Reactivated catalysts meet demands of sulphur recovery technology market

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The sulphur recovery technology market is forecast to increase significantly this decade – by $2.77 billion between 2023-2028. This growth is fueled by increasing demand for sulphur from end-user industries, driven by a variety of factors.

Rapid industrial development of countries such as China and India – and the parallel increase in their oil refining and natural gas processing capacities – has seen strong investment in the industry. Simultaneously, there is rising demand for energy resources and increased energy efficiency. Governments globally are also implementing environmental and emission regulations on sulphur emissions.

End-use is also behind increased demand. The agricultural industry requires sulphuric acid, used for digesting phosphate rock – the process by which we make agricultural fertilisers. In metallurgical industries, sulphuric acid produced from sulphur is used for the recovery of copper and phosphate. With oil and gas, sulphuric acid is used in the production of petroleum products (motor fuels, lubricants and chemicals) and is a necessity for refining and processing crude oil. New end uses are also being explored and developed, such as lithium-sulphur batteries and use of sulphur for thermal energy storage. These developments, if more widely adopted, could represent further increase in the demand for sulphur.

Regardless of the driving factors, engineers, refineries and businesses that work in more carbon intensive industries are adopting and improving sulphur recovery technologies as a proactive approach, to mitigate environmental impact and promote sustainable industrial practices.

To do so, the industry is turning to existing technologies and exploring new ones to meet this demand in a more sustainable way. Opportunities are presented by reactivated, rejuvenated and regenerated catalysts, as well as hydroprocessing catalysts.

Trends in the refining industry

A common practice in the global petroleum industry for more than 40 years, regeneration and/or rejuvenation treatments provide cost-advantaged catalyst configurations that boast similar performance to fresh catalysts. Refineries can take full advantage of all useful components of a spent catalyst – when a catalyst is reactivated, it can be used again – thus, leveraging maximum value.

Its influence – and growing popularity – can be seen with the fact that the global market for catalyst regeneration is projected to grow at a Compound Annual Growth Rate (CAGR) of 4.3% by 2030, for a total value of $8 billion. Looking at hydroprocessing catalysts in particular – which facilitate the removal of sulphur compounds from

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petroleum and other hydrocarbon feedstocks – 154,000 MT (metric ton) are replaced in refineries each year. Of this, more than 20% are catalysts that have been regenerated or rejuvenated via ex-situ processes, translating to more than 30,000 tons of regenerated and rejuvenated hydroprocessing catalysts being used per annum.

Doing so offers several advantages – both economic and environmental – in comparison to replacing spent catalysts with fresh catalysts. Extending the useful life of catalysts provides cost savings to refineries, in addition to eliminating the costs incurred when disposing of a spent catalyst in a hazardous waste landfill. This latter point also highlights the benefit of reduced waste generation as it minimises landfill waste; regenerated and rejuvenated catalysts also reduce the carbon footprint of catalysis on industrial scales.

Tail gas treating

With decades of experience in hydroprocessing catalyst recovery and sulphur recovery catalysis, the question was posed – could this tried and tested technology be applied to Claus tail gas treating?

Yes, with a lower cost catalyst that offers equivalent performance levels, boasts a lesser environmental impact, and contributes to refiners' proactive circular and sustainability objectives. Such a catalyst has been developed and patented by Evonik – one that offsets the differences between tail gas treating catalysts and hydroprocessing catalysts, and that fully maximises the potential of a spent catalyst.

EcoMax TG treats a spent catalyst from a refinery hydroprocessing unit by removing contaminants and optimising it for use in a tail gas treating hydrogenation reactor. It offers significant cost savings (between 20-40%) in comparison to typical fresh tail gas catalysts, and the advantage of having very high activity and a lower environmental footprint.

These ecological advantages have been evaluated using a Life Cycle Assessment (LCA) based on Evonik's internal manufacturing data, in addition to data from peer-reviewed publications. The assessment compared the carbon footprint between EcoMax TG and a fresh tail gas catalyst, using a 'cradle to gate' methodology – with results showing a 75% lower total carbon footprint for EcoMax TG. Unlike fresh catalysts, it does not require any new metal raw material mining or additional processing and transportation – demonstrating the substantial ecological and financial benefits that catalyst recycling can offer.

Additionally, this method is less energy intensive than the alternative process of forming particles to make a fresh catalyst. Scope 3 emissions – indirect emissions associated with 'upstream' processes involved in making a fresh catalyst – are effectively avoided with this more sustainable catalyst.

Case study: a large-scale oil refinery

The performance of EcoMax TG has been demonstrated at an oil refinery located on the US Gulf Coast (PADD 3) with a capacity of 270,000 barrels per day. The facility has four sulphur recovery units (SRU) with four tail gas treating units (TGTU) and a total design capacity of 470 tons per day.

The refinery required a mid-cycle catalyst replacement for the subject TGTU, which had a spherical conventional temperature tail gas catalyst installed. Overall SRU and TGTU throughput was limited, due to a recent process upset which saw a pressure drop across the tail gas catalyst bed. The decision was made to replace the tail gas catalyst and complete the remainder of the cycle until the next planned turnaround; EcoMax TG was chosen for one TGTU due to its price and availability, expected performance and pressure drop, physical properties and its sustainability benefits.

After six months, a series of tests were performed to assess the impact of this catalyst on the refinery. Results highlighted the challenging conditions for the tail gas catalyst – significant feed contaminations and soot generation resulted in an increased pressure drop and flow restriction. These strenuous conditions had likely been sustained since the early stages of the catalyst run, which meant that these performance test results indicate that EcoMax TG catalyst had been severely deactivated.

Regardless, the performance test results showed excellent conversion of SO_2 and CO, good conversion of COS and exceptional conversion of CS_2. At the various test conditions, the concentration of COS in the reactor effluent was measured between 15-22 ppmv (dry basis). No SO_2 or CS_2 was detected in the reactor effluent at any test condition (detection limit <1 ppmv).

It is also important to note that by using EcoMax TG, the refinery was able to meet its emissions targets, as well as identify two key additional benefits: lower costs (the catalyst required significantly less investment than other tail gas catalyst options), and the alignment with both the company and Evonik's overall goals of incorporating more sustainable practices.

Conclusion

The sulphur recovery technology market is growing – in large part driven by increasing demand for downstream products. Refiners looking to ensure operational effectiveness while improving sustainability can turn to catalyst reuse – such as the proven offering from Evonik – as a viable option. By reusing and recycling hydroprocessing catalysts for use in TGTUs, refineries stand to benefit from reduced costs, equal or enhanced performance to fresh catalyst use, and a lower carbon footprint – ensuring competitiveness in today's dynamic market.

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