OPERATION AND PERFORMANCE
OF STAINLESS STEEL CONVERTER

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Summary

Although the high strength of austenitic stainless steels at elevated temperatures has been well known for many years, it is only recently that economically viable converters manufactured from this material have been available to the Sulphuric Acid Industry.

The narrowing of the gap between the cost of carbon steel and stainless steel; the increasing cost of metallising, and the increasing cost of brick lining have all contributed to this new viability of stainless steel. However the major reason why stainless steel converters are being successfully introduced is the breakthrough in mechanical design concepts.

Instead of merely changing the material of traditional designs, a new design has been developed which fully utilizes all the excellent high temperature properties of austenitic stainless steel.

This paper deals with the installation and performance of one such converter with integral hot exchanger at Essex Chemical Corporation in Newark, New Jersey.

The special design and constructional features of the converter/exchanger unit are described, including the unique installation procedure adopted at this particular plant.

The plant start up procedure is explained as it related to the new converter and information on heating and cooling times is presented.

Introduction

The production rate of the Essex sulphuric acid plant in Newark had been limited in order to comply with local SO_2 emission standards. The existing converter was at its limit with regard to catalyst capacity and the Company had a long term requirement to increase the acid production rate by 16%.

These points combined with the excessive maintenance problems experienced with the existing converter, hot exchanger and associated pipework prompted Essex Chemicals to purchase a Chemetics patented stainless steel converter with integral hot exchanger. The order was placed on Dec. 2nd, 1982.

To minimize plant down time, the converter/exchanger unit was specially designed to enable it to be fully erected on a temporary foundation and after removal of the existing converter to be lifted in one piece on to the permanent foundations.

Also,to minimize plant down time it was essential that the new converter/exchanger unit could be installed without modification to the existing foundations.

The existing converter foundations were not designed to accommodate a central heat exchanger, therefore the new converter was designed such that the entire weight of the unit, including the weight of the heat exchanger would be carried by the outside shell of the converter.

The problems previously associated with the hot gas ducts connecting the old converter with the old separate hot exchanger were completely eliminated by placing the heat exchanger inside the converter.

Access to this exchanger was ensured by the suitable provision of manways and the unique design feature of having an easily removable tube bundle.

Further reductions in plant down time were also achieved by the insulation of the converter prior to lifting on to the permanent foundation.

Plant Flowsheet

The gas flowsheet is given on the following page

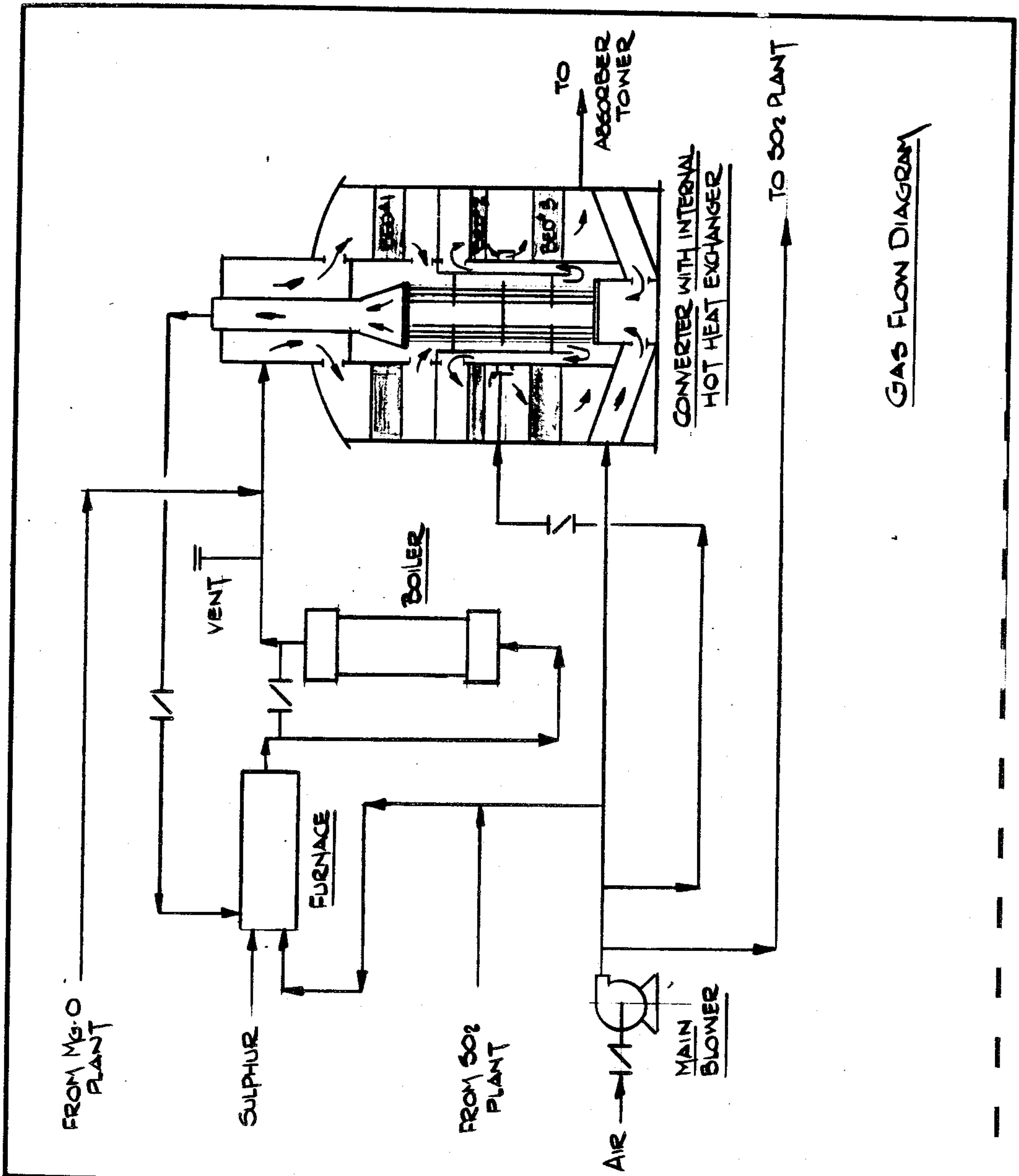
Special Design Features

To enable the entire weight of the combined unit to be supported by the outside shell of the converter the central core cylinder and heat exchanger were suspended on a double inverted cone across the base of the converter.

The age (28 years) of the existing foundations presented doubts as to its integrity and ability to continue tolerating the extremely high temperatures transmitted from the third bed. It was therefore decided to maintain cool foundations by sweeping the lower section of the converter with the relatively cold gas entering the tube side of the heat exchanger (i.e. air at 180°F).

Apart from keeping the foundations cool, this design feature minimized the radial thermal expansion of the shell, thus virtually eliminating the radial stresses in the outside concrete wall of the foundation. Examination of the existing foundation had highlighted the effects of this cyclical stress in the foundation caused by movement of the old converter. Various outside sections of the foundation had spalled away exposing sections of the re-bar.

Gas ducting modifications were minimized by maintaining the original converter bed arrangement.



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GAS FLOW DIAGRAM

CHEMETICS INTERNATIONAL COMPANY
A DIVISION OF C-I-L INC.
TORONTO, ONTARIO, CANADA

CLIENT & SITE ESSEX CHEMICAL - NEW JERSEY	DRWN RH	DATE	DWG NO	SIZE A	REV
	APPD	DATE			

A significant feature of the Chemetics stainless steel converter is the freedom to place the beds in the optimum arrangement to suit a particular plant layout, including having bed #1 at the bottom of the converter. This feature results from the high strength of stainless steel at elevated temperatures and the flexibility presented by having the hot exchanger in the core of the converter.

The gas flow to each bed is arranged to flow radially, thus ensuring excellent gas distribution and utilizing the catalyst to its maximum efficiency. Even the dilution air is introduced radially to ensure even mixing with the gas entering bed #3.

Access to each bed is via a novel welded manway design which can be readily removed, but provides a reliable gas tight seal. Access in each bed is also free from posts and pipes — a common feature of conventional converters. This is achieved by placing the catalyst on specially shaped all welded stainless steel plates which do not require any additional support.

The traditional requirement for an expansion joint in the shell of hot exchangers was eliminated in the Essex Chemical unit by the use of suitably positioned annular seal plates which separate the tube bundle from the core tube of the converter.

The cutting of these annular plates enables the exchanger bundle to be lifted free from the converter.

The all welded nature of the converter removes the possibility of any bed by-passing of gases — a common feature of more traditional designs.

Project Schedule

This is shown on the following page.

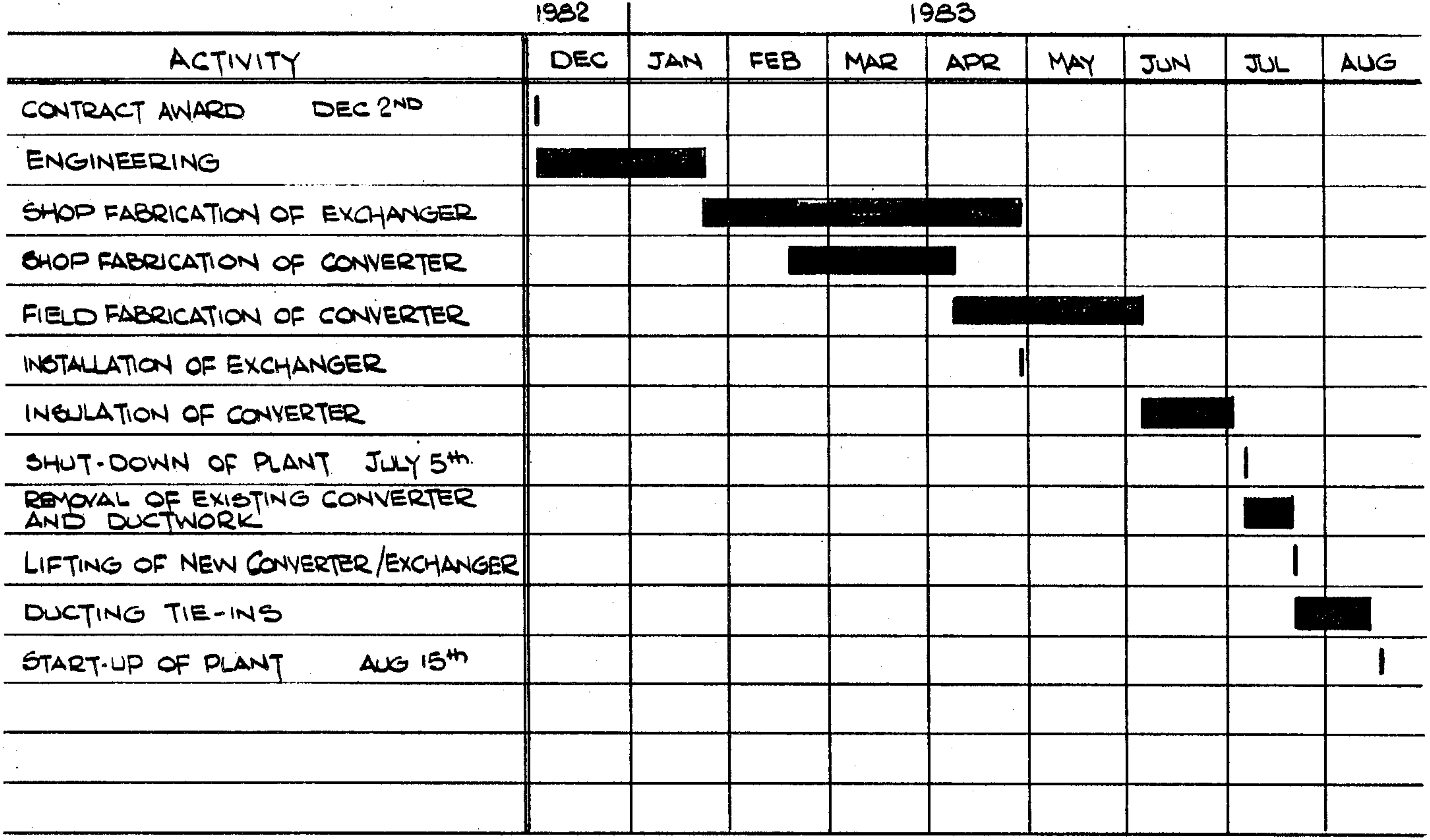
Construction Procedure

The converter shell was fabricated and erected by conventional tank manufacturing techniques. Upon completion of the outer shell and lower double cone assembly, the shop fabricated heat exchanger combined with the converter inner core tube was lifted and lowered into position.

The catalyst support plates and divider plates were built up and welded commencing with bed #3 and finishing with bed #1.

Finally the roof section was installed and welded.

PROJECT SCHEDULE



Insulation

Stainless steel has a thermal coefficient of expansion approximately 1.5 times that of carbon steel. Therefore, at the elevated temperatures experienced in a converter, the vertical and radial expansion can be significant, i.e. 3 in. and 2 in. respectively, for even a modest sized unit.

It is essential that the insulation and cladding fastening techniques can accommodate these movements without failure.

Material compatibility and integrity of cladding support is important to provide the freedeom of movement for thermal expansion and at the same time provide high integrity protection against adverse weather conditions.

A further advantage of the access manway design incorporated into the Essex converter was the ease with which it could be insulated without discontinuity in the cladding.

The selection of insulation thickness is a function of acceptable cool down time and the balance of installation cost versus the cost of energy in the plant. The client selected an insulation thickness of 8 in. for the converter at Newark.

There is clearly a significant saving in insulation cost for the converter with internal hot exchanger compared with separate converter and exchanger vessels connected by external gas ducting.

Lifting Into Position

The existing converter was too heavy (approx. 180 tons) and too corroded to allow removal by a single crane lift. Therefore once the catalyst was removed, the grid plates had to be dismantled and removed.

The total weight of the converter was thereby reduced to just below 100 tons enabling it to be lifted off the foundations. Two separate lifts were required to move the converter a suitable distance away to allow access for the new converter.

The old heat exchanger was also lifted away from the site.

The new converter and exchanger unit, which weighed around 50 tons, was lifted and moved into position in one single operation of the crane.

Ducting Ties and Access Platforms

Necessary new ducting and supports had been completed and insulated prior to plant shut down. Installation of the new ducts and the tie-ins were therefore completed quickly. The access platforms and ladder assembly for the converter was specifically designed to be completely shop fabricated and free standing.

Installation of this assembly consisted of simply lifting into position and bolting to the new foundations.

Plant Start Up Procedure

Historically the converter was preheated by a series of hot air blows. These were created by heating the furnace by the burning of oil whilst venting the combustion products to atmosphere; then with the oil burner switched off, transferring the heat from the furnace bricks to the converter.

Catalyst manufacturers recommend heating with air up to the firing temperature, prior to the introduction of SO_2 gas.

Essex Chemical have traditionally used this technique only until the converter bed #3 exit temperature reached 250°F. Once this temperature was attained the combustion products from burning oil in the furnace were passed through the converter to accelerate the heat up time.

Sulphur was introduced into the furnace only after catalyst firing temperature in bed #1 was reached.

This procedure was adopted for the new stainless steel converter.

It was discovered that instead of the multiple hot blows previously required for the old converter, the bed #3 exit temperature in the new converter reached the required 250°F after only one hot air blow.

Subsequent heating with combustion products from the oil burner was carried out slowly (8 hrs.) because the plant personnel believed this to be necessary for protection of the catalyst.

This controlled heating rate was not essential because of the strong resistance of catalyst to damage by thermal shock.

Once firing temperature had been reached and the SO_2 gas introduced to the converter, stable process conditions were obtained after approximately 60 minutes.

In traditional brick lined converters a further restriction to heat up rate was the poor thermal shock resistance of the brick — fast heat ups caused severe spalling of the brick lining.

Shutdown and Start Up

Five months after initial start up the acid plant was shut down for nine hours for minor maintenance.

After shutdown for the nine hour period, Sulphur was immediately introduced into the converter without the need for preheat and steady state conditions were reached after approximately 50 minutes.

Discussion of Heat Up and Cool Down Times

Clearly the rapid start up of the new converter was attributed to the low thermal capacity of the unit. The original converter had brick lining and heavy cast iron grids to heat as well as the catalyst.

The slow cool down was a feature of the excellent insulation of the new converter and the prevention of cooling draught through the converter by the suitable closure of ducting dampers. A traditional brick lined converter would take longer to cool down with the same degree of insulation and draught prevention by virtue of its increased heat capacity. However, having the hot exchanger inside the converter considerably reduces the exposed surface area for cooling.

The stainless converter was shown to maintain sufficient heat for short term shutdowns to enable restarting without the need for preheat. Start up time from long term shutdowns would be reduced as a function of the reduced heat capacity of the stainless converter.

ESSEX CHEMICAL NEW JERSEY CONVERTER COOLDOWN
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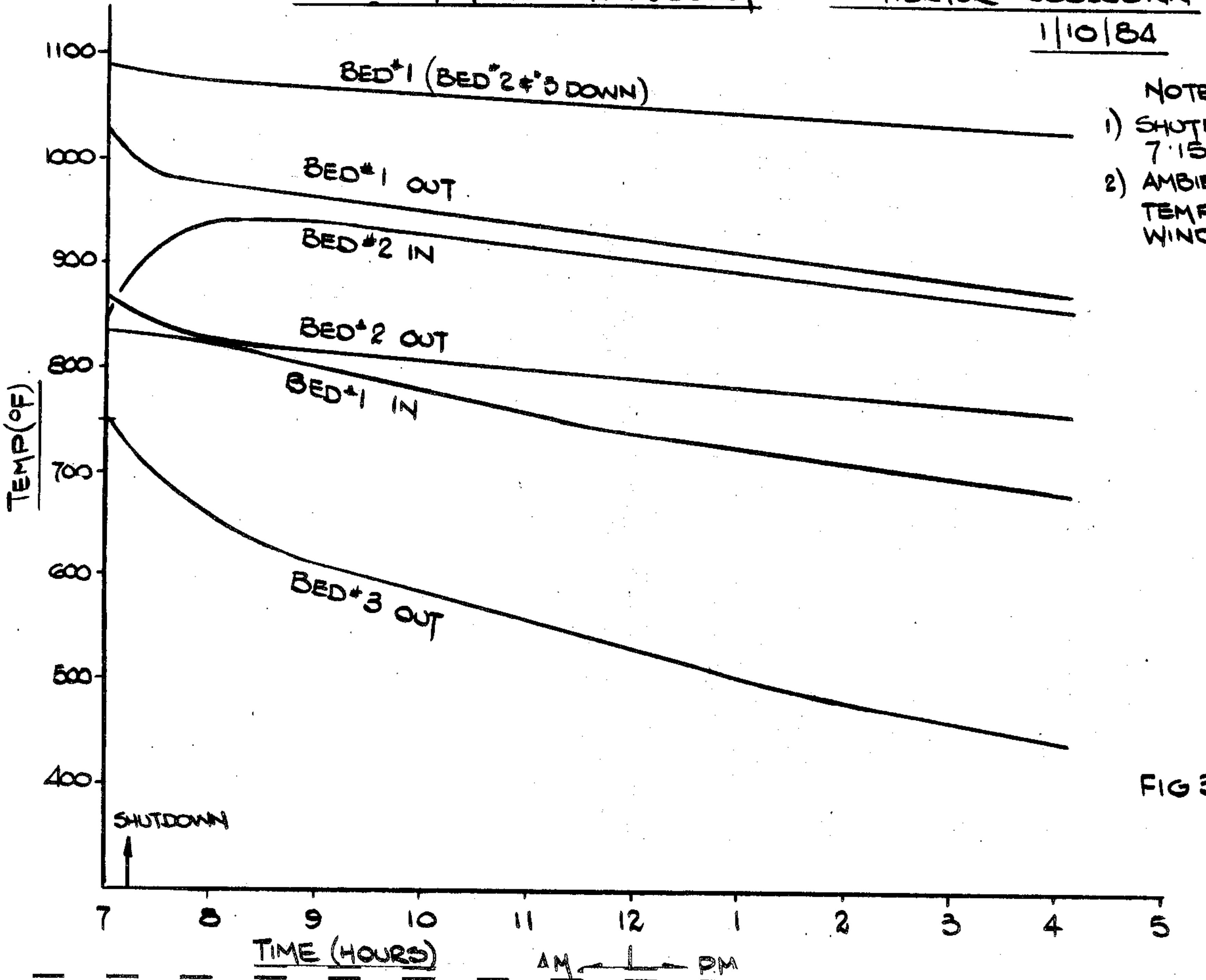

NOTES
1) SHUTDOWN AT 7:15 AM
2) AMBIENT CONDITIONS
TEMP - 41°F MAX
WIND - 15 MPH AV

FIG 3

Conclusions

1) The introduction of all welded stainless steel converters offers the industry a viable economic alternative to traditional carbon steel units.

2) This economic viability is enhanced by the flexibility of bed arrangement for plant retrofits and the ease and speed of installation.

3) The removal of the need for metallising and bricklining reduces maintenance and installation problems.

4) The all welded construction eliminates gas by-passing around beds.

5) The Chemetics patented converter with integral hot exchanger overcomes maintenance problems associated with the "hot" duct in sulphuric acid plants by eliminating the duct completely.

6) The extra thermal expansion associated with stainless converters requires special attention to duct expansion and insulation design.

7) The internal hot exchanger concept considerably reduces the exposed surface area for heat loss as well as reducing the vessel and duct area requiring insulation.

8) The reduced heat capacity of the stainless converter by virtue of its light weight significantly shortens the start up time compared with traditional brick lined carbon steel converters.

9) Cool down time is a function of insulation integrity and thickness, internal draught control and total exposed surface area.

Biography

Doug Shaw graduated in 1967 with A B.Sc. in Mechanical Engineering from Aston University in Birmingham, England.

He started his career working as a Project Engineer with the Steel Tube Division of Tube Investments Ltd.

Doug then worked with the synthetic fibre machinery division of Stone Platt Industries where he spent 5 years in the position of Research and Development Manager.

In 1977 Doug joined the Mono Pump Group where he worked as Project Manager controlling machinery development projects for the food and chemical industries.

He emigrated to Canada in 1981 and is currently employed as Design Manager with Chemetics International Company in Toronto,