Wet Sulfuric Acid Process

PEP Review 2021-09
November 2021
Contacts

**Vijayanand Rajagopalan**
Director
vijayanand.rajagopa@ihsmarkit.com

**Michael Arné**
Vice President, Process Economics Program
michael.erne@ihsmarkit.com
Abstract

In refineries, hydrogen sulfide (H₂S) is a by-product of processing sulfur-containing-crude-oils and is typically recovered as elemental sulfur. The Claus process is one of the most common methods for sulfur recovery and typically recovers 95–98% of the sulfur present in acid gas. With tightening regulations and sourer crudes, higher sulfur recovery levels (typically greater than 99%) are needed to meet the mandated emission limits. The wet sulfuric acid (WSA) technology, originally introduced in the 1980s by Haldor Topsoe, is an alternative to the Claus process for refinery sulfur management. It enables sulfur recovery in the form of valuable sulfuric acid, which is a key raw material for the fertilizer industry. While the technology can process a variety of sulfurous feeds originating from different processes, in this review, a generic wet sulfuric acid process is evaluated technically and economically for its capability to function as a sulfur recovery unit (SRU) in the refinery.

This review provides insight into a generic wet sulfuric acid process and covers its process chemistry, technology, and economics. The SRU configuration presented in this review produces 330 million lb/yr (150 ktpy) of commercial-grade sulfuric acid. The review can be used as a tool for the cost estimation for different plant capacities. It will be beneficial for planners, producers, and designers who are looking for independent data for conventional wet sulfuric acid process plants operating as refinery sulfur recovery units. This review includes the process flow diagrams, material balance, major equipment sizes, and specifications. Cost data, including the battery limit and offsite costs, variable costs, capex, opex, and overall production costs, is provided.

An interactive iPEP Navigator module of the process is included, which provides a snapshot of the process economics and allows the user to select the units and global region of interest.

The technological and economic assessment of the process is IHS Markit PEP’s independent interpretation of a commercial process based on information presented in the open literature (such as patents or technical articles) or in-house generated data (e.g., simulation, equipment cost estimation). While this assessment may not reflect the actual plant data fully, IHS Markit PEP believes it to be sufficiently representative of the process and process economics within the range of accuracy necessary for economic evaluations of a chemical process design.
Contents

1 Introduction 5
2 Summary 8
   Carbon and water footprint 8
3 Process economics 9
   Industry and technology background 9
   Industry status 9
   Technology review 10
   Process chemistry 13
      Acid gas combustion 13
      SO₂ conversion and acid formation 14
      NOx removal via SCR 15
      Catalyst technology 15
      Sulfuric acid condenser 16
   Basis of design 17
      Plant design capacity 17
   Process description 18
   Process discussion 22
      Acid gas combustion 22
      DeNOₓ SCR reactor 22
      SO₂ converter 23
      Acid dew point and condensation 23
      Pressure profile 23
      Materials of construction 24
      Emissions 24
   Cost estimates 24
      Fixed capital costs 25
      Production costs 25
      Economics summary 25
Appendix A—Cited references 28
Appendix B—Design and cost basis 31
Appendix C—Process flow diagrams 36

Tables

Table 2.1 Wet sulfuric acid process—Key performance metrics and economics summary 8
Table 2.2 Carbon and water footprint 8
Table 3.1 World annual capacity for sulfuric acid 9
Table 3.2 Sulfuric acid strengths and associated end uses 11
Table 3.3 Properties of catalysts—Haldor Topsoe 16
Table 3.4 Design basis and assumptions—Sulfuric acid production from refinery acid gas via a wet sulfuric acid process 17
Table 3.5 Feed gas composition for wet sulfuric acid process 17
Table 3.6 Wet sulfuric acid process—Major stream flows 19
Table 3.7 Wet sulfuric acid process—Major equipment 21
Table 3.8 Wet sulfuric acid process—Utilities summary 22
Table 3.9 Typical pressure profile in wet gas sulfuric acid process 23
Table 3.10 Tail gas desulfurization options for wet sulfuric acid plants
Table 3.11 Wet sulfuric acid process—Total capital investment
Table 3.12 Wet sulfuric acid process—Variable costs
Table 3.13 Wet sulfuric acid process—Production costs

Figures

Figure 1.1 Schematic of a typical wet sulfuric acid process
Figure 1.2 Process economics program sulfur portfolio
Figure 3.1 World consumption of sulfuric acid
Figure 3.2 Boiling point of sulfuric acid
Figure 3.3 Process block flow diagram of WSA process
Figure 3.4 Process block flow diagram of MECS® SULFOX™
Figure 3.5 Furnace zone configuration
Figure 3.6 Effect of water in feed gas on SO₂ conversion levels

Appendix C Figures

Figure 4.1 Process flow diagram—Wet sulfuric acid process
Figure 4.2 Process flow diagram—Wet sulfuric acid (steam generation and balance)