – Alexandra Graf, *SensoTech GmbH*

SULPHURIC ACID TRACK – 14:00-16:00

Sulphuric acid plant design: Equipment

- **Sulphur pit scrubber** – Alessandro Gullà, *AWS Corporation Srl*
- **Ducting design for sulphuric acid plants** – Robert Cane, *NORAM Engineering and Constructors*
- **Anton Paar's inline measurement solutions for sulphuric-acid and oleum** – Emanuel Hofer, *Anton Paar GmbH*
- **Panel Session: Sulphuric acid plant design: Equipment** – Panellists: Alessandro Gullà, *AWS Corporation Srl*; Robert Cane, *NORAM Engineering and Constructors*; Emanuel Hofer, *Anton Paar GmbH*

Exhibitor profiles

Running alongside the conference agenda there will be an exhibition of world-class solution providers serving the sulphur and sulphuric acid industries.

Academia Holtec — Stand 12

Academia.Holtec is a leading provider of professional technical education programs, oriented mainly at the mining and chemical industry, offering a wide range of courses covering mining and plant operations, safety procedures, equipment maintenance, etc.

Its asynchronous learning platforms for operations of metallurgical and sulphur burning sulphuric acid plant are based on 25 years of experience in the design, operation and maintenance of sulphuric acid plants.

In general, its educational programs are orientated at keeping operators up to date in an ever-changing industry and aim to address the challenges related to renewal of labour force and transfer of knowledge, increased automation and incorporation of new technologies.

Aecometric Corporation — Stand 17

For more than 50 years Aecometric has been a trusted name in providing industrial combustion equipment. The Aecometric High Intensity Burner technology stands alone in performance, quality and reliability. The Aecometric burner design lends itself perfectly to the combustion needs of the sulphur and sulphuric acid industry by providing maximum contaminant destruction, exceptional reliability and a high level of operational flexibility.

AGRU Kunststofftechnik Gesellschaft m.b.H. — Stand 55

Founded in 1948, AGRU is one of the world's most important suppliers for high-quality piping systems, semi-finished products, concrete protection liners and lining systems made from thermoplastic materials. Especially the wide range of semi-finished products (PE, PP, PVDF, ECTFE, FEP and PFA) solves corrosion even in extreme applications.

Agruquero — Stand 55

With more than 50 years of experience in the sector, Agruquero is a leading company in the distribution of thermoplastic products, such as double containment piping systems, storage tanks, valves for fluid conduction and process control, and ventilation, gas and odour washing systems.

Agruquero offers innovative and high-quality solutions that guarantee safety and efficiency in the storage, transportation and application of sulphuric acid and other chemical products for various industries.

AMETEK CSI — Stand 36

CSI specialises in engineered products for sulphur recovery units and sulphur handling in liquid sulphur applications for sulphuric acid plants. In SRU applications, CSI provides engineered heating systems which meet the specific thermal requirements of SRU vapour and liquid lines and also sulphur storage tanks and vessels These applications use its industry known ControTrace and ControHeat products which eliminate cross-contamination, corrosion and plugging. For sulphur sealing, CSI is the only company that provides three choices for sulphur sealing: Seal legs, and two above-ground options: SxSeal 1000 (A first generation float style) and SxSeal 2000 (a second generation model with many advanced features). CSI is now introducing a new product system, ICOn, which is a revolutionary approach to sulphur degassing.

Anton Paar — Stand 74

Anton Paar is the world leader in bench top density and concentration measurements and is now setting its sights on process analysis with the L-Dens, L-Com and L-Sonic sensors that measure in-line sulphuric acid density and concentration over the widest possible concentration ranges.

AWS Corporation Srl — Stand 6

AWS Corporation provides solutions in several fields of industrial applications and pollution control, with the following product range:

- Aerosol, spray and mist separation (candle filter, vanes and meshpads)
- Air pollution control (WESP, venturi, DeNOx)
- Tower internals (liquid distributors, random/structured packing, trays, gas distribution inlet devices, etc.)
- Oil mist separators
- Sulphuric acid plant equipment
- Atomising nozzles technology

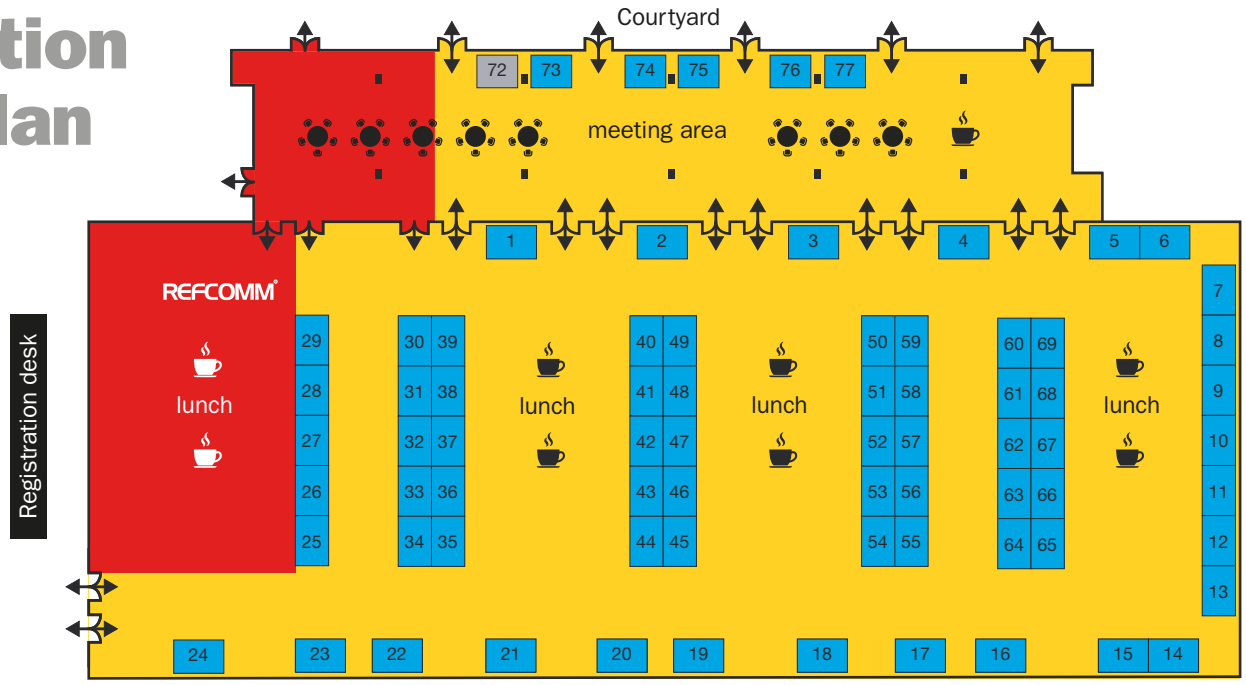
Axens — Stand 30

Axens, an IFP Group company, provides a complete range of solutions for the conversion of oil and biomass to cleaner fuels, the production and purification of major petrochemical intermediates, the chemical recycling of plastics and all natural gas treatment and conversion options. The offer includes technologies, equipment, furnaces, modular units, catalysts, adsorbents and related services. Axens is ideally positioned to cover the entire value chain, from feasibility study to unit start-up and follow-up throughout the entire unit life cycle. This unique position ensures the highest level of performance with a reduced environmental footprint. Axens' global offer is based on highly trained human resources, modern production facilities and an extended global network for industrial, technical supports and commercial services.

Ballestra S.p.A — Stand 50

Ballestra S.p.A. is a multinational company specialising in engineering and contracting for chemical plants, covering both organic and inorganic chemistry. Ballestra offers advanced solutions for fertilizers, acids, surfactants, and detergents, ensuring expertise, flexibility, and reliability. Ballestra's portfolio includes sulphuric acid and phosphoric acid technologies, a broad range of fertilizers, hydrofluoric acid and derivatives via Buss ChemTech. Ballestra offers its proprietary technologies as well as technologies licensed by its partners MECS, Prayon, and KVT. Its comprehensive services span from pilot tests to plant start-up, including feasibility studies, FEED, detailed engineering, procurement, construction management, field services, and aftersales support.

Exhibition floorplan



BASF Corporation — Stand 39

Since 1913 BASF has been running sulphuric acid production plants with the lowest SO_2-emission worldwide. BASF designs its catalysts for maximum outcomes. That starts with the unrivalled SO_2-emission performance they can deliver because of their large surface area. For its customers, that means effortless regulatory compliance, no additional emission reduction costs, higher conversion, and bigger profits. Because of their exceptional physical stability, BASF catalysts offer a longer lifetime, deliver energy savings, and minimise downtime risks. All of that comes with total service dedication, reliable customer support backed by the inventor of the sulphuric acid catalysts, and decades of experience.

Begg Cousland Envirotec — Stand 47

Begg Cousland Envirotec, based in Scotland, has experience and technology that spans over 70 years in the field of sulphuric acid plant applications. With production sites in the UK, Italy, India and China (under licence), the company specialises in mist elimination equipment for sulphuric acid and fertilizer plants and innovates to optimise performance and maintenance. Meshpad demisters and fibre bed candle filters remove acid or other contaminants from process gas, and control stack emissions. In addition, Begg Cousland Envirotec makes state-of-the-art gas scrubbers, using rotating brush technology and phase separation meshes for tank venting duty and for abatement of chemical emissions.

Blasch Precision Ceramics — Stand 19

Blasch's unique and innovative ceramic systems provide significant process improvement benefits for SRUs. Blasch VectorWall™ for the reaction furnace and incinerator provide higher reliability, ammonia/BTEX destruction, faster installation, capacity increase, energy savings and lower emissions. Blasch ProLok™ ferrule designs require no castable refractory and offer far superior tube sheet and boiler tube protection preventing costly shutdowns.

Boldrocchi — Stand 35

Boldrocchi is an international engineering and manufacturing firm with over 100 years experience, products in over 140 countries and offices worldwide. Its wide-ranging portfolio of solutions includes fans, blowers and compressors, heat exchangers and coolers, environmental solutions, noise protection, heavy-duty dampers & diverters and power generation/gas turbine ancillaries. Boldrocchi also offers an array of on-site services and provides turnkey projects.

The company portfolio includes sulphur recovery units using its API 672/617 compliant customised centrifugal compressors. These compressors, with pressure ratios of 1.5-14, are compact and low maintenance, offering lower operating costs and higher operating efficiencies. They, along with single and multi-stage blowers (with pressure rises up to 1 bar), are manufactured in Boldrocchi's own Italian workshops with special alloys and steam traced casings for acid gas applications. They are then tested in-house at full speed, with motor power up to 7 MW. Boldrocchi's systems can be found in several SRU projects worldwide, often with Claus/thermal reactors, offering a typical hydrogen sulphide conversion efficiency of 92-96%.

Christy Catalytics LLC — Stand 62

Established in 1922, Christy Catalytics manufactures and supplies inert bed supports for fixed beds of catalyst and adsorbents as well as a complete range of tower packing to the chemical, petrochemical and refining industries worldwide.

For sulphuric acid customers, Christy Catalytics offers PROX-SVERS® ceramic balls for converter vessels; Christy® Pak ceramic saddles and Christy® Pak Cross Partition rings for absorption/drying towers as well as thermoplastic packing for gas cooling towers.

Clark Solutions — Stand 4

Clark Solutions has been developing and producing equipment and disrupting technologies for the sulphur and sulphuric acid industries for over 30 years.

With thousands of installations in service, Clark Solutions is a leader in wire mesh and fiberbed mist eliminators, CSX coolers, piping and products and a whole range of state of the art technologies to enhance process performance and environmental compliance for sulphur and sulphuric acid operations.

Consultco Inc — Stand 73

Consultco is an engineering firm that offers inspection and consultation services, based on years of hands-on experience in the manufacturing of non-metallic equipment such as FRP and Dual Laminate process piping and vessels.

Combining over 85 years of experience, and with multiple offices in Montréal, in the north of Milan and in Vancouver, Consultco relies on extensive technical and practical expertise in the manufacturing of equipment and uses a rigorous and constant inspection methodology to ensure monitoring of the evolution of the equipment. The chronological execution of the different inspection steps is used to provide an accurate diagnosis. The company is committed to integrating this experience along with an in-depth knowledge of ASTM, ASME, EN DIN, DT-15, BS, DIN and AWS standards.

Continental Industrie SAS — Stand 20

Continental Industrie manufactures air/gas multistage centrifugal blowers up to 50,000 Nm^3/hr @ 1,5 bar. With more than 40 years of experience in research, development and manufacturing of centrifugal machines and with thousands of machines installed, its products provide proven reliability and confidence for continuous duty and extremely rugged service, 24/7. Continental Industrie is a leader in providing blowers for the oil and gas industry for combustion, desulphurisation, sulphur recovery, fluidisation, etc.

CS Combustion Solutions — Stand 63

CS Combustion Solutions was founded by a team of senior specialists in the field of combustion technology. As a member of Unitherm-Cemcon Group which has been successfully dealing with burner, kiln- and furnace construction since 1946, CS can refer to Unitherm's experience in boiler and rotary kiln burner construction. The CS Combustion Solutions team is experienced in engineering, supply and commissioning of vertical and horizontal burners and combustors for:

- Sulphur, spent acid and acid gas
- Waste gas and waste air
- Waste water
- Hazardous and special waste liquids
- Pasty waste fluids
- Burners and reaction furnaces for sulphur recovery units

Daltec Process Fans — Stand 54

Daltec Process Fans is a designer and manufacturer of high quality industrial fans and blowers with an extensive product range from low volume high pressure to large volume low pressure. Daltec products are available in carbon steels, stainless steels, nickel alloys, aluminum, titanium, FRP or a combination to meet the specific demands of the application.

Damper Technology Ltd — Stand 52

Damper Technology Limited (DTL) is an industrial damper manufacturer with over 50 years' experience of providing custom damper solutions to industry worldwide. At the Sulphur + Sulphuric Acid 2024 exhibition DTL will be showcasing specially engineered dampers for applications involving process gases containing SO_2 / SO_3.

Delta Controls Corporation — Stand 7

Delta Controls Corporation is an internationally recognised expert in the design, engineering, manufacturing, and support of engineered process equipment and instrumentation. Delta Controls' 50+ decades of instrumentation expertise allows it to provide innovative and quality solutions for demanding applications untouched by competitors.

Delta Controls offers three main product lines of temperature, level, and flow encompassing a variety of technologies including thermocouple, pyrometer, pressure, capacitance, mechanical, and more. All Delta products are manufactured to the extensive quality standards of its Louisiana based factory. Its temperature line ClausTemp™, QSeal™, ProSpection™ designs decrease maintenance and maximize uptime resulting in low costs. Delta's products are in approximately 175 sulphur plants internationally including refineries, gas plants, upgrade facilities, sulphuric plants, and more.

Duiker Clean Technologies — Stand 8

Duiker is a combustion engineering and contracting company, based in the Netherlands. The company has professional experience in designing, supplying and servicing sulphur recovery burners and a range of liquid and gaseous fuel burner systems and associated equipment for the petro-refining and petrochemical industries worldwide since the 1950s. Duiker products incorporate many typical features that improve overall plant performance and operation, safety and reliability.

Dütching Pumpen Maschinemfabrik GmbH & Co. Kg — Stand 14

Düchting Pumps is a pump manufacturer with over 80 years of global experience in the field of advanced centrifugal pumps designed to achieve superior reliability and performance in corrosive and abrasive services. The company specialises in engineered pump solutions and aftermarket repair capabilities through its unique SICcast material technology, an engineered matrix of silicon carbide particles and epoxy resin binder that simultaneously combines 100% corrosion resistance and diamond-like abrasion protection. SICcast provides optimised protection against erosion-corrosion wear in phosphate fertilizer production across a wide range of challenging applications including phosphoric acid slurry, gypsum slurry, phosphate rock slurry, and much more.

EFC NV European Filter Corporation — Stand 25

EFC NV is a Belgian based filtration technology supplier with over 25 years of experience. EFC NV offers a complete line of fibre bed mist eliminators and systems to abate liquid mist emissions. Its Atephos fibre bed mist eliminators, also referred to as fibre bed filters or candle filters, are optimal for removing sub-micron liquid aerosols from gas and air streams. EFC filters candles are innovative due to the variable bed densities technology offering its customers a wide range of possibilities to optimise their filtration process by increasing the efficiency, reducing the operational costs or to save on capital investment costs.

Besides liquid and air filtration, EFC NV has its own specialised oil filtration division and also provides technology and innovation to give pure air and pure liquid.

Fluor — Stand 18

Fluor Corporation is one of the world's leading engineering, procurement, construction, maintenance, and project management companies. Its unique experience and knowledge in

the design of sulphur recovery plants, tail gas treating units, and proprietary process technologies, provides a wide range of proven and innovative solutions for its clients. With over a century of experience in handling complex projects in challenging locations, Fluor's dependability, expertise, and safety record distinguishes it as a respected leader in sulphur recovery.

FluoroSeal — Stand 45

For over 40 years, FluoroSeal has been manufacturing and customising a wide range of valves for various industries. At Sulphur + Sulphuric Acid 2024, FluoroSeal will be displaying valves applicable for sulphur and sulphuric acid applications including jacketed sleeved plug valves, PFA lined plug valves, and GF2P/ PFA lined butterfly valves.

Glatt Ingenieurtechnik GmbH — Stand 10

Glatt Process Technology Food, Feed & Fine Chemicals provides product, technology, and system expertise for the entire value chain, from particle design to industrial production. The company focusses on powder synthesis and fluidised bed processes for developing, manufacturing, optimising, and refining powders and bulk materials such as granulates and pellets.

Gouda Refractories BV — Stand 1

Gouda Refractories BV, established in 1901, serves all primary industries, providing worldwide customer specific refractory solutions, added value with in-house design, manufacturing of high grade/ alumina refractory linings (bricks, monolithics, precast shapes), supervision/ installation services. Acquainted with the processes, Gouda Refractories co-operates with oil companies, refineries, chemical plants, licensors, engineering companies and has a proven track record within the SRU market.

HEC - High Efficiency Combustion Technologies — Stand 58

HEC is a global supplier specialising in burners and associated combustion equipment accessories for sulphur recovery installations ranging from 1 t/d to over 12,000 t/d+ capacities. Applications include custom engineered burners for reaction furnace, RGG/SCOT/reheat/Superclaus and tail gas incineration systems. CFD analysis is utilised for troubleshooting / root cause analysis, and extensively for product development and refinement. HEC offers RF expertise for challenging applications involving; high level oxygen enrichment, high turndown, very lean feed and rich feed acid gas processing, high content hydrocarbon (BTX) and ammonia destruction and more. HEC technical publications on a variety of topics related to SRU recovery technology are available upon request.

Howden, a Chart Industries Company — Stand 29

Howden specialises in the design, application and manufacture of customised turbo blowers and compressors for both sulphur production and recovery applications. As the leading global supplier, Howden draws on its extensive experience from its trusted product brands as well as working closely with customers to offer a unique range of mutually compatible compressors and drivers.

In addition, Howden offers robust and reliable steam turbines for power generation or as mechanical drive, for example, for waste heat utilisation in sulphur and sulphuric acid plants.

Hubei Sanfeng Turbine Equipment Co., Ltd — Stand 56

Hubei Sanfeng Turbine Equipment Co., Ltd. (founded in 1958) is a modern high-end equipment manufacturing enterprise specialised in the research and development, design and manufacturing, system consulting and service of blowers, compressors and fans. Today the company has a 300,000 sqm production facility with approximately 700 employees and thousands of production equipment of various types.

HUGO PETERSEN — Stand 44

HUGO PETERSEN's technology portfolio for sulphuric acid ranges from the production of high-quality sulphuric acid and oleum from elementary sulphur, metallurgical off-gas and spent gases.

In addition, HUGO PETERSEN is known for its expertise in hydrochloric acid and gas cleaning, where wet, dry and catalytic processes are being applied. The company also offers consulting, design and construction of new plants and plant units, as well as the revamping and refurbishing of existing plants.

Industrial Ceramics Ltd — Stand 69

For over 60 years, Industrial Ceramics Ltd has been a leading manufacturer and supplier of custom shaped refractory ceramics for use in the petrochemical and sulphur industries worldwide.

The company specialises in the design and manufacture of ceramic ferrules and inserts for the thermal protection of waste heat boilers, as well as nozzles and shapes for specialised applications. Specifically, the company is world renowned for the popular 2-piece Hexagon Head ferrule as well as its solid hexagon head design. With over 60 years' experience, Industrial Ceramics Ltd is trusted for its superior technical expertise and product reliability related to its customers' refractory needs.

IPCO — Stand 32

IPCO is a world leader in sulphur processing and handling solutions, and has delivered complete end-to-end systems to hundreds of companies around the globe since 1951.

Two systems are available to meet all throughput requirements: For small to medium capacity requirements, IPCO's well-known Rotoform® technology offers excellent product uniformity and environmentally friendly operation. The efficiency of this single step, liquid-to-solid process results in a premium quality product. The uniform shape and size of Rotoform pastilles makes them free-flowing for easy handling, while a predictable high bulk density is a major advantage in terms of storage and transportation. With more than 700 Rotoform pastillation systems installed to date, Rotoform remains the world's most widely used process for the production of premium quality pastilles.

For medium to high capacity requirements, IPCO's fully automated drum granulation system uses rotating drum technology to deliver high productivity "once through" performance. This is the highest capacity granulation unit available in the industry and delivers a uniform end product of a definable size. Other key benefits include low maintenance and continuous operation for high availability.

IPCO's newest drum granulator SG20 has been commissioned in Italy and serves as a global showcase for this patented system. Prospective customers are invited to visit the site and assess the system in operation.

ITT RHEINHÜTTE Pumpen GmbH — Stand 68

ITT RHEINHÜTTE Pumpen GmbH offers chemical, petrochemical, fertilizer and related industries a full range of vertical and horizontal pumps in metal, plastic, and ceramic materials.

RHEINHÜTTE Pumpen designs and manufactures safe and efficient pumping solutions for even the most difficult applications. An expert in corrosion and wear resistance, RHEINHÜTTE Pumpen leads the field with highly sophisticated know-how in many specific areas. The company specialises in chemically resistant centrifugal and axial flow pumps for handling molten suphur, sulphuric acid, and phosphoric acid.

J. Rettenmaier & Söhne — Stand 41

JRS is the world's leading producer of precoat filter aids that replace minerals such as diatomite and perlite in the filtration of molten sulphur. FILTRACEL filter aids offer the following benefits: significantly lower process costs, longer filter cycles, reduced filter aid consumption, less waste and less sulphur loss, longer lifetime of filter elements, no catalyst poisoning.

JL Goslar GmbH — Stand 16

JL Goslar, an expert in the processing of lead, tin and their alloys, has a portfolio which includes the following products and services:

- Wet electrostatic precipitators
- Star tube cooler bundles
- Spare parts for wet electrostatic precipitators
- Lead lined vessels and tanks
- Autoclaves
- Lead linings on site
- Assemblies on site

KALFRISA S.A.U. — Stand 34

KALFRISA S.A.U. is a Spanish family-owned engineering company with almost 60 years of experience in delivering advanced technological solutions for energy efficiency and environmental protection in industrial applications.

KALFRISA offers cutting-edge preheaters for sulphuric acid production, ensuring smooth start-up and optimal plant operation. Its start-up heaters, provide the converter with the necessary heat to reach the exothermic temperature required for catalytic conversion, crucial for the process.

KALFRISA's preheaters enhances plant reliability, flexibility and efficiency by leveraging state-of-the-art burner management units, latest automated control systems and remote support based on IoT solutions.

Kanzler Verfahrenstechnik GmbH — Stand 51

Kanzler Verfahrenstechnik GmbH (KVT) is a global engineering and technology company offering a full range of services from the initial concept to a turnkey industrial process plant commissioning. KVT's technology portfolio for wet sulphuric acid – OXYSULF comprises 360° solutions for the recovery, regeneration and production of sulphuric acid from various types of off-gases, spent acid or sulphur burning. The OXYSULF process is based on wet-catalytic oxidation of sulphur bearing compounds with recovery of concentrated sulphuric acid. A smart tail gas treatment system allows to reach exceptional high sulphur conversation rate and guaranteed low SO_2 emissions at stack.

Kimre — Stand 48

Kimre™ high-performance, interlaced mesh structure has provided revolutionary air pollution control and fluid separation products since 1973. Kimre™ technology is proven to economically meet the toughest applications at any gas flow rate, for horizontal or vertical flow. Proven applications in phosphate fertilizer plants include:

- Phosphoric acid production
- Ammonium phosphate and NPK production
- Animal feed ingredients production
- Super phosphate production
- Sulphuric acid production
- Rock production

Kimre™ Technology includes: B-GON® mist/fume eliminators, Kimre™ CANDLE fiber-bed coalescing filters, KON-TANE® scrubber tower packing, SXF™ semi-cross-flow contactors, AEROSEP® multi-stage aerosol separation, Kimre™ Technology; scrubber/mass transfer equipment; DRIFTOR® drift eliminators and LIQUI-NOMIX® liquid/liquid separation.

Knight Material Technologies — Stand 22

Founded in 1910, Knight Material Technologies (KMT), Canton, OH, (formerly Koch-Knight) designs, manufactures, installs, and services acid-resistant linings for vessels/towers in the sulphuric acid industry worldwide. KMT produces industry-leading brick, mortars, PYROFLEX® membranes, internals, FLEXERAMIC® structured and random packing media. Subsidiaries Electro Chemical and Superior Dual Laminate Products specialise in fluoropolymer lining for the chemical processing industries.

Lanexis — Stand 5

Lanexis is a specialised acid resistant lining and refractory company. For sulphuric acid and phosphoric acid plants the company supplies anti-acid carbon bricks, silica bricks, specialised graphite filled membranes, mortars, grid bars, high strength grid blocks, high alumina refractories and refractory coatings with a focus on CO_2 reduction & reducing heat losses.

Lechler GmbH — Stand 9

Lechler is Europe's no. 1 and one of the world's leading manufacturers of precision spray nozzles and systems for over 140 years, for all industrial applications with more than 700 employees worldwide. The company headquarters are located in Germany, and there are 14 subsidiary companies which are part of the worldwide Lechler group.

Matrix Service Company — Stand 43

Matrix Service Company, through its subsidiaries, is a global leader in sulphur recovery, processing, storage, and handling. Technologies include proprietary Devco II prilling, high capacity sulphur melting, material handling, and sulphur block pouring. Its design and execution expertise include the world's largest sulphur melting facility, as well as sulphur forming facilities in the United States, Canada, Saudi Arabia, China, and elsewhere.

Messer — Stand 60

Messer is the world's largest privately-held industrial gases company, with unrivalled technical development capabilities and agility from people you know and trust. Messer sustainably grows

and innovates with its chemical and energy customers with gases application technologies that boost throughput and lower their carbon footprint.

Metso — Stand 21

Metso is a frontrunner in sustainable technologies, end-to-end solutions and services for the aggregates, minerals processing and metals refining industries globally.

With over 650 sulphuric acid plant installations worldwide, Metso's Metals and Chemical Processing business line is a leader in sulphuric acid plant design and delivery. The portfolio includes plants based on elemental sulphur combustion and metallurgical off-gas handling, as well as plants for special processes such as the thermal decomposition of iron sulphate and spent sulphuric acid. These are complemented by processes for the production of liquid SO_2 and SO_3, various concentrations of oleum, and special high-grade sulphuric acid.

The Metso Edmeston Product Center specialises in the design and supply of strong acid equipment, mainly manufactured from the proprietary alloy Edmeston SX®. Edmeston SX® stainless steel was introduced to the market in 1984 and is characterised by an excellent corrosion resistance over a wide concentration range of sulfuric acid at high temperatures.

NORAM Engineering and Constructors Ltd — Stand 59

NORAM designs and supplies equipment and technologies for the process and resource industries. For sulphuric acid clients, NORAM offers improved equipment including sulphur furnaces, stainless steel converters, radial and split flow gas exchangers, ducting and expansion joints, acid towers (traditional brick-lined and NORAM SX® alloy as well as HP™ packing), and other NORAM SX® components including, acid valves, acid distributors (trough and Smart™), piping and acid coolers. NORAM also offers debottlenecking and emission reduction studies. NORAM is a specialist at refurbishing existing acid plants with enhanced equipment to make them run better.

Nuberg Industries Ltd — Stand 77

Nuberg EPC is a global EPC and turnkey project management company, providing end-to-end solutions for plant engineering & construction. With 65+ projects across 32 countries, Nuberg specialises in fertilizers, chemicals, hydrocarbons, and green energy.

Nuberg has successfully executed over 20 LSTK sulphur projects worldwide, including key projects like NPK fertilizer, sulphuric acid, sulphur recovery unit (SRU), and sulphur bentonite in Saudi Arabia, Egypt, Ethiopia, India, Turkey, and more. Highlights include 500 t/d and 300 t/d sulphuric acid plants in Egypt and a 550 t/d sulphuric acid unit modernisation in the Czech Republic, reinforcing its global leadership in sulphur-related EPC projects.

Ohio Lumex — Stand 13

Specialising in monitoring solutions for industrial applications for 25+ years, Ohio Lumex is excited to bring its expertise to the sulphuric acid industry with the introduction of the Ei4200 Dew Point Monitor for instant leak detection and dew point measurement.

Combining cutting-edge technology, application expertise, and a culture of service excellence, Ohio Lumex offers a full array of tools to meet our customers' unique requirements. From analytical instruments, to laboratory services, to onsite testing, Ohio Lumex aims to provide comprehensive solutions to industry needs.

OHL Gutermuth Industrial Valves GmbH — Stand 28

OHL Gutermuth has been making valves for more than 100 years. Control and shut off valves from OHL Gutermuth are the right choice when it comes to regulating the flow of gases, vapours, liquids and granulates in a safe and economic way.

Special projects such as desulphurisation Claus and tail gas treatment units, sulphuric acid plants, methanol plants, concentrated solar power, steelworks and shipbuilding are supplied with various valve designs.

Optimized Gas Treating, Inc — Stand 33

SulphurPro® is best in class simulation software for sulphur recovery units (SRUs). SulphurPro is based 100% on fundamental reaction kinetics and sound heat transfer models that allow all aspects of the SRU to be accurately predicted. SulphurPro SRU simulations can be seamlessly integrated into ProTreat®, a 100% rate-based simulation tool, for a full assessment of the complete sulphur recovery system including AGRU, AGE, SWS, SRU, and TGTU.

P & P Industries AG — Stand 65

P & P Industries is dedicated to achieving sustainable industrial solutions. Its expertise lies in green technology for a cleaner industry. With over 20 years of global experience, the company offers a range of products and plant systems for waste gas treatment, sulphuric acid technology, precious metal catalysts as well as comprehensive engineering solutions.

P & P Industries' track record of delivering customised and sustainable solutions sets it apart with its success underpinned by its competence, entrepreneurial spirit, and profound passion for ecotechnological advancements.

PegasusTSI Inc — Stand 11

PegasusTSI, Inc. (PegasusTSI) is a privately owned company delivering engineering, procurement, and construction management (EPCm) services worldwide. With over 40 years of expertise, PegasusTSI has built a strong reputation in the implementation of sulphur and sulphuric acid technologies. Its experience involves sulphur handling, storage, and transportation, sulphur burner systems, waste heat boilers, heat recovery systems (HRS), and sulphuric acid plant converter replacement. PegasusTSI has successfully managed numerous complex projects in these areas, providing innovative solutions for established industry leaders and new start-ups

QMAX Industries, LLC — Stand 15

Since 2010, QMax has been a leading manufacturer and designer of modern pipe tracing and tank heating equipment. The company's streamlined approach to implementing heating systems, using its innovative products, makes QMax the best solution for pipe and tank heating. QMax commits to simplifying your project with an effective heating solution with every BTU in mind.

REMA TIP TOP — Stand 26

REMA TIP TOP manufactures rubber adhesives, repair materials, pulley lagging and industrial rubber products for wear and corrosion protection; providing expert factory and field installation of rubber linings, tankage corrosion linings, and wear linings. The company helps its customers prevent, reduce or repair wear caused by abrasion or corrosion.

SBS Steel Belt Systems — Stand 57

SBS Steel Belt Systems manufactures, installs and commissions continuous machinery and plants equipped with stainless steel belts for chemical, petrochemical, fertilizer, sulphur, food, rubber and powder coating industries. The most advanced techniques in the industrial fields have led SBS to work for the best European, American and Asian companies, as well as for the most important engineering groups. SBS is able to offer complete packages, starting from the design, through the construction, the installation, the commissioning up to the after sales service of their machinery. The company is part of the international group Berndorf Band GmbH / Austria, provider of stainless steel belts.

Schenk Stahl GmbH — Stand 76

Schenk Stahl was founded in 1986 by the Schenk family as a trading company selling stainless steel and heat-resistant stainless steel products from its main office in Vienna. After opening a warehouse in Dusseldorf-Heerdt in 1989 the company started to tailor the company's own product range to customer requirements. For over 40 years the company's business has revolved around stainless steel quality pipes, specialising in heat-resistant materials, especially pipes in welded and seamless design. Its customers can be found throughout Germany and its neighbouring countries, in Eastern Europe and Turkey, in India, the USA and the United Arab Emirates.

SENSIA Solutions — Stand 24

SENSIA Solutions is a leading company in the infrared imaging market with systems operating worldwide. SENSIA's RedLook solution uses comprehensive optical gas imaging technology designed for 24/7 automatic operation and real-time gas detection in multiple applications. RedLook's continuous monitoring technology combines computer vision and artificial intelligence to provide automated real-time classification and information on everything of interest to their customers, such as gas detection alarms and gas leak flow rates, the combustion efficiency of flares, early flame detection alarms, monitoring temperature levels of critical components, or controlling intrusions into forbidden areas.

SensoTech — Stand 53

SensoTech manufactures analysers for concentration measurement of sulphuric acid and oleum in various applications. The LiquiSonic® sensor technology is based on sonic velocity measurement providing an accuracy of up to 0.03 wt-%. SensoTech offers both inline sensors measuring the sulphuric acid strength directly in pipes or vessels, and laboratory systems. The analysers are robust, maintenance-free and made in Germany. The LiquiSonic® controller displays the concentration values and transfers the real-time information online to process control systems.

Shandong Junfei Environmental Protection Technology Co., Ltd — St. 37

Shandong Junfei is the new player in the SRU catalyst market. With over 30 years of experience in manufacturing high-quality catalysts, the company has built a reputation for providing high-activity catalysts with over 6 models. Shandong Junfei is committed to providing excellent service and customised solutions for global clients.

Sharplex Filters (India) Pvt. Ltd. — Stand 27

Sharplex Filters (India) Pvt. Ltd. Is a company with experience in molten sulphur filtration having supplied more than 60 filters in sulphuric acid and sulphonation plants worldwide. Sharplex offers horizontal pressure leaf filters for molten sulphur filtration in shell retraction or bundle retraction design. Sharplex also manufactures and supplies polishing cartridge filters for molten sulphur filtration. Sharplex is strong in design, engineering, manufacturing and supplies filters with ASME, Merkblatter codes as well as PED certifications. Filter screens for molten sulphur filters are a 5 layer design with strong backing screens. Rigidrain backing screens can also be provided for screens.

Smart SCOPE GmbH — Stand 61

Smart SCOPE is a provider of engineering services for sulphric acid and industrial gas cleaning plants. With its innovative concepts Smart SCOPE addresses the specific needs and challenges of its customers and develops tailor made solutions for them. Focusing on plant revamps and optimisation Smart SCOPE identifies ways to maximise plant performance and provide process and equipment design for reliable operation. The experience of its engineers in plant design and operation is the key to identify the potential of each individual plant in a flexible and smart way.

STEULER-KCH GmbH — Stand 61

Steuler Linings is a complete service provider for surface protection and acid proof /refractory linings in sulphuric acid and gas cleaning plants. Its Plastic Linings division also offers bundles in WESP, apparatus- and piping construction. Steuler Linings is a provider for almost every type of engineering, material supply, installation, repair and maintenance.

Sulphurnet — Stand 42

Sulphurnet focuses its activities on the design and manufacturing of equipment for sulphur processing plants. The company offers engineering services and suppies proprietary equipment.For the sulphuric acid industry, Sulphurnet provides complete solutions, where it designs the entire sulphur melting and filtration process, from solid feed to liquid sulphur storage tanks.

Sulphurnet is also a provider of solutions to purify sulphur waste streams to make them suitable for sulphur forming and commercial trade. The company also uses state of the art techniques to offer its clients environmental solutions such as gas cleaning systems for sulphur melting and filtration plants.

Sulzer — Stand 46

Sulzer, with 180 years of experience in developing pumping solutions for production processes involving corrosive or abrasive media, adds value to its customers' processes through best-in-class products and services. As Sulzer and Ensival-Moret have joined forces, the company is now able to offer an even deeper process understanding for demanding applications.

Sulzer offers a complete range of horizontal and vertical pumps, as well as agitators, tailor-made to satisfy the customer specifications for molten sulphur and sulphuric acid. Its solutions cover various applications of the petrochemical, chemical, fertilizer and metal industries. Advanced design and materials, a wide range of shaft seals and sealing systems, and the overall operating efficiency ensure a reliable process and a maintenance-free operation.

Teknokon Group — Stand 31

Teknokon Grup companies provide services to a wide range of customers, which include sulphuric acid plants, chemical plants, mineral processing and refining plants, petrochemicals, power plants, oil refineries, petroleum and gas storage facilities, air separation plants, food & beverage plants, and iron & steel plants.

With its multi-disciplinary structure that includes individually specialised companies, Teknokon Grup plays an active role in all stages of industrial facilities and projects: from engineering to commissioning, and later followed by maintenance. The Group gathers all of its services under a single roof, allowing its customers to easily get support and access streamlined project management tools, while leading the market with its 360° approach that includes all components

Topsoe — Stand 40

Topsoe is a global leader in development and supply of technologies, catalysts and services for the sulphur and sulphuric acid industry. With its Smarter Sulfur Solutions portfolio, Topsoe works to ensure that its customers enjoy the benefits of a highly efficient and reliable solution while complying to the most stringent emission requirements. Its high-activity catalysts enable higher conversion and energy efficiency, while simultaneously reducing pressure drop and improving production stability.

Voovio Technologies SL — Stand 66

Voovio is a global deep tech company, headquartered in Houston (US) and Madrid (Spain). Founded by a group of experts in machine vision, industrial R&D and automation, Voovio was created to make the process industry more efficient, more profitable, environmentally friendly and safer using proprietary enhanced reality technology.

WEIR — Stand 3

The Weir Minerals range of Lewis® pumps and valves are made with Lewmet® alloys to provide superior erosion resistance and corrosion protection. Lewmet® nickel-chrome alloy is engineered to withstand long-term exposure in the harsh operating environment of contact process sulphuric acid plants. The company's continuous research, development and innovation mean that it is constantly improving performance, extending wear life, simplifying maintenance practices and delivering the lowest total cost of ownership to its customers. The company prides itself on its ability to work closely with its customers and build long-term relationships.

WIKA — Stand 2

The WIKA group is a worldwide leader in pressure, temperature, level, force and flow measurement, as well as calibration technology. Founded in 1946, WIKA is today a strong and reliable partner for all the requirements of industrial measurement technology, thanks to a broad portfolio of high-precision instruments and comprehensive services.

Worley Chemetics — Stand 49

Worley Chemetics is a leading provider of technology, solutions and equipment fabrication for sulphuric acid, chlorine chemicals and other specialty chemical facilities.

Since 1964, it has been servicing worldwide customers in the chemical, oil and gas, fertilizer, pulp and paper industries with specialised design and fabrication of proprietary and non-proprietary equipment, engineered systems and plants. Its technology helps its customers to achieve higher capacities and reliability, lower their operating costs, substantially decrease emissions, improve safety and maximize long-term profits.

With its CORE-SO2™ sulphuric acid plant technology Worley Chemetics unlocks green fertilizer and sustainability goals across industries. By leveraging co-produced oxygen from water electrolysis and green ammonia, CORE-SO2™ decreases acid plants' environmental footprint and greenhouse gas emissions, recovers CO_2-free electrical power and enhances profitability. Its small physical size confers significant construction advantages, while low internal gas flows and fewer pieces of equipment enable modularisation.

Worley Comprimo — Stand 49

Worley Comprimo is a global provider of gas treating and sulphur recovery technology focused on reducing emissions, increasing site reliability and improving plant economics. For over 60 years, its technology has been at the forefront of sulphur recovery, featuring in more than 1,200 sulphur recovery units worldwide.

Worley Comprimo's portfolio covers the full range of technologies in gas treatment, sour water stripping, sulphur recovery, sulphur degassing and sulphur handling, storage and transportation. Through its desulphurisation and carbon capture technologies, it helps its customers to reduce emissions of SO_2 and CO_2, shaping the future of sustainability in this industry.

Wylton (China) Chemical Co., Ltd — Stand 23

Wylton (China) is proud to be known as the pioneer that significantly influenced the development of the sulphuric acid industry in China, by offering integrated services to sulphuric acid plants worldwide: Technical process design participation, project construction management, equipment and spares supply, catalyst supply and screening, operators training, start-up/commissioning service, maintenance and overhaul, full management of acid plant etc.

As the largest privately owned sulfuric acid producer and the largest market-share holder of sulphuric acid catalyst in China, Wylton is eager to establish a long term good cooperation partner relationship with all clients from all over the world.

Zeeco — Stand 67

Founded in 1979, Zeeco has steadily become the world leader in designing and manufacturing advanced combustion and environmental solutions. Headquartered in Tulsa, Oklahoma, USA, Zeeco is a privately held business with more than 2,500 employees and 30+ global locations. The company executes 10,000+ projects yearly for refining, production, petrochemical, LNG, power, pharmaceutical, biogas, and other industries. ZEECO® products and solutions include ultra-low-NOx burners, flare systems, thermal oxidizers, vapor control, rentals, aftermarket solutions, global field services, and combustion electronics.

Zeeco's comprehensive offering helps customers reduce emissions, optimize processes, and maximise operating efficiency while meeting global environmental compliance requirements. Zeeco also operates the world's largest combustion research and test facility and a manufacturing facility on a 250-acre campus at its Global Technology Center in Broken Arrow, Oklahoma, USA.

More out of ore: recycling mine tailings

PHOTO: METSO

As more focus extends to a circular economy, there are industry wide discussions on whether future global sulphur demand will be challenged by the energy transition and decarbonisation. **Hannes Storch, Collin Bartlett** and **Marcus Runkel** of Metso discuss how the recycling of pyrite tailings could address some of these issues.

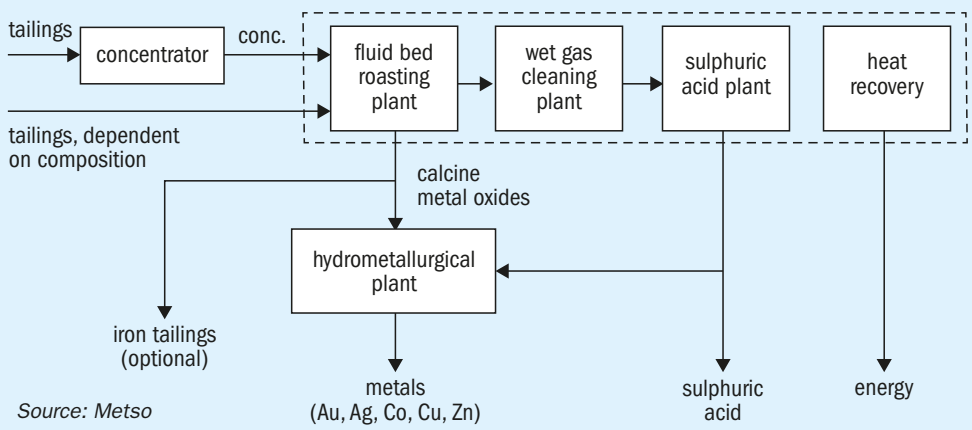
In bygone days the predominance of sulphuric acid production was from the processing of pyrite. Today pyrite is a by-product of the mining industry that often ends up in tailings. With concerns over future global sulphur demand being challenged by the energy transition and decarbonisation, refocussing on pyrite could also address some of these issues. A 2017 report by the International Council on Mining and Metals (ICMM) estimated that the mining industry produced between 10 and 20 billion tonnes of tailings annually. Most of the pyrite tailings originate from copper mining, and mainly consists of sulphur, iron, SiO_2, Al_2O_3, CaO, as well as valuable non-ferrous metals. Globally there are 580 operations exploiting copper, with 190 cases from where resources and reserves are reported[1]. As most of the mined waste material is tailings, the assumption is that there are ~204 billion tonnes of current and future tailings globally with pyrite content varying between 4-8%.

Pyrite is a common mineral in many types of metal ore deposits, and it is often found in association with other minerals that contain gold, copper, cobalt, and zinc amongst others. The amount of pyrite present in the tailings can vary depending on the specific deposit and the extraction process used. Sulphur content in pyrite tailings concentrate is typically anywhere between 30-50 wt-%.

As global ore grades further deplete over time[2], the volume of tailings per tonne of metal is continuously increasing. The mine operator has the challenge of treating an increased volume of mineral to maintain the same metal production rate; this increases tailings waste and the associated operational costs. The environmental impact is a direct result of the contact of the metal sulphides with oxygen, where oxidation proceeds rapidly, resulting in acidity and release of metals and sulphates to the water system, eventually leading to potential groundwater and surface water pollution.

To cope with the future challenge of a circular economy, technology needs to adapt towards larger processing units. Metso is working to increase the capacity of individual roasters, using its unique knowledge of this technology. Recycling mine tailings can help reduce the volume of tailings for disposal, mitigate water contamination, and generate new revenue streams such as valuable metals extraction, sulphuric acid production, and energy generation.

Fig. 1: **Roasting process block flow diagram – product streams**



Source: Metso

Fig. 2: **Project location**

Pyrite tailings as a source of metals

Pyrite tailings have been identified as a sustainable source for recovery of cobalt, copper, nickel, and gold. Raw material is available in large volumes and the processing route is well proven and established. Today, metallurgical processing plants are evolving to recover not only one major metal, but all valuable metals available in the pyrite concentrate. The roasting of pyrite tailings can be seen as a pretreatment process before processing the calcine in a hydrometallurgical process for the recovery of the metals. In addition, roasting allows for important revenue streams such as sulphuric acid, steam, and, in some cases, iron oxide may well add further revenue upsides to the project. Fig. 1 shows all relevant material streams for a conceptual evaluation.

Whilst the fundamentals of the roasting process have not changed significantly, each plant has its specific and optimum key plant configuration. The pyrite roasting process chain consists of the roaster section followed by a boiler system for energy and sulphuric acid production. The off-gas with dust entrainment is cleaned in the cyclone and hot electrostatic precipitator system. The solid product (calcine) is cooled and transported to storage for further processing for metals recovery in a hydrometallurgical plant section. After the hot gas cleaning, the off-gas enters the wet gas cleaning section, which traditionally includes the quench tower, gas cooling tower, wet ESP and mercury removal step. Finally, the purified SO_2 gas enters the sulphuric acid plant.

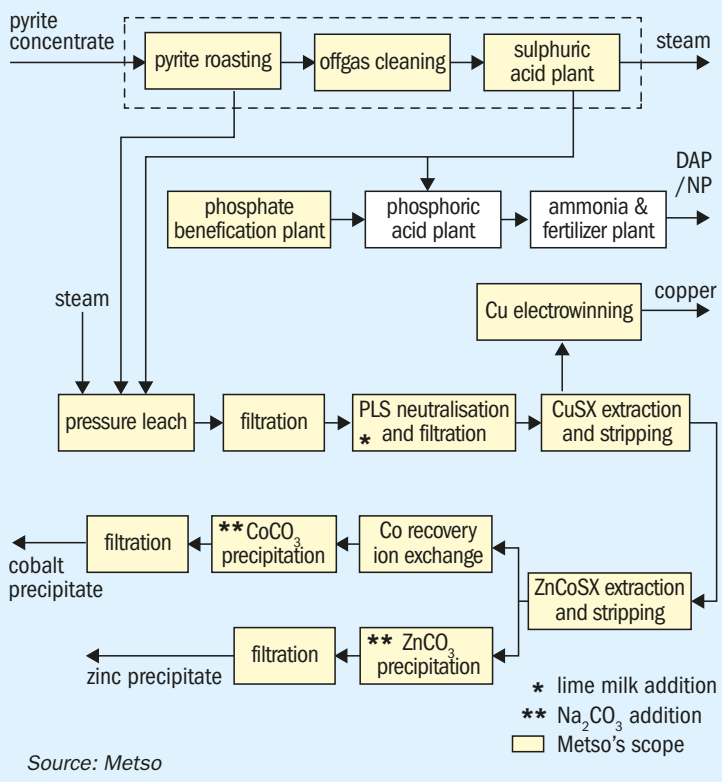
Cengiz: a project case study

In 2018, this integrated plant complex entered full operational status and as such Eti Bakir A.S. has fulfilled its intent to produce a portion of Turkey's fertilizer needs indigenously, a strategically critical factor for a country relying on agriculture and fertilizer imports. With the additional revenues from metals recovery, the project became economical and since Metso's technology portfolio covers a large portion of key plant sections for the industrial complex, they were therefore chosen as the key technology partner for the project.

The project, located in the Mazidagi district, belongs to Mardin province of Turkey (Fig. 2).

The key facilities comprise a pyrite roaster, off-gas cleaning, sulphuric acid plant,

Fig. 3: **Overall project flowsheet and Metso's scope at Mazidagi**



Source: Metso

Table 1: **Roasting process chain process data**

Roasting plant	
Plant feed	1,500 t/d pyrite (S 48%, Fe 46%, Cu 0.5%, Co 0.5%, Zn 0.2%, Ag 8 g/t, Au 1.3 g/t)
Roaster configuration	2 x 750 t/d, each 123 m^2 bed area
Calcine	total 45 t/h (S < 0.6 wt-%)
HP Steam (WHB)	total 129 t/h (60 bar, 400°C)
Gas cleaning plant	
Gas flow from roasting units	152,000 Nm^3/h
SO_2 concentration	12.6 vol-%
Temperature	350°C
Sulphuric acid plant	
Sulphuric acid production	2,080 t/h
Sulphuric acid quality:	As < 0.1 mg/kg acid, Hg < 1 mg/kg acid
Plant emissions:	< 2 kg SO_2 / t acid

Source: Metso

Table 2: **Typical composition of pyrite tailings with low and high sulphur content**

Products	Sulphur (%)	Iron (%)	Cobalt (%)	Copper (%)	Zinc (%)	Silver (ppm)	Gold (ppm)
Non-ferrous metal, acid, energy, iron	46-49	43.44	> 0.5	> 0.3	> 0.2	> 8	> 1.3

Source: Metso

phosphate beneficiation plant, phosphoric acid plant, ammonia plant, fertilizer plant, and hydrometallurgical plant (see Fig. 3).

For specific cases, an alternative to sulphur burning is that of pyrite roasting as a source for sulphuric acid production, especially when pyrite is available from local sources. This is particularly the case for a landlocked location such as Mazidagi, where the logistics associated with supplying sulphur to the plant location become challenging. The roasting process chain has process data as shown in Table 1.

Metals recovery

The composition of the pyrite concentrate varies depending on the ore body. Table 2 shows a typical composition of pyrite concentrates that has been analysed in recent projects or already treated today in existing operations.

For economical evaluation of a concentrate, all valuable and deleterious metals must be considered along with the local market conditions for sulphuric acid and power generation. Under such conditions, a project may well be economical. The economics of the metal recovery section depends on the metal content and the market value of the metals. Today, due to the trend to electromobility and energy transmission, the most important is the cobalt content. With today's value of 26,000 US$/t, it is far above all other metals of the pyrite concentrate mentioned in Table 2. However, copper and zinc can also bring more "stable" revenues to the project.

Today, such pyrite is often not further treated in a hydrometallurgical section. But in such a case, the low content of non-ferrous metals can be seen as an advantage in the economical evaluation. It allows production of calcine with high iron content and with a low sulphur content, that can be accepted in the iron ore industry sectors.

In general pyrite test work must be carried out for every potential project. The target of these tests is to optimise the recovery of valuable metals, such as cobalt, copper, zinc, silver, gold, etc. while keeping the iron portion in solid form. Only with a low iron content in leaching solution can high volumes of waste be avoided and provide a revenue stream by selling the final residues to the ferrous industry.

Pyrite roasting and atmospheric leaching tests have been performed to demonstrate the flowsheet concept. Fig. 4 shows the recovery results in relation to the roasting temperature, leaching temperature, and acidity process conditions.

The overall best plant performance can be reached at optimised roasting temperature in a typical pyrite roasting window between 750 to 850°C and optimised autoclave leaching (test 10). The high recovery rates of around 85 to 98% found in laboratory conditions correlates with industry indices, whilst the industrial applications tend to operate at the higher end of this spectrum[5]. With respect to a gold roasting plant, the operating temperature window is normally lower[6]; however, when operated in combination with autoclave leaching, extraction is optimised. There are several advantages for this change in roasting process conditions for the metal recoveries, which are related to better heat recovery, lower effluents, and higher acid production in the roaster. All these factors are important for an attractive and feasible process.

Fig. 4: **Metals recovery rates based on roast and leach conditions**

Test no.	Roasting temperature (°C)	Leaching temperature (°C)	Leaching acid (g/l)	Extraction rates Co (%)	Cu (%)	Zn (%)	Fe (%)
1							
5							
6							
10							
range	*640-870*	*20-220*	*20-100*	*24-95*	*33-95*	*19-97*	*0.1-11*

Source: Metso

Additional revenues and environmental benefits

Traditionally, the key product for the roasting process, especially in zinc and gold roasting applications, is the calcine with its metal content for further extraction. While pyrite roasting in former days was only focusing on sulphuric acid production, today the calcine from pyrite roasting can be considered as an additional revenue stream for the iron and cement industry alongside the points mentioned below:

Sulphuric acid production: Pyrite feed materials and the roasting process can support increased sulphuric acid production for the fertilizer or other local industries regionally. It is foreseen that a gradual decline of sulphur availability from the oil refining industry will take place in the second half of this century, and this will lead to the need for alternative sources of sulphur feed for acid production.

Green energy production: Roasting of pyrite is an exothermic process, ideally positioned to produce green energy. As tailings do not contain any carbon, there are no CO_2 emissions; hence, the plant can be considered a green energy producer and obtain the relevant financial incentives offered in many jurisdictions. Dependent on the composition of the pyrite and the volume of tailings to be processed, several different processing scenarios can be offered by Metso.

Environmental effects: The problematic elements usually found in tailings, such as Hg, As, Se and Sb are separated and collected in the roasting / wet gas cleaning process stage. Depending on the amounts of each element, specific treatment process can be applied, which reduces the amount of waste significantly. Reducing the volume

of tailings dams and the treatment of existing tailings will positively affect environmental topics such as water stress levels[4] and groundwater pollution through acid mine drainage.

Avoidance of waste landfill in this context receives continuously higher ratings in trade-off studies. While the roasting process transfers 96-98% of the sulphur from tailings into marketable sulphuric acid, a direct leaching process produces far more gypsum as landfill and emits more CO_2 gas to the atmosphere and as a result of the pyrite direct leach reaction (1) compared to the pre-treatment with roasting (2):

$$FeS_2 + 3.75O_2(g) + 4.5H_2O + 2CaCO_3 \rightarrow FeO{\cdot}OH + 2CaSO_4{\cdot}2H_2O + 2CO_2(g) \quad (1)$$

$$2FeS_2 + 7.5O_2(g) + 4H_2O \rightarrow Fe_2O_3 + 4H_2SO_4 \quad (2)$$

Compared to direct leaching processes, the roasting allows the reduction of landfill gypsum by 2.8 tonnes gypsum per tonne pyrite mineral. Processing of 1 million tonnes of pyrite per year via roasting allows production of 1.63 million tonnes of sulphuric acid. Comparing the two processes, roasting prevents landfilling of 2.8 million tonnes of gypsum on a dry basis, as well as prevention of approximately 719,000 tonnes of CO_2 emission to atmosphere.

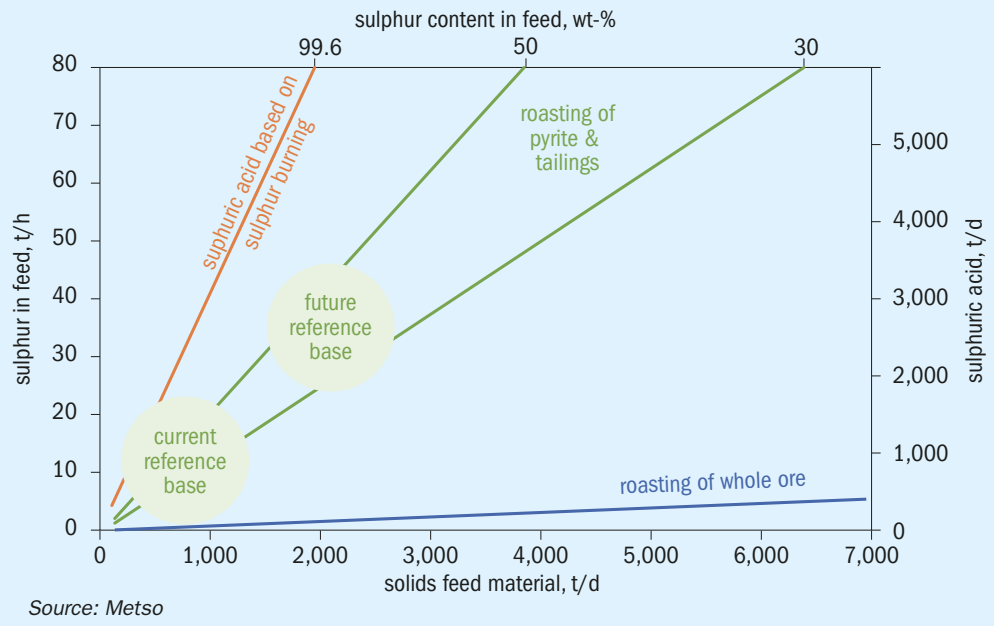
Economical evaluation of pyrite roasting

Metso is minimising the technical risk of development by applying a proven roasting technology for the treatment of pyrite tailings (Fig. 5). The current target is to move towards a mega-roaster based on existing references with a capacity of about 1,500 to 3,000 t/d of concentrate and acid production of 2,000 to 3,500 t/d. This will certainly enable a significant economy of scale to the financial equation.

On the earnings side, it is particularly important to use a realistic local market value for the acid. Many projects are not considered viable by using wrong or very conservative figures for the local acid price.

For an example study case, assume a pyrite roaster plant based on CFB technology with a capacity of 2,000 t/d pyrite plant with the metal composition of Cu 0.5%, Co 0.5%, Zn 0.2%, Ag 5 g/t, and Au 1 g/t. For a hypothetical operating cost on essential plant units (including leaching), the ROI can range anywhere from 2 to 4 years.

Fig. 5: **Future plant capacity development of pyrite roasters**



Source: Metso

Besides the earnings for metals, sulphuric acid and power, the benefits for credits or reduction in penalties regarding CO_2, groundwater effects, or tailings volumes will have to be considered in the future.

Summary

While environmental, social and governance aspects are increasingly a driver for industrial investment decisions, the treatment of tailings becomes an economically viable option for the industry. Metso has a well proven treatment process for tailings using the fluid bed roasting process, which can generate multiple revenue streams.

The industry trend indicates the need for upscaling of the existing technology and Metso's circulating fluid bed technology "Circoroast" process is a response to this development. It allows for large throughput, due to the flexibility in the heat balance of the roaster and, by physically having a more compact plant footprint, the capex can be reduced making the project even more economical.

The application of tailings roasting process can contribute to a sustainable project development. Environmental topics related to tailings dams may become more relevant in the future as focus turns to how local water resources are affected. Additionally, the increasing demand for regional sulphuric acid production can be addressed, at the same time as producing CO_2-free energy. Considering all the factors detailed above, it becomes clear that an evaluation of a new project requires a comprehensive multi-faceted economical study, commencing with the tailings characterisation and categorisation according to their potential revenue streams.

New, innovative plant improvement concepts are being explored to push the boundaries of plant sizes beyond the traditional limits. This is all in respect to more efficient plant operations to reduce CO_2 emissions, increase energy recovery, lower the specific investment costs, and working towards a circular economy.

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A big plus for sour water strippers: low GWP ammonia recovery

Refinery sour water strippers are an often overlooked resource of low GWP ammonia. **Martin A. Taylor** and **Charles L. Kimtantas** of Bechtel Energy Technologies and Solutions, Inc. (BETS) show the results of a study on reusing an existing SWS as one of the major systems in a SWSPlus unit for the recovery of ammonia for sale. Relative cost factors will compare a complete SWSPlus unit versus reusing an existing SWS.

With concerns about global warming potential (GWP100) and the carbon intensity (CI) of processes growing, the use of ammonia (NH_3) as a hydrogen carrier and fuel is generating more and more interest. One source of low GWP ammonia that is commonly ignored is from refinery sour water strippers (SWS). However, that ammonia exists with hydrogen sulphide (H_2S) and is routed to a Claus sulphur recovery unit (SRU) for combustion, resulting in the destruction of the ammonia on the path to recovery of the sulphur. Other emissions (NOx, CO, CO_2, PM10) are also increased by the processing of SWS gas in the SRU. Bechtel's SWSPlus® technology can be used to separate the ammonia and hydrogen sulphide into separate streams, which enables a high-value, low CI, saleable ammonia product plus a cleaner feed to the SRU.

History

SWSPlus was originally known as WWT when first developed by Chevron in the 1960s. It is a two-column SWS where the first column produces a high concentration H_2S + CO_2 stream and the second column produces a high concentration NH_3 stream which can be further purified for sale. The process was patented in 1967 and the first unit was licensed outside of Chevron the very next year. In 2011, the process technology was sold to Bechtel Energy Technologies & Solutions, Inc. (BETS). When any technology has been around for that long, putting a new set of eyes on it will invariably allow for improvements. The first improvements were awarded patents in 2018 (prompting a rebranding as SWSPlus) and there are now a total of four patents issued with three others pending. In various ways, they focus on capex, opex, and product purity.

At the time of writing, there are a total of 27 licensees of the technology, most recently at a biorefinery in the Los Angeles, California, area, where the relatively small amount of acid gas could not be flared due to strict environmental regulations. Instead, SWSPlus recovered the NH_3 and another home was found for the H_2S in the refinery. Thus, SWSPlus acted as an enabling technology for the project.

Isn't ammonia dangerous?

A frequent query received when discussing the technology is around the safety of handling NH_3. The answer is that yes, it is dangerous, as are H_2S, propane, octane, and benzene. Do you have those in your refinery? Table 1 shows the relative values for LEL, autoignition temperature, minimum ignition energy, and two US-based exposure limits for workers (8-hr TWA and 15-min STEL).

The table shows that the LEL, autoignition, and minimum ignition energy values for NH_3 make it a safer chemical than the counterparts. It is only when compared to health hazards that propane and 100 octane become less hazardous. The 15 minute STEL for propane is not listed as it becomes an asphyxiant before becoming a toxin.

Global warming potential

GWP100 is the phrase used to describe the global warming potential over the course of 100 years for a given chemical process. Sphera, a third party consultant, was hired by a potential licensee to evaluate the GWP100

Table 1: **Relative hazards of commonly found refinery chemicals**

	H_2S	Propane	100 Octane	Benzene	NH_3
LEL, vol-%	4.3	2.2	1.4	1.2	**15**
Autoignition temperature, °C	232	480	246	560	**651**
Minimum ignition energy, mJ	0.068	0.25	8.2	0.2	**680**
8-hr TWA (USA), ppmv	10	1,000	300	1	**20**
15 min STEL (USA), ppmv	15	–	500	5	**50**

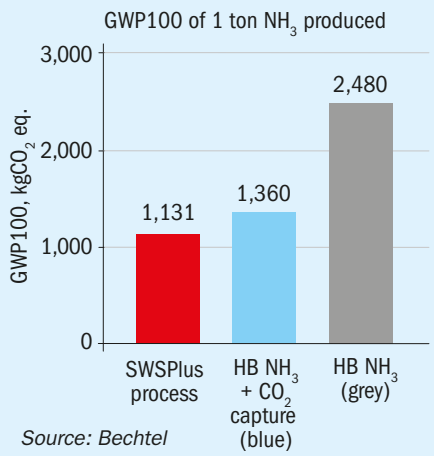
Source: Bechtel

of SWSPlus compared to the Haber Bosch process, which is the worldwide standard for production of NH_3 from natural gas and air.

The study considered an incremental tonne of NH_3 from an existing Haber Bosch facility against an incremental tonne of NH_3 from a refinery using SWSPlus. Specifically, the values for steam, electricity, caustic (used in the purification process), sulphur recovered, and ammonia recovered came from BETS for the SWSPlus process and the GaBi database for the Haber Bosch process. For clarity, steam changes in the SRU were considered in the study.

Fig. 1 shows the results were a 54% lower GWP100 vs "grey" NH_3 and 17% lower than "blue" NH_3. If a refinery is being pushed to be more environmentally friendly in the form of GWP100 or carbon intensity, then SWSPlus is a valuable addition.

Fig. 1: **Global warming potential comparison**



Source: Bechtel

Benefits of NH_3 removal

Integration of SWSPlus into a refinery allows processing of higher nitrogen and higher sulphur crudes without SRU expansion. It also mitigates the potential of ammonium polysulphide salt deposition in the SRU and increases SRU capacity. It adds NH_3 as a revenue stream for the facility and can do so at half the capex expenditure compared to an additional SRU train (Claus, TGTU, Degassing, Thermal Oxidiser). Best of all, no new air permit is required for anhydrous ammonia recovery!

The chemistry benefits of NH_3 removal from a refinery Claus unit are well documented elsewhere and so will not be repeated here, except to summarise by saying removing one tonne of NH_3 can make room for processing approximately three tonnes of H_2S in the Claus unit.

Process walk-through

There are typically four steps in processing: feed preparation, acid gas stripping, ammonia stripping, and finally purification/liquefaction. Fig. 2 shows a sketch of the first three steps of the SWSPlus process.

Step 1: Feed preparation

Sour water from the refinery is typically generated at medium to high pressures in contact with various hydrocarbons. When released to a lower pressure for storage in an atmospheric tank, lighter hydrocarbons along with some H_2S and NH_3 will be released, so the first destination of sour water is a degassing vessel. Flashed vapours are sent to flare or a sour gas recovery system. The liquid is sent to a deoiler, which makes the first attempt at removing free hydrocarbon phases from the sour water. The sour water is then sent to at atmospheric storage tank for process stabilisation, feed homogenisation, and surge capacity.

Step 2: Acid gas stripping

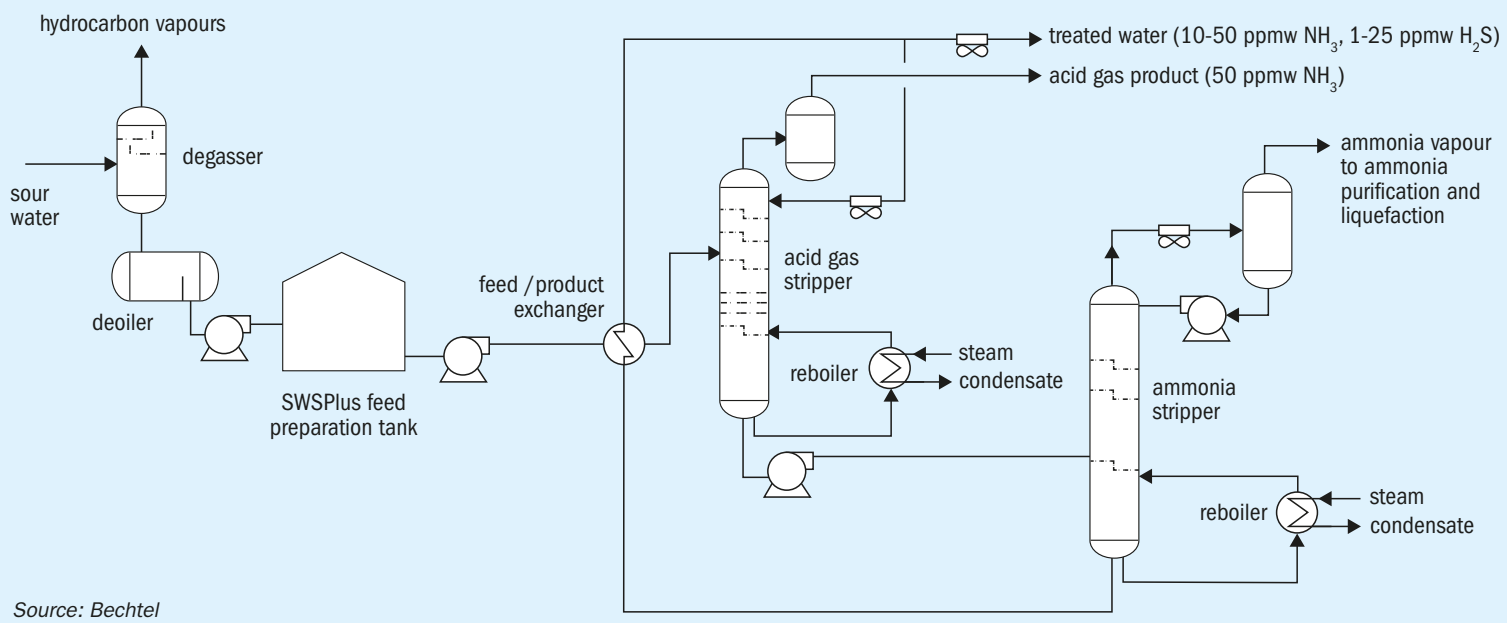
The sour water is pumped through some heat integration with the ammonia stripper's bottoms stream before being sent to the first distillation column, the acid gas stripper. The acid gas stripper is a reboiled distillation column. It does not generate enough water overhead to make its own reflux, so a water wash is used instead.

Note this is not the same chemistry which occurs in a traditional SWS – simply breaking an acid-base bond and creating steam to carry it upward. In an acid gas stripper, multi-component distillation occurs. Here, we want to let the H_2S (and any CO_2 present) escape as vapours through the top of the acid gas stripper but keep the ammonia in the aqueous phase. SWSPlus technology keeps NH_3 in the resultant acid gas to under 50 ppmw, resulting in a high purity H_2S stream, which is perfect for feeding to a Claus unit or sulphuric acid unit.

Step 3: Ammonia stripping

From the acid gas stripper, the process water is sent to the ammonia stripper, which operates at a significantly lower pressure than the acid gas stripper.

Fig. 2: **First three steps of the SWSPlus process**



Source: Bechtel

This column is a reboiled and refluxed distillation column whose liquid product is stripped water. That stripped water will contain typical levels of NH_3 compared to a SWS, for example, 50 or 25 or 10 ppmw, as desired. H_2S is typically single digit ppmw or less. The vapour product contains ammonia in a highly concentrated stream (90+%) along with any H_2S not removed by the acid gas stripper.

Step 4: Purification/liquefaction

The potential dispositions of the NH_3 are incineration, anhydrous ammonia (via either compression or refrigeration), and aqueous ammonia. Fig. 3 shows the purification and liquefaction steps which may be used to render the NH_3 recovered from the ammonia stripper saleable. The ammonia can also be used to generate heat or power by combusting the NH_3 in an incinerator with appropriate heat/energy recovery.

Case study

As a case study, consider a facility which processes 500 US gpm of sour water in a single SWS. It has 1,000 ppmw NH_3 and 2,000 ppmw H_2S with typical values of contaminants such as CO_2, mercaptans, and hydrocarbons. An expansion opportunity presents itself wherein recovery of ammonia would offset an increased Claus SRU load. For simplicity, assume the total sour water load remains constant, while noting mild to moderate increases in flowrate would only help the economics of the project.

The objectives are to reuse the existing asset (the SWS), add a revenue stream, and do so while being mindful of the carbon intensity of the facility.

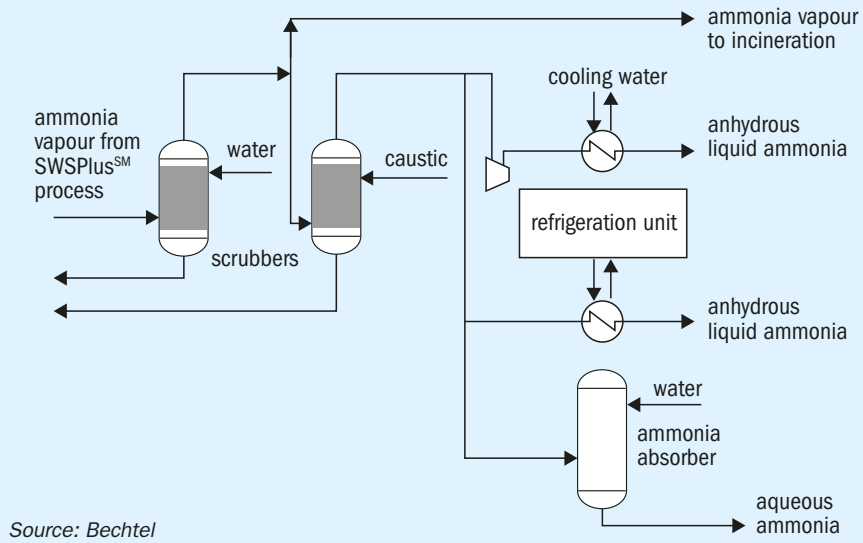
In considering reuse of the existing column, many refiners desire to use it as the first of two in a SWSPlus. This is not normally possible considering the higher temperatures and pressures required in the acid gas stripper. There are various mechanical issues that result, not to mention the different diameter requirements at the higher pressures. In addition, metallurgical requirements are different in the acid gas stripper.

However, if repurposed as an ammonia stripper (that is, the second column in a SWSPlus) then the SWS column does well. The existing column operating temperature and pressure can be left as-is. In that case, the only chemistry change is a composition with less H_2S and CO_2. In an SWSPlus unit, most of the H_2S and CO_2 are removed by

PHOTO: BECHTEL

A refinery SWSPlus unit.

Fig. 3: **The purification and liquefaction steps of SWSPlus**



Source: Bechtel

the acid gas stripper, so the partial pressure of H_2S would be significantly reduced in the repurposed ammonia stripper. From a metallurgy perspective, it is a friendlier application than the original design.

If wall thickness measurements indicate the temperature and pressure can be modified to improve performance, then that means:

- potentially higher capacity;
- more efficient purification steps;
- lower utility costs in those steps;
- more efficient compression (lower hp).

In this case study, changes in existing asset operating pressure are not considered.

SWS equipment reuse considerations

In maximising the reuse of existing assets, and assuming similar overall sour water flow, the same degassing drum and pumps, the same feed preparation tank, the same column (as the ammonia stripper), and the same feed/bottoms exchanger will be used. There is notable optimisation to be done regarding trays vs packing and potentially increasing the duty of the feed/bottoms exchanger vs steam prices, both of which are application specific.

Results

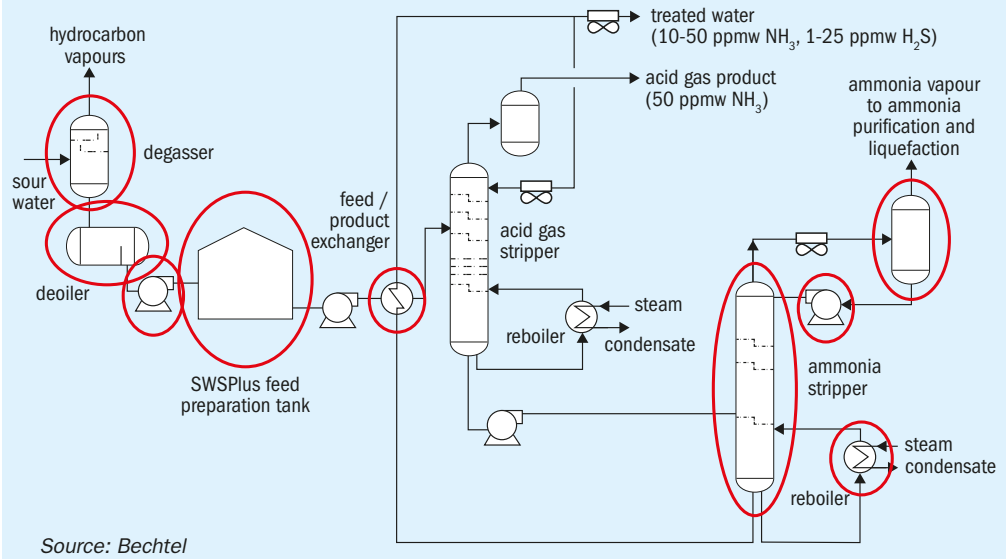
In this example, Fig. 4 identifies which parts of the SWSPlus are repurposed. As can be seen, only two of the existing pieces of equipment (charge pump and overhead cooler) could not be reused. Put another way, almost half of the equipment required for ammonia recovery and purification can be reused from an existing SWS. The most expensive item, the column, is reused.

Table 2 provides representative information regarding equipment and utilities. All equipment successfully reused is labelled “Acceptable”. The acid gas stripper operating pressure increases the horsepower requirement of the charge pump and stripped water pump. The overhead duty of the ammonia stripper also increased.

Regarding utilities, Table 3 shows MP steam is required due to the operating temperature of the acid gas stripper’s reboiler. Because of the low quantity of H_2S in the ammonia stripper, that reboiler duty actually decreases. The electrical requirement significantly increases, primarily due to the addition of compressors to make anhydrous ammonia via compression. If aqueous ammonia is desired, the power consumption is typically $^2/_3$ this value.

Plot and capex are significant concerns in any revamp. Based on full spacing requirements, the required plot can increase by 50% compared to the original SWS. Note the columns can be remote from each other. This excludes tankage, of course, and full spacing requirements are frequently compromised during retrofits. Capex requirements relative to a grassroots SWS are about 2.1 times the cost, that is to say, an SWSPlus unit is around 3.1 times the cost of a stand-alone SWS. Put another way, this approach is about 30% less than a new SWSPlus.

Fig. 4: **Reused equipment**



Source: Bechtel

Table 2: **Evaluation of existing equipment**

Existing equipment	SWS	SWSPlus
Feed degassing drum	4.5 x 17	Acceptable
Transfer pump, hp	23	Acceptable
Feed preparation tank, kgal	720	Acceptable
Charge pump, hp	50	90
Feed/bottoms exchanger, MMBTU/hr	31	Acceptable
SSW cooler, MMBTU/hr	6.4	Acceptable
SWS column	6.0 x 87	Acceptable
SWS column internals	Trays	Acceptable
Overhead cooling duty, MMBTU/hr	23	46
Reflux pump, hp	3	Acceptable
Reboiler, MMBTU/hr	35	Acceptable
Bottoms pump, hp	48	81

Source: Bechtel

Table 3: **Comparison of utilities**

Incremental utilities	SWS	SWSPlus
MP steam, k lb/hr	0	26
LP steam, k lb/hr	40	37
Electricity, hp	145	638

Source: Bechtel

Conclusions

SWSPlus is a proven technology with a lower GWP100 than Haber Bosch ammonia production. It expands SRU capacity by removing NH_3 from the feed and adds that NH_3 as a revenue stream to the refinery. SWSPlus can be retrofitted to an existing SWS if plot is available, even remotely, and capex is 30% less than a grassroots SWSPlus.

Enhancing sulphuric acid production

In this case study, **Florian Kistl** of CS Combustion Solutions presents a comprehensive strategy for the capacity enhancement and optimisation of a sulphuric acid production plant that was facing several operational challenges that were hindering its efficiency and reliability. As a result of a series of targeted optimisations, including the innovative use of ultrasonic nozzles and CFD modelling, downtime and maintenance costs were reduced, and a substantial capacity increase was achieved.

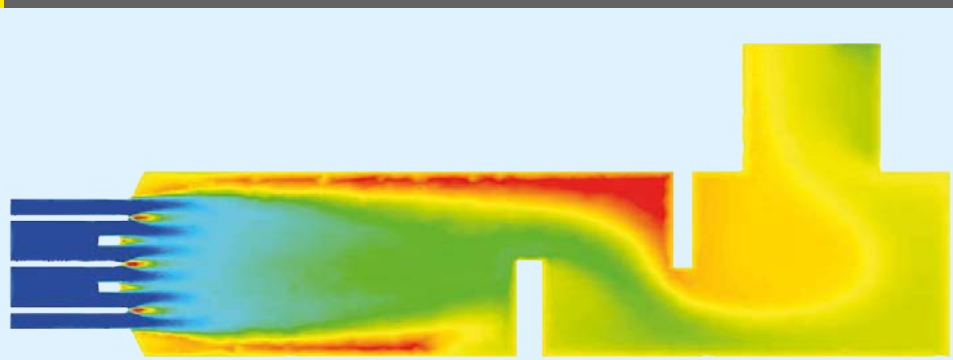
Sulphuric acid production is a critical process in various industrial sectors. This particularly applies to mining, where H_2SO_4 is extensively used for a wide range of applications. In the mining industry, H_2SO_4 plays a pivotal role in processes such as leaching of copper, cobalt and precious metals. In this beneficiation process it is used to extract these metals from their ores. Additionally, it is used in the production of phosphoric acid, which is essential for manufacturing fertilisers, and in the descaling of equipment to remove mineral deposits, ensuring the smooth operation of mining machinery.

As demand for sulphuric acid continues to rise across these industries, plants must find ways to increase output while minimising operational expenditures (opex) and maintenance requirements.

This article discusses a case study involving a sulphuric acid plant located in the African Copperbelt region, where significant upgrades have been implemented to boost production capacity from 2,200 t/d to 3,000 t/d. The measures taken by CS Combustion Solutions, including the use of ultrasonic nozzles and advanced combustion technologies, played a pivotal role to support the plant in achieving these goals.

Fig. 1: Ultrasonic atomisation nozzle

Fig. 2: **Temperature distribution inside furnace before revamp**



Source: CS

Challenges before optimisation

The sulphuric acid plant faced several issues that hindered its performance and efficiency. These challenges included incomplete combustion of sulphur, leading to sulphur droplets reaching the waste heat boiler (WHB) ferrules and catalyst beds. This not only caused fouling but also increased the overall pressure drop, causing unplanned shutdowns for cleaning and maintenance. The previously used pressure atomisers contributed to these problems by causing frequent nozzle plugging, which required costly and time-consuming replacements. Additionally, the plant's refractory lining suffered from hot spots, which most likely are also caused from bad atomisation quality.

Together with the plant management, CS identified the following key challenges:

Incomplete combustion due to pressure atomisers: Resulting in sulphur droplets contaminating downstream equipment (fouling).

Nozzle plugging and wear: Frequent stoppages due to nozzle issues, increasing downtime.

Pressure drop and overheating: Inefficient combustion, high droplet size and inappropriate refractory design leading to operational inefficiencies and hot spots.

High maintenance costs: Frequent part replacements and the inability to perform maintenance without stopping production, increased operational costs. According to operators data the consumption of nozzle tips and guns summed up to > $200,000 in less than two years of operation.

Uneven temperature distribution: Chamber design and pressure atomiser principle led to hot spots and overheating of the outer shell (see Fig. 2)

CS Combustion Solutions' approach

To address these issues, CS Combustion Solutions proposed and implemented a comprehensive revamping and optimisation strategy. The key measures included:

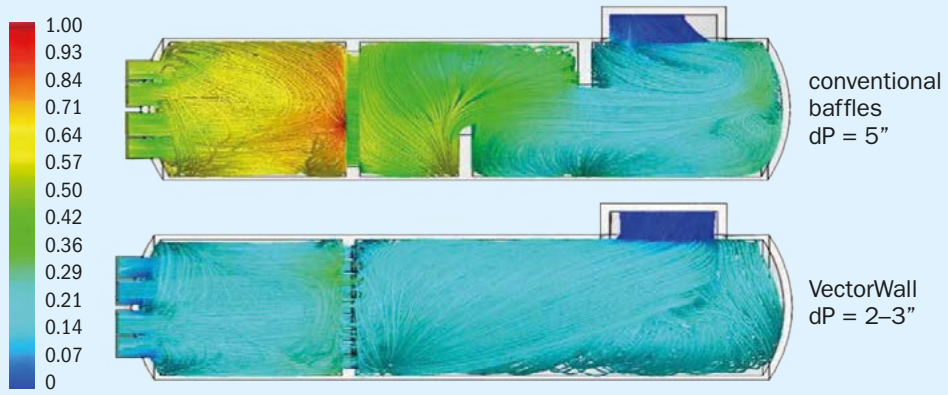
Ultrasonic nozzle atomisation: The replacement of traditional pressure atomisers with ultrasonic nozzles significantly improved the atomisation quality. The droplet size could be reduced from 400 µm to 110 µm, enhancing the efficiency of sulphur combustion and minimising the risk of fouling in the waste heat boiler and catalyst beds as well as wear on the refractory material

Swirl bodies for enhanced combustion: The introduction of swirl bodies into the combustion system induced rotational motion in the combustion air. This modification promoted optimal flame formation, resulting in more efficient and complete combustion of sulphur and oil (in start-up case).

Single vector wall installation: The originally installed baffle walls, which introduced insufficient turbulence and increased the overheating effect caused by bad atomisation quality, were replaced with a single vector wall. This innovation ensured superior mixing within the combustion chamber, preventing unreacted sulphur from carrying over into downstream processes (see Fig. 3).

Computational fluid dynamics (CFD) study: A CFD study was conducted to calculate, visualise, and optimise the proposed changes before their implementation. This step was crucial, ensuring that the modifications would yield the desired improvements in performance and reliability. Fig. 4 shows the temperature distribution inside the furnace after the CS revamp.

Fig. 3: **Reduction of pressure drop and improved mixture**



Source: CS

Results and benefits

The implementation of these measures led to significant improvements in plant performance and operational efficiency. The most notable outcomes included:

Increased production capacity: The plant's capacity was successfully increased by 30%. This resulted in the incineration of 40 tonnes of sulphur per hour, corresponding to 3,000 t/d of sulphuric acid.

Improved maintenance flexibility: The ability to change out sulphur guns during operation without shutting down the plant resulted in reduced downtime and higher overall productivity.

Enhanced combustion efficiency: The use of swirl bodies and ultrasonic nozzles improved SO_2 conversion time, leading to more complete combustion and lower emissions despite reduced residence time after capacity increase.

Reduced pressure loss: The new combustion chamber design with the vector wall significantly reduced pressure loss, leading to opex savings on blower operations by $160,000/year.

Elimination of hot spots: The improved and controllable atomisation angle of the ultrasonic nozzle prevents big sulphur particles on the refractory, enhancing the operational life time and safety of the furnace.

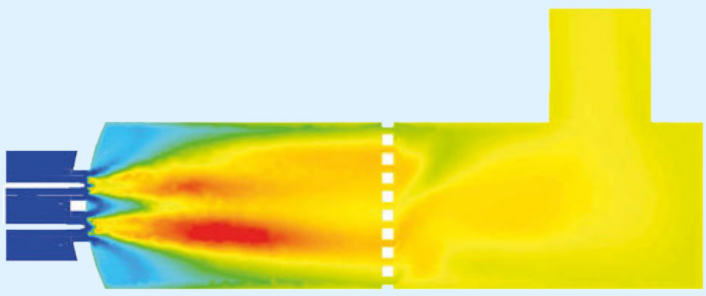
These improvements not only enhanced the plant's operational efficiency but also reduced the frequency of unplanned shutdowns, resulting in substantial cost savings. The strategic use of advanced combustion technologies and thorough pre-implementation analysis provided a robust framework for optimising sulphuric acid production.

Fig. 5 shows the relation between droplet size and time needed for conversion for sulphur to sulphur dioxide.

Conclusion

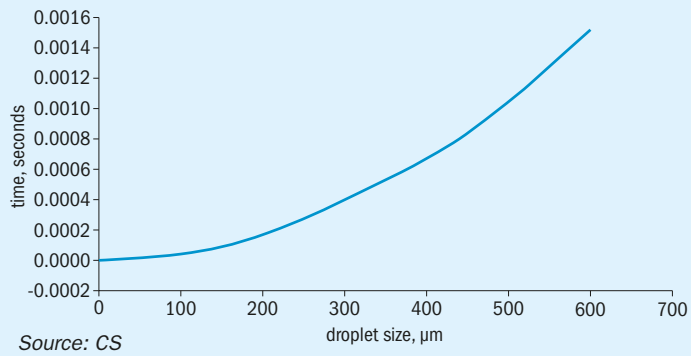
This success story can provide valuable insights for similar facilities facing comparable challenges. It underscores the importance of high atomisation quality/low droplet size to minimise stress on downstream equipment. Ultrasonic nozzles by CS Combustion Solutions are a quick and easy upgrade on existing furnaces.

Fig. 4: **Temperature distribution inside furnace after CS revamp**



Source: CS

Fig. 5: **Relation between droplet size and time needed for conversion of S to SO_2**



Source: CS

Channelling in SRU converters

Abhilash K. A., M Venkata Sudhakar, Pavan Kumar R (Bharat Petroleum Corporation Limited) and V. Kamesh Jayanthi (Engineers India Limited)

This troubleshooting case study describes an incident at one of the sulphur recovery units at BPCL Kochi Refinery, India. Following a maintenance turnaround of the unit in 2022, unusually high H_2S and SO_2 were observed at the outlet of the Claus section. This created an additional load on the tail gas reactor, which led to frequent plugging in the quench column and frequent outages in the tail gas unit, creating environmental and reliability issues in the unit. The activities to identify the root cause of the incident are described and the measures to solve the problem are shared.

Design basis

Bharat Petroleum Corporation Limited (BPCL) Kochi Refinery has three sulphur recovery units SRU1 (140 t/d), SRU2 (80 t/d) and SRU3 (2 x 337 t/d). SRU3 has two identical trains (Train A and Train B) consisting of a Claus section, tail gas treatment unit (TGTU) and thermal oxidiser with a common amine regeneration facility (see Fig. 1). SRU3 is designed to process acid gases from the amine regeneration unit and sour gases from the phenolic sour water units (SWS1) and non-phenolic sour water units (SWS2) with a design sulphur recovery of 99.9% (min).

Table 1 shows the design basis of the SRU Claus section and Table 2 shows the design conditions of the TGTU.

Background

SRU3 Train A and B were shut down for maintenance and inspection (M&I). All equipment was opened and inspected, planned M&I jobs were completed and catalyst was replaced in all converters including the TGTU reactor. SRU3 converter 1 contains one layer of activated alumina and another layer of titania-based catalyst. Converter 2 contains only activated alumina.

Post turnaround observations

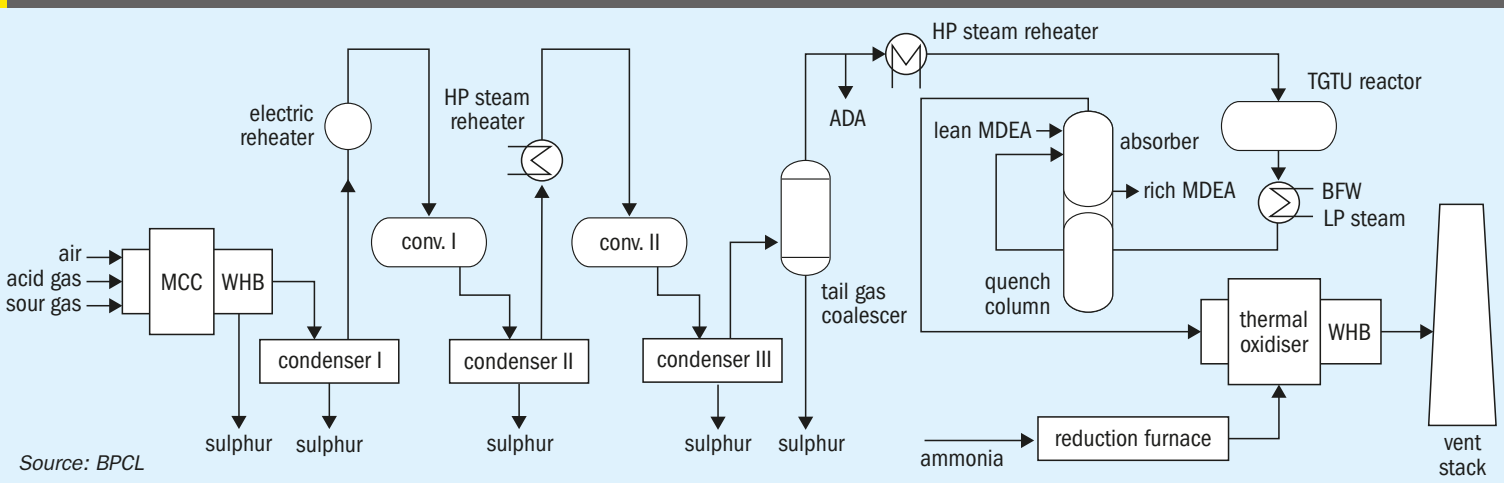
Post turnaround, the unit was taken back in line in the third week of October 2022. SRU3 Train B had higher molar concentrations of H_2S and SO_2 observed at the air demand analyser (ADA). As shown in Table 3, there was a significant deviation

Table 1: **Catalyst testing conditions**

Component	Acid gas from ARU	Sour gas from SWS1	Sour gas from SWS2	NH_3 gas from SWS2	Recycle from TGTU
H_2S, mol-%	90	30.34	90.47	2.59	96.25
NH_3, mol-%	0.05	32.7	0.02	65.23	
HC*, mol-%	0.29				
H_2O, mol-%	8.66	36.96	9.51	32.18	3.75

Source: BPCL

Fig. 1: **SRU process flow diagram**



Source: BPCL

Table 2: **Design conditions of TGTU**

Component	Design case composition	Check case composition
H_2S, mol-%	1.16	0.76
SO_2, mol-%	0.57	0.38
H_2O, mol-%	36.6	36.96
N_2, mol-%	57.93	57.48

Source: BPCL

Table 3: **Parameters pre and post turnaround of SRU3 Train B**

Parameter	Average pre TA	Average post TA
Acid gas flow, t/h	11.3	10.43
Air flow to MCC, t/h	19.72	19.18
WHB outlet temperature, °C	247	243
Condenser 1 outlet temperature, °C	163	159
Converter 1 inlet temperature, °C	267	269
Converter 1 outlet temperature, °C	299	302
Converter 2 inlet temperature, °C	197	195
Converter 2 outlet temperature, °C	244	220
Coalescer outlet temperature, °C	139	139
H_2S at outlet of coalescer, %	**1.01**	**2.44**
SO_2 at outlet of coalescer, %	**0.29**	**0.59**
Converter 1 ΔT, °C	32	33
Converter 2 ΔT, °C	47	25

Source: BPCL

from the normal operation which forms the basis of this article and the troubleshooting undertaken to resolve the issues.

Additional observations were as follows:

- SO_2 checked with Dräger tubes at the TGTU reactor outlet was always < 1.5 ppm (indicating no SO_2 slippage).
- Minimal ammonia injection to the quench column had to be kept (previously always closed) to maintain the pH in Train B quench water.
- Sulphur vapour differential in the ADA measured at the TGTU inlet was found to be around 0.0075 wt-% both before and after the turnaround – indicating no additional carryover of sulphur vapour to the TGTU.
- A yellow sulphur layer was observed at the quench column inlet line during isolation. Gray colour colloidal sulphur is present in the quench column packings.
- Post turnaround, quench column plugging was observed frequently leading to outages.
- The Claus converters outlet temperature was lower than the last bed layer temperature.

Troubleshooting

The troubleshooting carried out to investigate the issue is listed below.

General actions recommended by catalyst vendor

- The air demand ratio (H_2S to SO_2) was varied from ~ 2 to 4, but SO_2 was always >0.65 mol-%.
- Strawman sample points de-plugged in condenser 1 (inlet and outlet) and sample showed higher H_2S than design.
- ADA action tuned by instrument personnel.
- Ammonia from cylinders / caustic of 5% strength were used separately to maintain the pH in the quench column to avoid contamination from the ammonia stream on a trial basis.

Air demand analyser (ADA) calibration

During this period, the ADA was calibrated several times and found to be okay. The analyser readings were cross-checked by testing gas samples in the lab and using Dräger tubes. Both methods showed similar values, indicating that a faulty ADA could be ruled out.

Input streams to the quench column

No slippage of SO_2 from the TGTU reactor was observed but the quench column pH was dropping. DM water was analysed, and no acidic components were present.

Coalescer performance

It was suspected that sulphur was slipping from the tail gas coalescer to the TGTU. The differential pressure (DP) transmitter across the demister was faulty providing no reliable information about the condition of the demister inside the coalescer. Given the unit's history of demister failure, inspecting this demister was deemed critical for identifying the root cause. The tail gas coalescer was later opened during a shutdown opportunity and the demister was found to be in intact condition. The connected spare and main sulphur run-down lines were checked, and no plugging issues were detected.

Converter performance

The temperatures across the converter beds indicated normal activity in both SRU Train A and B converters, which was also confirmed by the catalyst vendor during on-site evaluation. The catalyst vendor recommended online catalyst rejuvenation to enhance the catalyst performance. The converter 1 inlet temperature was increased to 285°C from 260°C and the converter 2 temperature was increased to 220°C from 195°C keeping the bed outlet temperatures below 355°C for converter 1. These conditions were maintained for 12 hours. The TGTU reactor inlet temperature was increased to ~ 240°. However, this catalyst rejuvenation did not resolve the downstream quench column plugging issues.

Licensor study and recommendations

The TGTU licensor also analysed the data to identify the root cause and couldn't firmly conclude the reason. Engineers India Limited (EIL), SRU licensor, was entrusted with conducting a detailed analysis of the problem. EIL conducted test runs on 27 and 28 September 2023, simulated the data and identified that low conversion in SRU3 Train B is due to channelling of acid gas in the converters. Various cases had been considered for matching the plant converter bed temperatures and air demand analyser values.

No channelling case simulation study of converters

For an inlet temperature of 271°C, the simulated bed temperature would be approximately 334°C. However, plant data shows the bed temperatures are near 328°C. This means the process gas temperature at the inlet of converter 1 is approximately 264°C as per the simulation (see Fig. 2).

For an inlet temperature of 195°C in converter 2 and with no issues of channelling in converter 1, the bed temperatures would be approximately 225°C. However, plant data shows the bed temperatures are near 238°C (see Fig. 3).

Loss in catalyst activity

Considering that the catalyst has been loaded just one year before, it can be considered as relatively fresh catalyst. Also, as there is an exotherm in both converters, the case of loss in catalyst activity has been ruled out.

Effect of channelling

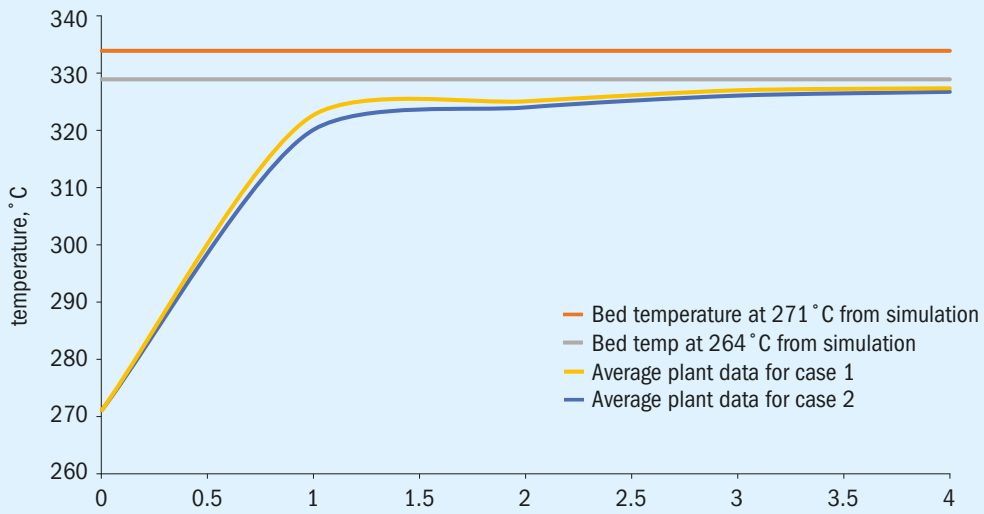
Various bypass fractions have been considered and it has been observed that with approximately 25% of bypass in both converters, ADA values and converter 2 bed temperatures match plant data (see Fig. 4).

Post this simulation study EIL gave the following observations and recommendations:

- Channelling in both converters in Train B was predicted.
- Both Claus converters in SRU Train B to be opened for inspection.
- After inspection, catalyst and support balls to be unloaded from both reactors and mesh to be reinstalled as per recommendation and catalyst to be reloaded:
  - One layer of wire mesh between the grating and support balls with proper overlap and fixed to the first strip plate. A floating wire mesh i.e. not connected to the converter wall, between the support balls and catalyst is provided.
  - Catalyst support balls to be loaded up to 100 mm height on wire mesh and catalyst to be loaded above the support balls as per PDS requirement.
  - Gap between refractory and wire mesh to be filled with ceramic rope around the periphery of wire mesh.

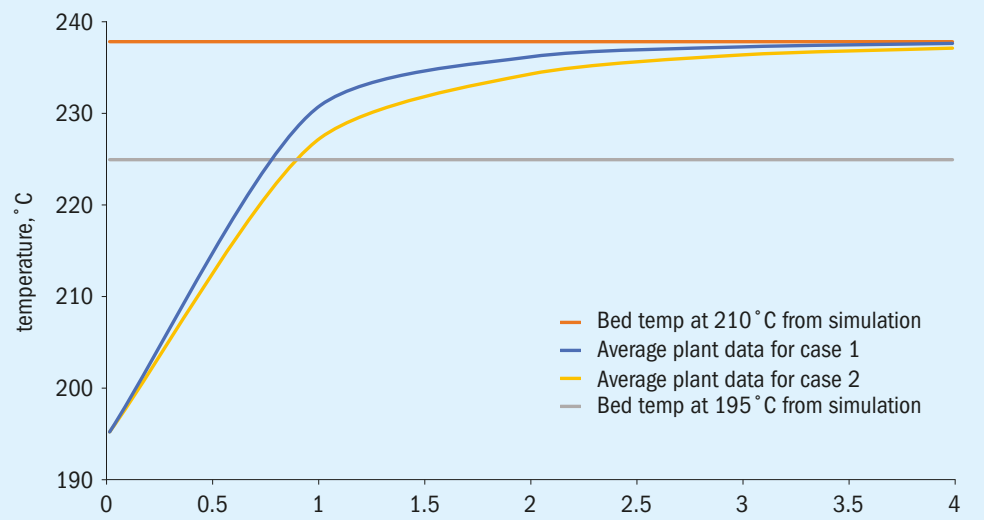
Based on EIL's recommendations, Train B SRU was shut down for converter mesh modifications in February 2024.

Fig. 2: **Converter 1 simulation**



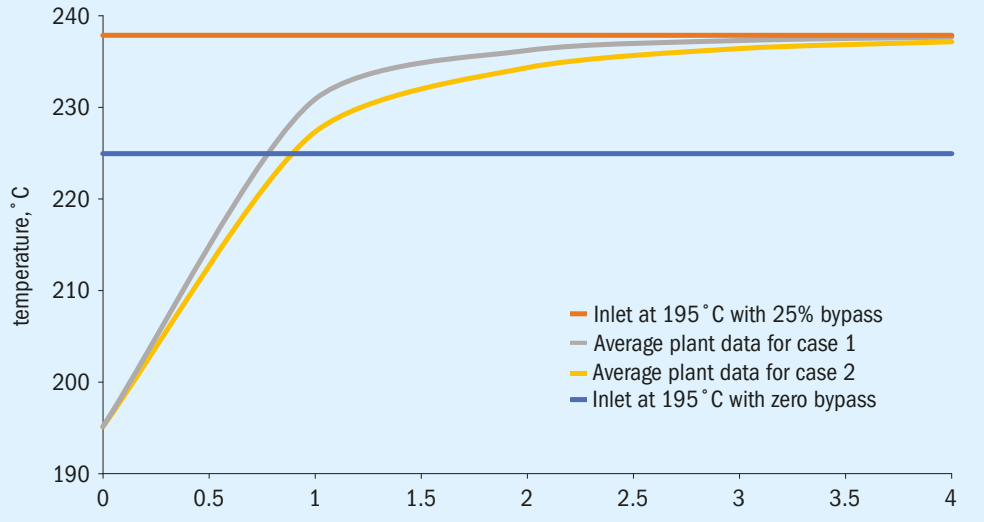
Source: BPCL

Fig. 3: **Converter 2 simulation**



Source: BPCL

Fig. 4: **Converter 2 performance with 25% bypass in converter 1**



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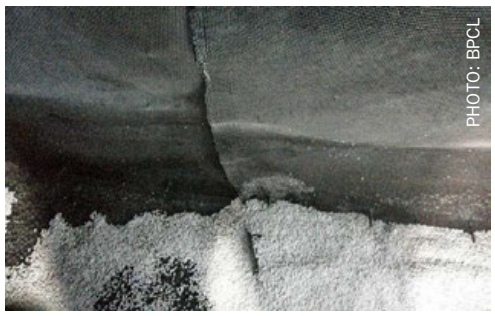


Fig. 5: Loose mesh near bottom grid

Fig. 6: Pit near mesh-catalyst interface

Fig. 7: Loose mesh near bottom grid

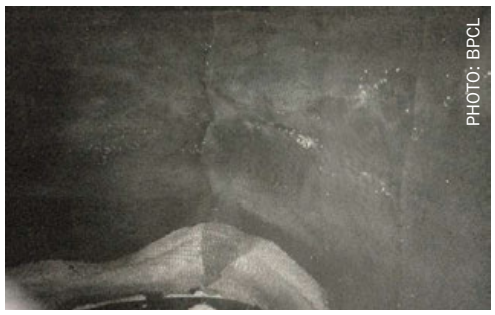


Fig. 8: Loose mesh on refractory wall

Fig. 9: Bottom grid after mesh modification

Fig. 10: After loading ceramic balls

Observation

After opening the converter, it was observed that the bed profile was flat, which infers that there was no undulation due to maldistribution of feed gas. Also, it was observed that at multiple locations around the perimeter, where catalyst touches the mesh, catalyst had caved in and pit-like structures had formed. From these locations, it is understood that gas is bypassing the catalyst bed. Also, after catalyst unloading, it was observed that the gap between the mesh and the refractory wall was significant enough for process gas bypassing the catalyst (see Figs. 5-8).

Post mesh modification

The existing mesh has been completely removed in SRU3 Train B converters, re-laid extending up to 200 mm from the support grid as shown in Figs. 9 and 10. A layer of mesh has been laid between the ceramic balls and the catalyst for easy unloading and separation. The mesh has been fixed with studs welded to the retainer plate. A mesh partition has been provided between the ceramic balls and the remaining catalyst layers without fixing the mesh to the refractory wall. This aids unloading of alumina/titanium based catalyst without mixing with ceramic balls.

Table 4: **Summary of mesh modification**

Parameter	Pre mesh modification	Post mesh modification
H_2S, %	1.76	0.55
SO_2, %	**0.54**	**0.2**
ΔT across converter 1, °C	43	64
ΔT across converter 2, °C	31	14
Converter 1 last layer temperature, °C	327	326
Converter 1 outlet temperature, °C	299	324
Converter 2 last layer temperature, °C	245	226
Converter 2 outlet temperature	231	224
Converter 1 / 2 bypass pre-modification, %	**~ 32 / 25**	**0 / 0**

Source: BPCL

Impact of mesh modification on converter efficiency

Following the mesh modification, H_2S and SO_2 levels at the TGTU reactor inlet had reduced (see Table 4). The improvements can be summarised as follows:

- Reduction in H_2S and SO_2 levels: H_2S and SO_2 values reduced to 0.5 mol-% and 0.25 mol-% compared to previous values of 2 mol-% and 0.65 mol-% respectively.
- Differential temperature indications: The increase in ΔT across converter 1 and the decrease in ΔT across converter 2 indicating no channelling in converters.
- No plugging issues across the quench column in TGTU.

Conclusion

Activities carried out to identify the root cause of high SO_2 and H_2S at the outlet of the Claus section revealed that channelling of the Claus converter was the critical issue. Post mesh modifications in SRU3 Train B converters were carried as per licensor recommendations. The following results were observed:

- SRU Claus section efficiency increased from 93% to approximately 96%.
- SO_2/H_2S load to tail gas treatment section reduced by 50%.
- No quench column plugging issue observed in TGTU Train B.
- Approximately 30% reduction in hydrogen consumption in TGTU Train B.
- Reduced stack SOx emissions.

Real-time SO_2 leak detection

Optical gas imaging technology, enhanced by artificial intelligence, offers a groundbreaking approach to monitoring SO_2 emissions in real time. **Andrés Russu** of SENSIA introduces SENSIA's RedLook solution which offers fully autonomous, 24/7 continuous monitoring of SO_2 leaks, providing industries with the tools they need to maintain environmental integrity and operational safety.

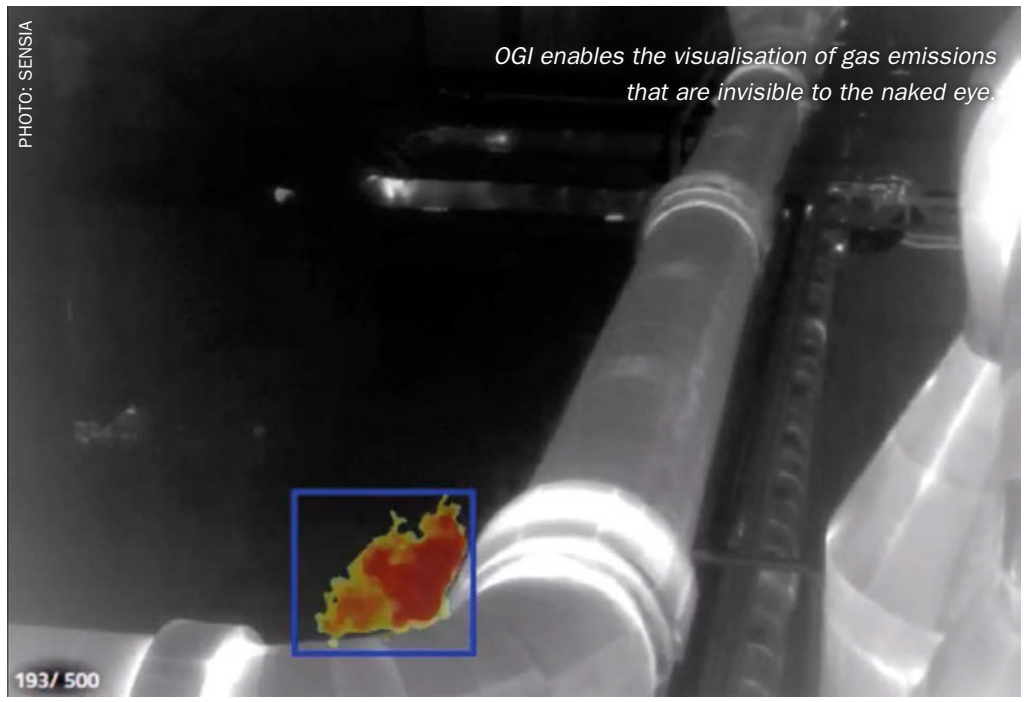
In an era where industrial operations in modern economies are at risk due to their environmental impact on surrounding communities, it is critical to implement technological solutions that promote sustainability in heavy industries so that they can continue contributing to economic prosperity. One of the most significant environmental impacts comes from the effect of pollutant gas emissions on air quality. Among these gases, sulphur dioxide (SO_2) stands out due to its significant contribution to local air contamination and acid rain. Real-time detection of SO_2 leaks is paramount for ensuring air quality and compliance with stringent environmental regulations. Optical gas imaging (OGI) technology, enhanced by artificial intelligence (AI), offers a groundbreaking approach to monitoring SO_2 emissions, providing industries with the tools they need to maintain environmental integrity and operational safety.

Optical gas imaging: How infrared works

OGI is a powerful and established technology that enables the visualisation of gas emissions that are invisible to the naked eye. OGI leverages infrared (IR) imaging where a spectrally tuned camera sees the thermal radiation emitted or absorbed by objects and gases and transforms this radiation into visible images. In the case of SO_2, which absorbs IR radiation at a sub-band within the long wave infrared (LWIR) spectrum, OGI cameras can detect and visualise the presence of gas emissions, providing real-time insights into leak sources. OGI cameras allow operators to see gas leaking

PHOTO: SENSIA

OGI cameras are particularly valuable in industrial sites where SO_2 emissions need to be closely monitored.



OGI enables the visualisation of gas emissions that are invisible to the naked eye.

from compressors, pipelines, pumps, flanges and other industrial equipment. This visual representation of gas emissions is crucial for rapidly identifying leaks, already a standard in the oil and gas industry for the detection of methane and hydrocarbons in leak detection and repair (LDAR) campaigns. SENSIA OGI technology can also quantify the gas leak size, enabling industries to make informed decisions in terms of maintenance, and subsequently address it.

Sulphur dioxide and detection with IR

Sulphur dioxide is commonly produced in essential industrial processes such as metal smelting and the production of sulphuric acid. It is a significant pollutant, contributing to respiratory and cardiovascular illness in humans and forming acid rain, which can have devastating effects on ecosystems and infrastructure. The detection of SO_2 is critical not only for environmental protection but also for the safety of industrial facilities and surrounding communities.

The ability of SO_2 to interact with IR radiation makes it detectable by OGI cameras. These cameras are designed to be sensitive to the specific wavelengths at which SO_2 absorbs and emits radiation, allowing for the precise identification and visualisation of SO_2 leaks. This capability is particularly valuable in industrial sites where SO_2 emissions need to be closely monitored to prevent environmental contamination and ensure compliance with regulatory standards.

The danger of poor SO_2 emissions management

Poor management of SO_2 emissions can have severe health, environmental and financial consequences. When released into the atmosphere, SO_2 can react with other compounds to form fine particulate matter (PM2.5), a major component of air pollution that can penetrate deep into the lungs and cause respiratory illnesses, cardiovascular diseases, and other health issues. Additionally, SO_2 can combine with water vapour to form sulphuric acid, leading to acid rain. Acid rain has a corrosive effect on buildings, infrastructure, and natural ecosystems, damaging forests, lakes, soil and heavily damaging equipment near leak sources.

Organisations that fail to adequately control their SO_2 emissions risk not only legal penalties but also the potential for significant environmental damage, harm to public health, and faster deterioration of operational assets. Because of this, most industrialised countries have enacted regulations regarding SO_2 emissions such as the National Ambient Air Quality Standards (NAAQS) established by the Environmental Protection Agency (EPA) in the United States, Directive 2008/50/EC (also known as the Ambient Air Quality Directive) in the European Union and the Gothenburg Protocol internationally, which establish standards and commitments for reducing SO_2 emissions.

Compliance with these regulations is a common challenge for industries operating in sectors where SO_2 emissions are prevalent. Failure to adhere to these standards can result in hefty fines, legal action, and irreparable reputational damage. As such, the ability to accurately monitor and manage SO_2 emissions is a critical component of any industrial operation. SENSIA's RedLook infrared imaging technology provides a tried and tested solution for SO_2 fugitive emission detection.

SENSIA's RedLook technology

SENSIA, a leader in AI-powered infrared imaging technology with systems operating worldwide, has developed RedLook, a comprehensive OGI-based solution designed for 24/7 automatic operation and real-time gas detection among multiple other applications.

During the past few decades, OGI technology has always required human supervision (camera operators) to benefit from its gas detection capabilities. In the current global scene, SENSIA is the pioneer in evolving OGI technology from the past into more complex and advanced systems that allow fully autonomous operation. RedLook's continuous monitoring technology combines computer vision and artificial intelligence to provide automated real-time classification and information on everything of interest to its customers, such as gas detection alarms and gas leak flow rates, the combustion efficiency of flares, early flame detection alarms, monitoring temperature levels of critical components, or controlling intrusions into forbidden areas.

The reliability of the detection provided by RedLook's artificial intelligence algorithms has, in many cases, even surpassed the human observer. Additionally, thanks to its great versatility and interconnectivity with third-party systems, RedLook has become an indispensable technology for industrial plant operators, as it enables preventive maintenance, safety, and environmental compliance strategies without human cost or risk while increasing operational efficiency. RedLook for SO_2 detection utilises cutting-edge OGI cameras, the Caroline FY continuous monitoring OGI for autonomous site scanning in industrial facilities and the portable Caroline Y OGI for field inspections and surveys. These cameras are specifically engineered to detect SO_2 and other industrial gases, providing operators with the tools they need to manage fugitive emissions effectively.

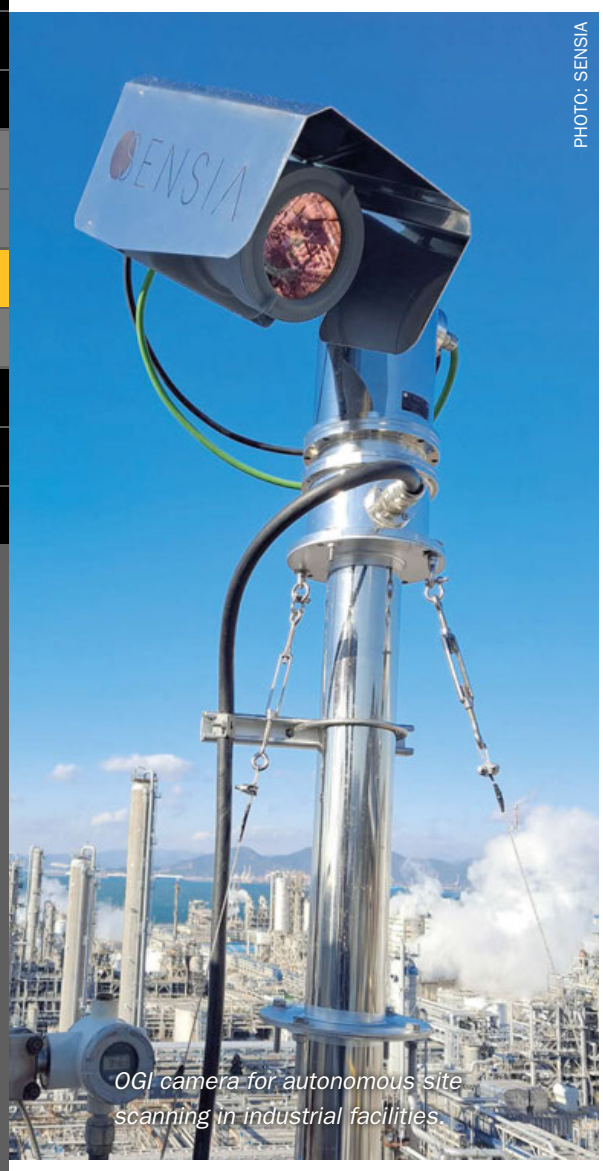


PHOTO: SENSIA

OGI camera for autonomous site scanning in industrial facilities.

A pioneer in infrared imaging

Based in Madrid, Spain, SENSIA has over 15 years of experience in developing innovative infrared imaging technology for gas detection and other industrial cases of use. SENSIA is the IR provider with the highest level of control over its proprietary technology, fully developing the hardware, software and analytics of our solutions, allowing it to offer a very distinctive added value compared to its competitors. SENSIA is always at the forefront in terms of infrared remote monitoring technology and innovation and has recurrently been the pioneer IR manufacturer in the world, providing benefits to the industry such as, but not limited to, the first automated continuous monitoring OGI-based system, the first uncooled handheld OGI camera, the first built-in quantification analytics on handheld OGI, and the first bi-spectral OGI for flare efficiency monitoring. This continuous innovation enables its customers to benefit from a level of performance and reliability that is far superior to other alternatives.

SENSIA specialises in AI-driven solutions for gas detection, but its capabilities also include fire detection, flare efficiency monitoring, intelligent thermography for preventive maintenance, surveillance, and more. With a strong presence in more than 40 countries and a global distributor network, SENSIA has established itself as a trusted provider of advanced imaging technology for industries such as oil and gas, security, defence, and chemical manufacturing.

SENSIA's proprietary solution, RedLook, is designed to meet the diverse needs of its clients, ensuring accuracy, reliability, compliance with regulatory standards and increased safety. The complete RedLook solution is the result of SENSIA's expertise in infrared imaging and AI, offering state-of-the-art, multifunctional systems empowering companies to overcome their HSE challenges.

RedLook solution for SO_2

RedLook is a fully integrated system that combines high-performance continuous monitoring cameras, advanced analytics, and user-friendly software to deliver unparalleled performance in gas detection. The system is designed to be scalable and adaptable, making it suitable for a wide range of industrial applications.

The Caroline Y camera, part of the RedLook solution, is a portable OGI device that allows operators to conduct field inspections and surveys with ease. Its lightweight design and powerful imaging capabilities make it ideal for detecting SO_2 fugitive emissions in remote or hard-to-reach areas. Meanwhile, the Caroline FY camera is designed for autonomous continuous monitoring in industrial facilities, providing real-time video and data on SO_2 emissions and alerting operators to any irregularities.

RedLook's analytics software is powered by physics-guided AI, enabling the system to automatically detect SO_2 leaks with a high degree of sensitivity. The software also generates videos and detailed and automated reports, helping operators to document compliance with regulatory standards and track the effectiveness of their emissions management strategies.

Advantages of RedLook

When compared to traditional gas detection methods such as point detectors, SENSIA's RedLook technology offers several distinct advantages:

- Greater sense of awareness: The high-quality real time IR video can provide a clear understanding of the nature and magnitude of the gas emissions occurring.
- Visual identification and pinpointing of the emission sources that allow more accurate and faster response from the site operators: It is essential for repair efforts to spot the leak source immediately and gain visible evidence of emissions and repair results.
- Faster, real-time monitoring for efficient leak detection: Rather than waiting for concentrations to reach minimum thresholds of point detectors, SENSIA's RedLook can detect leaks immediately as they occur.
- AI-powered analytics for low false alarm rates and immediate alerts: RedLook's powerful artificial intelligence algorithms are based on laws of physics, thousands of data points and scenario-based tuning techniques to provide the must trustworthy solution on the market.
- Remote, long-range detection: Eliminating the need for direct contact with the gas, SENSIA's OGI technology can detect leaks remotely. In addition to this, RedLook eliminates the difficulty/inability of single point detectors to monitor emission sources on elevated locations.
- Multifunctionality: RedLook not just replaces gas sensors, it also replaces flame and perimeter security sensors with the same camera system.
- Wider range of coverage: Customisable lenses and pan-and-tilt features allow our cameras to autonomously scan wide areas of a facility or dynamic locations.
- No dependence on wind direction: Unlike traditional point detectors, RedLook image-based detection can effectively spot SO_2 leaks no matter the wind direction.
- No calibration or replacements required: our intrinsically safe and anti-corrosive systems last over ten years.

Case studies of RedLook technology: Aurubis and Rio Tinto

The adoption of SENSIA's RedLook technology has already yielded impressive results in the field.

For instance, Aurubis, an influential global provider of copper and other metals, has integrated RedLook into its operations to detect SO_2 emissions in real time. The first project became such an internal

success for the company that they decided to extend the solution to a different sector of the plant just a few years after. The purpose of RedLook for Aurubis was to monitor the outflowing SO_2 pipe from the smelting furnace, which crosses near the offices area implying a direct risk for Aurubis personnel in case of an SO_2 leak. To solve this, SENSIA deployed a turn-key project based on RedLook with four continuous monitoring Caroline FY cameras plus three additional units for the second phase. Given the harsh environment in this area of the plant, the cameras, and the rest of the accessory equipment were specially designed using anti-corrosive enclosures with pressurised air systems.

Prior to RedLook, the detection and repair activities of leaking equipment were simultaneously performed during the scheduled maintenance shutdowns of the plant. On many occasions, it was not feasible to spot the source of the leak and determine which component was defective. In addition to this, once the failure was identified there wasn't enough time left during the maintenance stop to order, receive, and replace these components so the repair couldn't be carried out until the next scheduled shutdown resulting in permanent SO_2 emissions for prolonged periods of time. Thanks to RedLook, the inspection times to spot SO_2 leaks in the plant were drastically reduced in relation to the previously used methodology, not only leading to the consequent decrease in the net amount of SO_2 emissions to the atmosphere but also having a critical impact in terms of cost saving for Aurubis. These situations, now part of the past, illustrate the benefits of adopting RedLook technology, which is now seamlessly integrated within the Aurubis distributed control system (DCS) and video management system (VMS).

Similarly, Rio Tinto, another global leader in mining and metals, has recently implemented RedLook for continuous monitoring of SO_2 emissions at its refining facilities in the United States. Also deployed as a turn-key solution, RedLook has enabled Rio Tinto to optimise maintenance costs while spotting fugitive SO_2 emissions in multiple critical sectors of their site, including the acid plant and the conversion process equipment. For Rio Tinto, it was crucial to detect all the emissions occurring in these areas where the gas temperature and the SO_2 concentration are very high, causing a fast deterioration of the affected components if immediate action is not taken. For this reason, RedLook is now considered a critical system for Rio Tinto that allows them to significantly reduce operation costs and optimise maintenance activities.

Conclusion

The use of AI-powered IR imaging for sulphur dioxide leak detection represents a significant advancement in sustainability and efficiency of industrial operations. SENSIA's RedLook solution offers fully autonomous, 24/7 continuous monitoring of SO_2 leaks, enabling a cost-effective preventive maintenance strategy, seamlessly connected to the digital ecosystem of the operator (DCS, SCADA....) As regulations become increasingly intense and the need for sustainable practices grows, technologies like RedLook will play a crucial role in protecting both public health and the environment while saving maintenance costs for industrial operators.

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