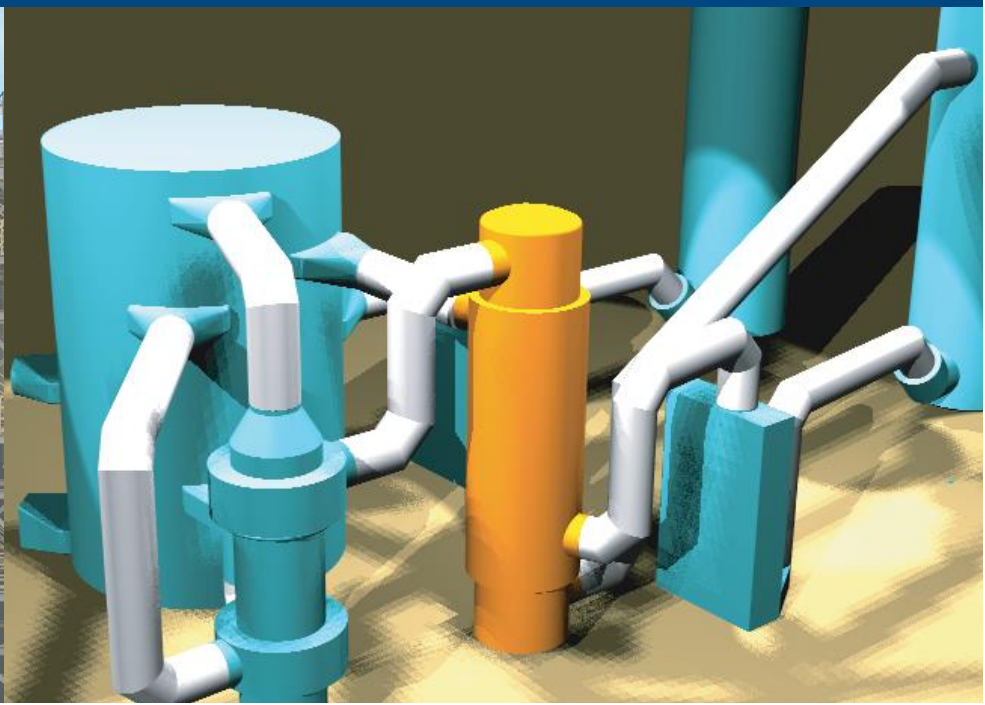


NORAM

SULFURIC ACID
Products and Services

ACID PLANT UPGRADE & DEBOTTLENECKING STUDIES



Acid Plant Upgrade & Debottlenecking Studies

NORAM projects in the sulfuric acid business area typically involve the supply of proprietary equipment of superior process performance and reliability, and may include the engineering associated with installing the new equipment in existing acid plants. These projects often include an engineering analysis of existing plant operations and may take into account the owners' requirements for a plant expansion. The owners generally do not have access to the design basis for the original equipment and they often are unsure where in the plant's true bottleneck lies. Only rarely will owners be able to specify a major piece of acid plant equipment unless it is a replacement in kind.

As a technology supplier to sulfuric acid industry, NORAM has a full comprehension of all aspects of acid plant design and operation. It is this in-depth understanding of the technology which has allowed NORAM to successfully undertake over 200 acid plant debottlenecking studies and which has enabled NORAM to supply a substantial number of proprietary equipment components.

A debottlenecking study undertaken by NORAM typically starts with a review of existing plant operations, including temperature and pressure surveys and a review of the performance of existing equipment. The acid plant is then modeled using NORAM's flowsheeting program and bottlenecks are identified. Suitable replacement equipment is specified and costs for equipment and installation are developed. When a project proceeds, NORAM can perform all necessary engineering to integrate proprietary equipment into an existing acid plant. Field advisory assistance can be provided during project execution.

Acid Plant Operation and Maintenance

By their nature, which is the combination of high temperature operation in a potentially corrosive environment, sulfuric acid plants generally require major maintenance efforts and expenditures during annual or biannual turnarounds. Typically catalysts have to be screened and topped up, acid distributors have to be cleaned, an acid tower may have to be repaired or replaced, fouled acid coolers have to be cleaned, and gas heat exchangers may have to be cleaned, repaired or replaced. Major equipment replacement projects in acid plants are often scheduled several years in advance since equipment deliveries can be fairly long and since major equipment wear is usually predictable.

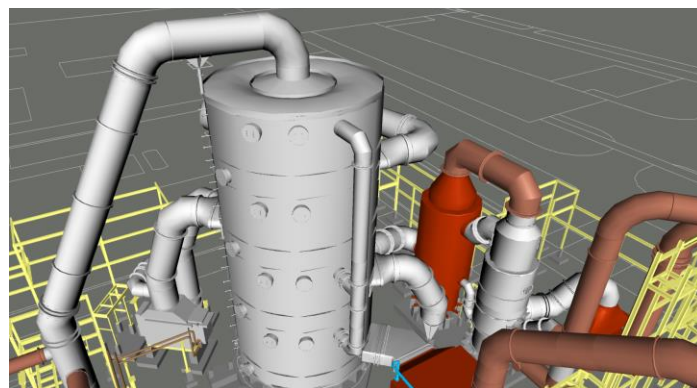
These regular major maintenance projects, typical in the sulfuric acid industry, offer the plant owners the opportunity to routinely upgrade their plants using the latest technologies and to economically raise the plant capacities by eliminating bottlenecks. An acid plant technology provider such as NORAM is the natural ally of an owner in acid plant upgrade and debottlenecking projects, in that the best proven technologies and equipment designs can be provided.



NORAM Proprietary Equipment and Technologies

NORAM has established an extensive track record as a supplier of acid plant equipment always providing superior reliability and process performance.

NORAM has been an innovator in the acid industry for over 25 years and offers state-of-the-art technologies. Some examples are the Anodically Protected Acid Cooler, the Stainless Steel Converter, the RF™ Radial Flow Gas Heat Exchanger, the SMART™ Acid Distributor and HP™ Saddle Packing. NORAM's offerings to the sulfuric acid industry are comprehensive in that all the major custom designed equipment in an acid plant can be provided.



Engineering Capabilities

In order to be able to offer equipment with superior reliability and process performance in the sulfuric acid business area, NORAM has developed a comprehensive portfolio of design techniques and programs:

Physical Properties Database

An in-house database for physical properties of sulfuric acid and sulfur oxide gases has been developed. Data can be imported into proprietary equipment rating and design programs. An important part of the physical properties database is a dewpoint program which can accurately predict the dewpoint in all parts of an acid plant and which takes into account entrainment in acid towers. Acid condensation in cold spots is the major cause of equipment wear in an acid plant.

Flowsheeting Program

A flowsheeting program has been developed to carry out rigorous mass and energy balances for sulfuric acid plants. An extensive library of flowsheets for most of the common acid plant designs is available, including flowsheets for sulfur burning, acid regeneration and metallurgical plants, as well as for single and double absorption plants. This flowsheeting program is available to simulate any plant under any normal operating condition and is eminently suitable to assess the merits and feasibility of debottlenecking options in acid plants.

Computational Fluid Dynamics (CFD)

CFD techniques are extremely useful in that they allow mapping detailed velocity, pressure, and temperature contours in acid plant equipment. Through CFD studies NORAM has gained invaluable insight into which factors affect equipment performance. NORAM has modeled converters, sulfur furnaces, gas heat exchangers, acid coolers, superheaters and economizers, acid towers, and merging duct segments. NORAM relies on CFD techniques to accurately predict the pressure drop in gas heat exchangers.

Catalyst Simulation

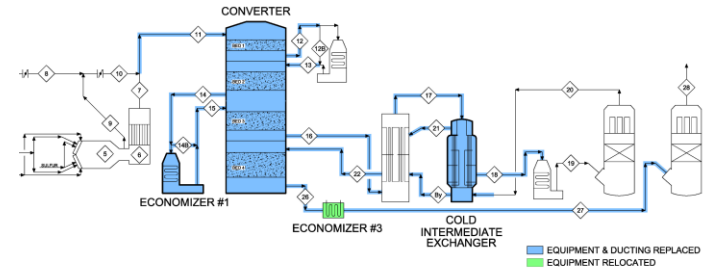
NORAM has developed a model to predict catalyst performance. This model is used in preliminary designs and engineering studies. At the project stage, NORAM relies on catalyst suppliers to offer performance warranties.

Heat Exchanger Rating Programs

NORAM has developed proprietary rating programs for RF™ Gas Heat Exchangers and for acid coolers. These programs have been verified through data from a number of operating plants.

Finite Element Analysis

NORAM has used finite element analysis to establish stress contours in converters supplied by NORAM and to help clients in analyzing the failure of converter sections supplied by others as well as to recommend repair options. The technique has also been used to design the tubesheets in large RF™ Gas Heat Exchangers.

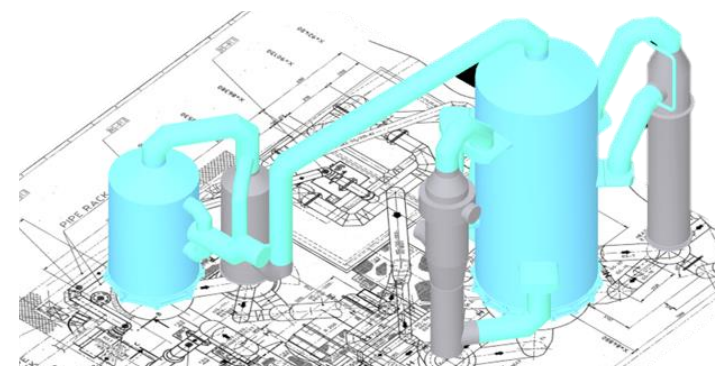


Pipe and Duct Stress Analysis

NORAM uses Caesar II to establish the stress in piping and ducting systems and to develop the design criteria for expansion joints in gas ducts.

Tower and Acid Distributor Hydraulics

NORAM has developed programs to model the hydraulics of acid distributors and of tower packing. The models have been verified through measurements in operating acid plants.



Ask about the products and services
NORAM supplies to the sulfuric acid industry:

NORAM PLANTS, PROCESSES, SYSTEMS, AND PROCESS EQUIPMENT

NORAM PLANT UPGRADE AND DEBOTTLENECKING ENGINEERING STUDIES
NORAM/CPPE HYBRID SULFURIC ACID PROCESS (HSAP)
NORAM CLEAN START™ PROCESS
NORAM PLANT PREHEATING SYSTEMS
NORAM'S TURBOSCRUBBER FOR GAS SCRUBBING
NORAM STAINLESS STEEL CATALYTIC CONVERTERS
NORAM RF™ RADIAL FLOW GAS-TO-GAS HEAT EXCHANGERS
NORAM SF™ SPLIT FLOW GAS-TO-GAS HEAT EXCHANGERS
NORAM BRICK-LINED ACID TOWERS
NORAM SULFUR & SPENT ACID BURNERS
NORAM CELLCHEM SULFUR BURNERS
NORAM ANODICALLY PROTECTED ACID COOLERS
NORAM SX® ACID COOLERS
NORAM SX® TOWERS AND NORAM SX® PUMP TANKS

NORAM EQUIPMENT INTERNALS, PERIPHERALS AND ANCILLARY EQUIPMENT

NORAM HP™ SADDLE PACKING FOR ACID TOWERS
NORAM SMART™ ACID DISTRIBUTORS FOR ACID TOWERS
NORAM TROUGH ACID DISTRIBUTORS FOR ACID TOWERS
NORAM SX® CHIPGUARD CG™ ACID STRAINER
NORAM ENTRAINMENT MITIGATION DEVICE (EMD)
NORAM ACID DILUTION SYSTEMS
NORAM SX® MATERIAL
NORAM SX® ACID DISTRIBUTORS
NORAM SX® PIPING
NORAM SX® VALVES
NORAM GAS DUCTING
NORAM DAMPER
NORAM SULFUR GUNS

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