LURGI

AICHE CLEARWATER CONVENTION

1991

CONVERTER REPLACED

in 18 DAYS

by

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Summary:

In 1967, a sulphuric acid plant with a nominal capacity of 615 mtpd was put on stream by Lurgi in a chemical complex near Frankfurt. The sulphuric acid serves as a feedstock for a variety of chemical processes. Starting from pyrite, which was processed in a fluidized bed roaster, the plant produced 100% liquid SO_3 and oleum in concentrations from 20 to 30% as main products.

For economic reasons, the sulphuric acid plant was modified to permit combustion of sulphur in place of pyrite roasting in 1975. The roasting and gas cleaning sections were shut down and a new sulphur furnace and heat recovery boiler were installed. At that time the plant`s production capacity was increased to 735 mtpd.

Early in 1990 there were indications that the original converter, which had not been changed since its first start-up might be defective. The following paper describes how this converter was replaced within a shutdown period of only 18 days, the new design for the converter, the installation procedures, and performance data for the modified plant.

Introduction:

In 1967 Lurgi put into operation a sulphuric acid plant in a facility near Frankfurt, Germany. The feed material of the plant was pyrite which was roasted in a fluid bed roaster.

The roaster gas was cooled in a waste heat boiler, then cleaned and fed to the sulphuric acid plant. The sulphuric acid is utilized in this facility for many other chemical processes. The nominal capacity of the original plant was 615 MTPD. A major portion of this was produced in this plant as 100% liquid SO_3 and oleum in concentrations between 20% and 30% free SO_3. (Figure 1)

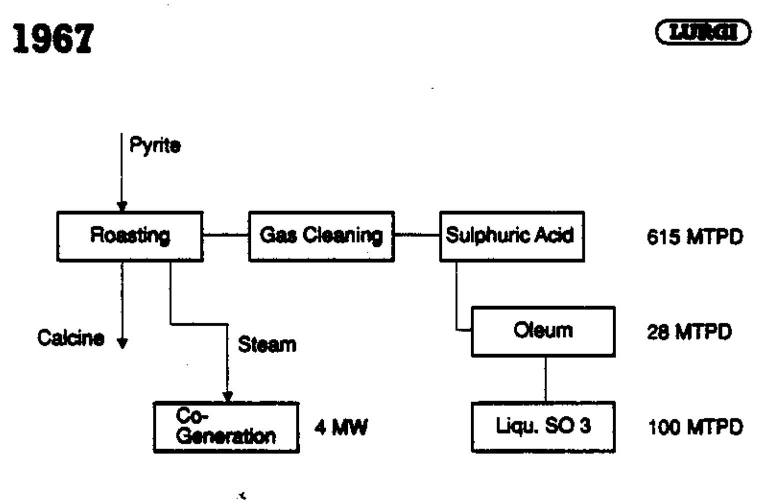

Fig 1: Block Diagram Sulphuric Acid Plant in 1967

The calcines obtained from roasting essentially comprising iron oxide, were transported by ship to the Duisburg "Kupferhütte" where the non-ferrous metals such as copper, zinc and lead were recovered.

A cogeneration plant was integrated in this plant. The high pressure steam produced in the waste heat boiler was coverted to power using a backpressure turbine and generator. The power generated was sufficient to maintain the overall plant in island operation. Normally the power was fed into the works' network.

Plant Modification

For economical reasons the sulphuric acid plant was revamped in 1975 to accomodate burning of liquid sulphur. The roasting and gas cleaning sections were shutdown, a new sulphur furnace including waste heat boiler were installed and at the same time, the capacity of the sulphuric acid plant increased to 735 tpd (Figure 2)

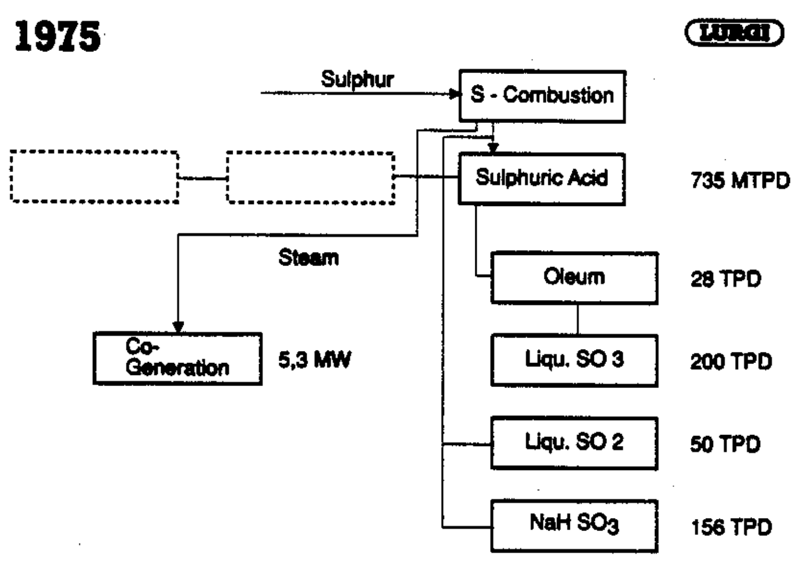

Fig 2: Block Diagram Sulphuric Acid Plant in 1975

The feature of the new sulphur combustion unit was the double-stage process with substoichiometric sulphur combustion. The advantage of this process is the production of gases of high sulphur dioxide concentration and low nitrogen oxides (NO_x) content (1).

As is known, the sulphur combustion temperature rises proportional to the SO_2 concentration and NO_x forms above the usual combustion temperatures of about 1000°C in proportion to the temperature. Only above a concentration of about 18 vol. % SO_2 does the oxygen shortage cause a drastic drop in the thermal NO_x formation. Nevertheless nitrogen oxides formation can be avoided, even at a combustion temperature of 1750°C, if the combustion of the sulphur is divided into two stages (Figure 3).

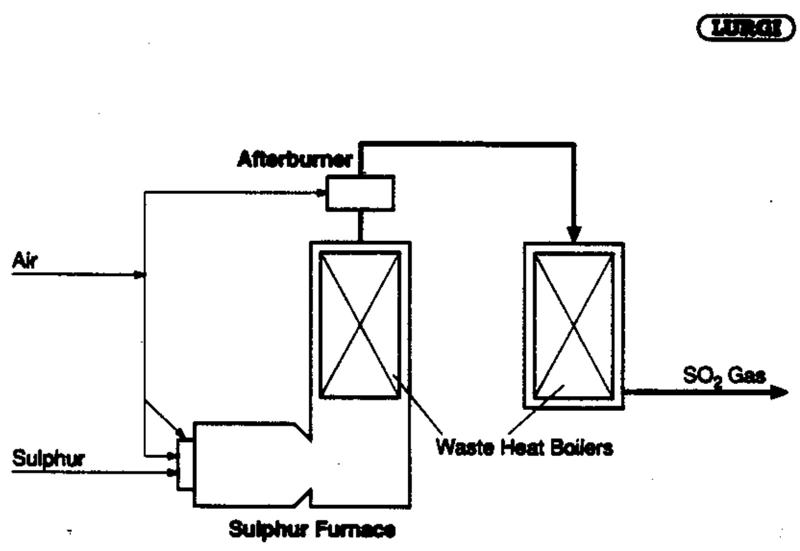

Fig 3: Lurgi Substoichiometric Sulphur Combustion Process

In the first stage the sulphur is burned with a stoichiometric deficiency of oxygen. It is particularly important in that stage to ensure that the gases are extremely well mixed so that all the oxygen is consumed and nitrogen oxides cannot form. This is accomplished using the Luro rotating cup burner. The combustion gas containing about 21 % SO_2 and some unconverted sulphur vapour is cooled in a waste heat boiler to abut 620-650°C and then passed into the second stage, an after- burning chamber. There, enough dried air is added to convert the remaining sulphur vapour completely to sulphur dioxide leading to a final gas concentration of about 18 vol. % SO_2. The combustion temperature in the second stage is not high enough to form nitrogen oxides. The gas mixture leaves the afterburning chamber at a temperature not exceeding 700°C and is cooled in another waste heat boiler unit (in this case a steam superheater) to approx. 430°C before being distributed to the sulphuric acid plant, the new additional sulphur dioxide liquification plant and the sodiumbisulfide section. The downstream units are of conventional design with the purpose of ensuring the most reliable operation possible of the overall plant.

Here are a few figures of interest:

Combustion temperature in the sulphur furnace	1750°C
Quantity of steam produced	40 t/h
SO_2 concentration upstream of converter	10 %
Rate of conversion	> 99.7 %
NO_x in the tailgas	12 mg/Nm^3
NO_x in the produced acid	< 10 ppm

In 1989 there were indications that the brick-lined converter, unchanged since the first start-up in 1967, may be damaged. The design was in accordance with the state of the art at the time of construction (see Figure 4).

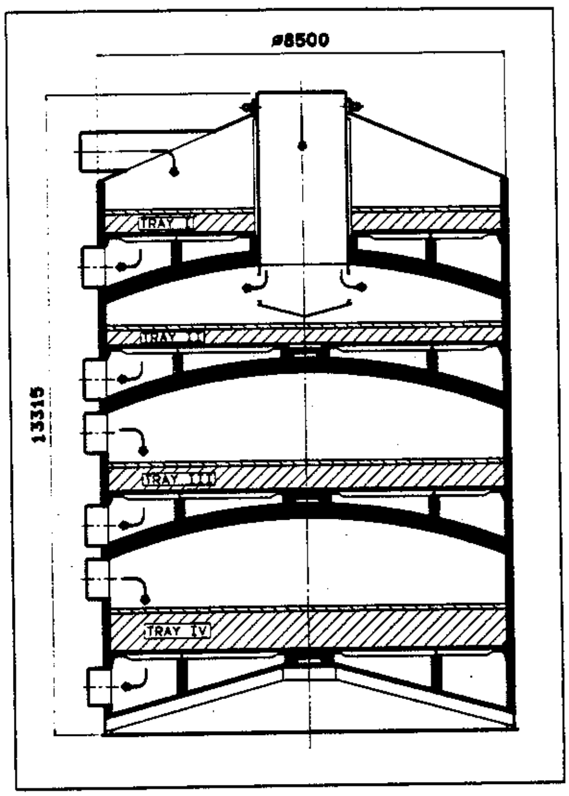

Fig 4: Bricklined Converter

The four layers with catalyst are arranged from top to bottom. The catalyst rests on perforated plates supported on bricked domes. The cylindrical converter also has a brick-lining, then a plate shell and thermal insulation with mineral wool and aluminium sheets.

As mentioned, this converter was in operation for more than 20 years, never caused trouble and the operators were very satisfied with its service.

On planning a repair or replacement two essential aspects were taken into account:

1. Important production shops in the facility are dependent on the product 100% SO_3. Procurement from outside is not possible. Storage of the SO_3 in liquid form without stabilization is only possible for a few weeks; storage capacity for maximum 3 weeks is available. That means replacement or repair of the converter would have to be carried out within an overall shut-down period of 18 days including cooling down and heating up. Thus, repair to the existing converter was out of the question because the brickwork for the domes, etc. would certainly take longer, as would a new brick-lined converter.

2. Accessability to the overall converter system, the possible duct routing to the tray inlets and outlets (a total of 8 nozzles) as well as the construction site conditions demanded that the new converter be located on the existing converter foundation.

The two criteria led to the decision to build a stainless steel converter without any brick lining and, thus, replace the existing brick-lined converter with bricked domes (Figure 5).

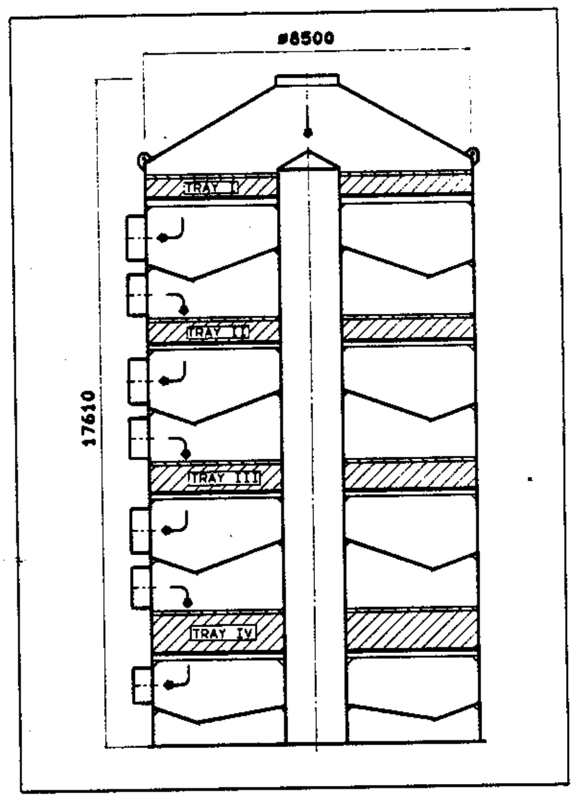

Fig 5: Stainless Steel Converter

We utilized our experience gained from converters of carbon steel and stainless steel we have already built. The largest converter is 12200 mm in diamater and is in a sulphuric acid plant producing maximum 1500 MTPD sulphuric acid from 7 % gases.

In order to actually fulfil these two criteria, i.e. short shut-down periods and location on the existing foundation, it was necessary to:

1. to design the new stainless steel converter in regard to diameter and bottom in such a way that the existing foundations could be used without change (for schedule reasons),

2. to design and dimension the new stainless steel converter in such a way that the existing gas lines are retained to the greatest degree (cost and time savings) but the greater thermal expansion of the stainless steel, the charging of sufficient quantities of catalyst, and above all, retaining the plant performace to date including optimum SO_2 conversion were taken into account,

3. to supply the new converter prefabricated to the greatest degree and assemble it completely on an available open space including insulation application.

4. find a suitable solution to disconnect the existing converter on the duct side in the shortest time from the remaining contact system and remove it from the plant and locate it on an open space in such a way that the new converter could be moved and lifted onto the existing foundation and connected to the heat exchangers of the contact system in the shortest time (Figure 6).

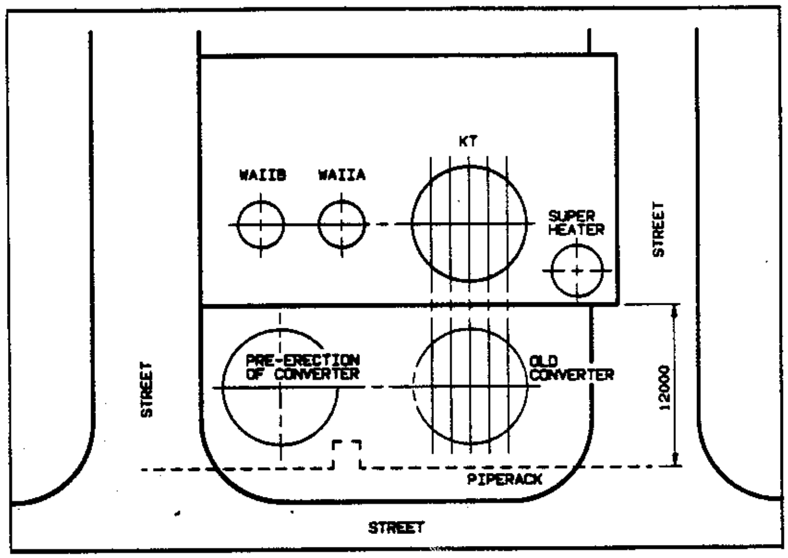

Fig 6: Arrangement of Converter

Lurgi won the award of this project based upon its superior concept in competitive bidding.

The order was placed in November 1989 and the revamped converter was to be ready for heating up on 8th October, 1990. Revamping encompassed the following steps:

1. Fabrication of the converter in the largest sections possible was carried out in the shops of the supplier. The transport routes to and in the facility, the size of the individual parts as well as the completion date and the sequence of the sections had to be precisely planned.

2. The sections were transported to the customer by ship applying a detailed transport and assembly schedule. The new converter was assembled on an available space next the existing contact system. The pipe racks in the plant could not be modified and the operation of the plant not impaired for transporting the components in the works and to erection.

3. The assembly sequence for the converter with insulation and catalyst charge were precisely planned with the customer as were the shut-down of the sulphuric acid plant with blow out, disconnection of the old converter and removal.

4. After disconnecting the old converter from the heat exchangers and cutting out the sections of the gas duct the converter was hydraulically raised to place heavy rollers and moved away on a supporting structure
It was removed in one day.

5. During the residual work on the new converter and the new sections of ducting and the duct connections the foundation was repaired as necessary.

6. Finally the new converter was lifted on to the foundation with a 1000 t crane.

7. The prepared pipe sections were positioned and connected in accordance with detailed installation time schedule.

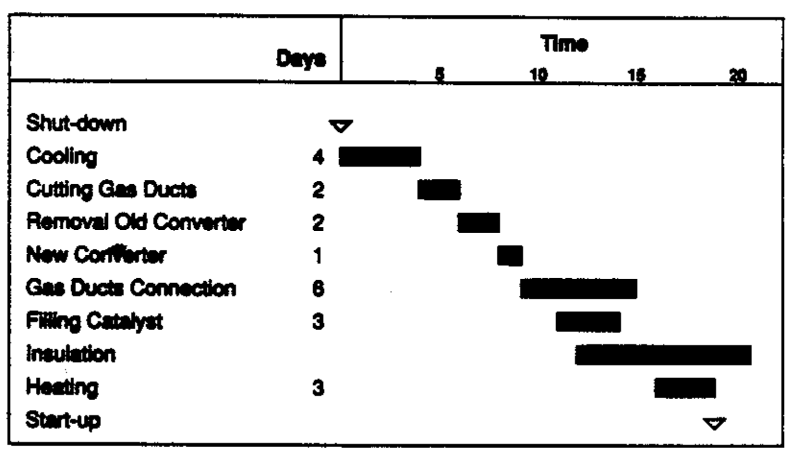

Fig 7: Time Schedule for Converter Replacement

An extract from the detailed time schedule covering the last phase of erection is shown in Figure 7.

The sulphuric acid plant could be placed back into operation one day ahead of schedule. The mode of operation with the new converter does practically not differ from the previous one.

The operation found the following items were especially positive in comparison with the old brick-lined converter.

1. shorter heating-up time,

2. the normal operating conditions to be reached in the shortest time after the beginning of sulphur feed,

3. the higher SO_2 conversion resulting, at least partially, from the absolutely tight welded partition between trays 3 and 4. The intermediate absorption takes place here between trays 3 and 4 of the 4-tray converter. In the case of the bricked domes absolute gas-tightness between the trays was no longer ensured after 20 years of operation.

The replacement of the converter was part of a major overhaul of the sulphuric acid plant. The tight schedule required close coordination with the owner of the plant and other contractors considering the limitations of space, access to equipment and poor weather conditions.

Finally the schedule and budget were met and the performance of the new converter is equal or better than the original.

Literature

(1) Sulphur, Sulphur Dioxide and Sulphuric Acid
A.I More, The British Sulphur Corporation Ltd.