MODIFYING A SULFURIC ACID PLANT ON A LIMITED BUDGET

200 S.T.P.D. CAPACITY FOR $150,000

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ABSTRACT:

This "in-house project consisted of converting a 4/1 double absorption sulfuric acid plant to a 3/1 gas flow configuration; without adding major equipment. An evaluation of all pieces of equipment in this 20 year old plant was necessary to determine the plant's bottleneck after modifications. The process of evaluation and implementation; including the results are summarized.

INTRODUCTION:

During 1981 and 1982 major modifications to the E.Tampa complex of Gardinier Inc. were implemented. By 1983 operating experience had been gained with our new "Dorrco" wet rock process phosphoric acid plant. As a result it became obvious that when the complex was operated at maximum capacity a small imbalance with the sulfuric acid plants production capacity had developed.

Under normal circumstances major engineering companies would have been invited to look at our existing sulfuric acid production facilities and propose a remedy. However, due to the financial circumstances of our company at that time, and the low market value of our products, this was not possible. It was then through this combination of circumstances that the internal efforts to provide an increase in capacity - the subject of this paper - developed.

PRELIMINARY EVALUATION:

The Gardinier complex has three sulfuric acid plants - Nos 7,8,and 9 (1-6 were demolished before 1977). The #7 plant had undergone a major capacity expansion in 1981* which took it to its capacity limit. A quick look at our #9 acid plant indicated that the boiler's capacity was being exceeded when the plant operated beyond 115% of its 2400 S.T.P.D. original design capacity. The objective of obtaining increased capacity with limited capital was then not possible in the #9 plant.

The preliminary evaluation narrowed to the #8 acid plant. This plant was operating as a 4/1 Double Absorption plant, and had a very similar gas flow configuration to that of our #7 acid plant , prior to its modification. Therefore, a more in depth look at this plant was begun.

* "Plant Expansion and Modifications-Gardinier #7 Sulfuric Acid Plant"; G. Cameron and R. Fernandez; 1982 CLEARWATER Convention Central Fla. A.I.C.H.E.

THE #8 ACID PLANT PROCESS REVIEW:

A quick look at the operating pressure drop profile of the plant indicated that a reduction of pressure drop of 14-16 inches would be obtained by paralleling the existing 3rd and 4th passes of conversion. A second look indicated that since the existing superheater between tne 3rd. and 4th. passes would also see a split flow,a further reduction of 4-6 inches could be expected. Since the capital was not available, it was intended to implement the paralleling without adding any major pieces of equipment, and the new gas flow would have to be from the 3A exit through the existing superheater then re-enter the converter through the bottom of the 3B mass and combined with the 3B mass through the rest of the plant (see fig. 1).

With the projected gas flow configuration settled, an evaluation of the blower and turbine drive, the boilers, and the conversion capacity of the plant could start. From the boiler's original equipment manufacturer's information we knew that the drum would be expected to have carryover at 218,000 #/HR of steam generation, and this would limit production to something less than 2100 S.T.P.D. .

The plant had operated at about 1850 S.T.P.D. clean, cold weather conditions with a 2 lbs. of SO_2/ton of H_2SO_4 production conversion performance. In changing to a 3/1 gas flow configuration we could not expect to duplicate this. However, utilizing catalyst manufacturers' analysis of our existing converter loadings, and our own operating experience on our two other 3/1 gas flow plants, a level of 3 lbs/ton appeared a reasonable expectation.

Our #8 Acid Plant was originally built in 1965 as a single absorption, quench-air type plant with a 1430 S.T.P.D. capacity. The plant was modified by Monsanto Enviro Chem to double absorption in 1977, including the replacement of the quench air system with gas to gas exchangers and a new superheater. At that time the removal of the quench air flow provided extra capacity in the original blower, even with the additional pressure drop from the double absorption equipment. Since our new proposed modification removed pressure drop, it was thus expected that the blower would perform as required. This was verified by a detailed look at the blower performance curves originally provided with the equipment. These performance curves also indicated that the additional gas flow through the plant would bring the horsepower requirements from the turbine to the maximum.

Therefore, the combination of the above limits led us to use a new design basis of 1970 S.T.P.D., with a 215,000 #/HR. maximum steaming rate. These figures were then used in the next step of our analysis.

EQUIPMENT REVIEW:

At this point a list was made of all pieces of equipment in the plant (see table 1), and a detailed comparison between the target performance and the equipments' capacity was made. This became a team effort, in that the expertise of other company personnel such as the instrument Dept, structural, electrical and mechanical engineers were utilized as needed in the evaluation.

The evaluation effort was not limited to the major pieces of equipment; such as burner and towers , but it also included such things as control valves, sulfur nozzles,pumps and motors, steam systems, etc.

In evaluating equipment that has been in service as much as 20 years, with wear, scaling, fouling etc., the use of tools such as heat transfer calculations is very limited. For most cases, things such as percent opening of a by-pass valve, temperature changes at different operating conditions, performance of similar equipment, amp. readings,etc. were the key factors in analyzing expected performance. The first priority in this evaluation process was to insure we looked at everything in the plant, and identified any questionable items. Once the items of concern were identified then steps were taken to make detailed calculations, contact vendors, review operating data, etc. as needed to arrive at a decision.

In our particular plant some of the questionable areas which were identified consisted of:

a) acid cooling system- cast iron pipe cascade cooler
b) boiler feed water and level control system
c) steam export valve and boiler pressure control
d) steam superheat temperature to the main turbine

Obviously, after the original identification of the possible process change, this evaluation is a crucial step, and needs to be done as carefully as possible.

DESIGN:

Once the equipment evaluation was complete; actual design and cost estimating of the required changes began.

In an operating company, such as ours, it is higly desirable to involve not only the Engineering Dept., but also the Maintenance and Operating Depts. as much as possible in the design phase of the modifications. They can be helpful in providing solutions, as well as in identifying mistakes during design review; plus, they will be familiar with the project when implementation takes place.

In our case the physical changes to the plant needed for this project were:

1) Installed a short new duct from the exit of the Hot Gas to Gas Heat Exchanger into the 3B mass.

2) Modified the exit duct and superheater at the exit of the 3A mass.

3) Sealed gas tight the partition between the 3A and 3B masses inside the converter.

4) Modified the steam flow system to the main blower turbine, and to the 3A mass exit superheater.

5) Blanked the original gas inlet to the 3B mass.

The operating and maintenance depts. had already planned to correct existing plant deficiencies in the boiler level control and superheated steam export systems. These were to be done during the same plant overhaul, and benefitted this project. Also, it was agreed that special efforts would be made to de-scale the cast iron acid cooling pipes and restore proper water distribution over them.

During the 1977 modifications of the plant the steam from the boiler was routed 100% through the superheater exit the 3rd. mass. It then split, with some going to the blower turbine, and the rest through additional superheaters and exit the plant. At this time we were planning to reduce the gas flow to this superheater by about two thirds; and since the main blower turbine had a narrow range of acceptable superheated steam temperatures, a modification of the steam flow system became necessary. Therefore, a change was made to have the steam flow split ahead of the 3A mass (parallel flow). Fortunately this could be accomplished with the installation of two blanks and a new 20 in. section of 12 in. steam piping.

Our design efforts also benefitted from an idea by the mechanical engineer in charge of the design. This consisted of splitting the existing superheater tubesheets, leaving the top half in place, and relocating the bottom half only with its own existing duct; thus adding only steam piping and a transition piece. This was easier and less costly to implement than the previously anticipated removal and reducting of this superheater.

IMPLEMENTATION:

In order to maintain minimum capital costs, and since additional production was the objective, it was essential that the work be accomplished with straight time; and within the normal 10 days scheduled overhaul. Once the project was awarded in a competitive bid basis- which included a detailed execution schedule; the coordination among the contractor, our own maintenance forces, and the other overhaul subcontractors was of primary importance.

The project contractor was asked to participate in our normal overhaul planning meetings and describe his activities and schedule; besides listening to the rest of the scheduled overhaul activities. Pre-shutdown activities, catalyst screening, access for hoisting equipment, pressure piping code requirements, inspections and safety considerations, testing, etc. were thoroughly discussed. Also, during the actual overhaul the contractor continued to participate in our daily coordination meetings.

In this particular occasion, with the cooperation of the weather and a lot of efforts from all involved, the planning paid off and the project and overhaul came off as scheduled.

RESULTS:

The project was successful in that it was accomplished on time and within the $150,000 budget, and the production capacity of the plant was increased from a 1850 S.T.P.D. clean cold weather capacity to a 2050 S.T.P.D. production rate. The plant reached this capacity against a series of almost simultaneous equipment limitations as follows: conversion, boiler steam capacity, turbine horsepower and blower speed. Since we wound up at the limits of these conditions, it would have been difficult to conceive any outside party undertaking and willing to guarantee the results of this particular modification.

However, as usual not all the results were as expected. We had anticipated that the gas flow distribution between the 3A and 3B masses would be very unbalanced. The gas path for the 3A mass also had to go through the superheater before joining the 3B mass exit gas, and it was anticipated that the gas flow to the 3A mas would be only one third (1/3) of the total. Nevertheless, the #8 plant converter was of large diameter, and with significantly reduced gas velocities in both these masses, near equilibrium conversion was still expected.

What we did not anticipate was that from the single gas duct exit the Hot Gas to Gas Heat Exchanger the entrance temperature to the 3B mass would be 21 degrees F cooler than the 3A entrance. Operating data (see table 3) confirmed this difference; and even at various production rates this temperature difference persisted.

Using 20/20 hindsight and trying to explain this data, we concluded that there is a significant temperature difference within the Hot Gas to Gas Heat Exchanger exit duct. This gradient follows the pattern of the cross flow in this heat exchanger, with the hotter gases on the east side of the duct and into the 3A mass. The duct we installed was connected to the west side of the main duct, and drew the lower temperature gases into the 3B mass. Fortunately, due to the temperature range exit the exchanger, and the extremely low gas velocities within the split masses, the temperature rise from both masses is the same; even when at different production rates and with varying gas temperatures.

CONCLUSIONS:

If circumstances indicate that additional production from sulfuric acid plant modifications is required; it may be that one of the plants in the complex is a likely candidate. Also, if the use of a major engineering firm is not feasible; then by utilizing your own organization's personnel resources, doing a careful review and planning, it may be possible to obtain the additional production at a modest cost.

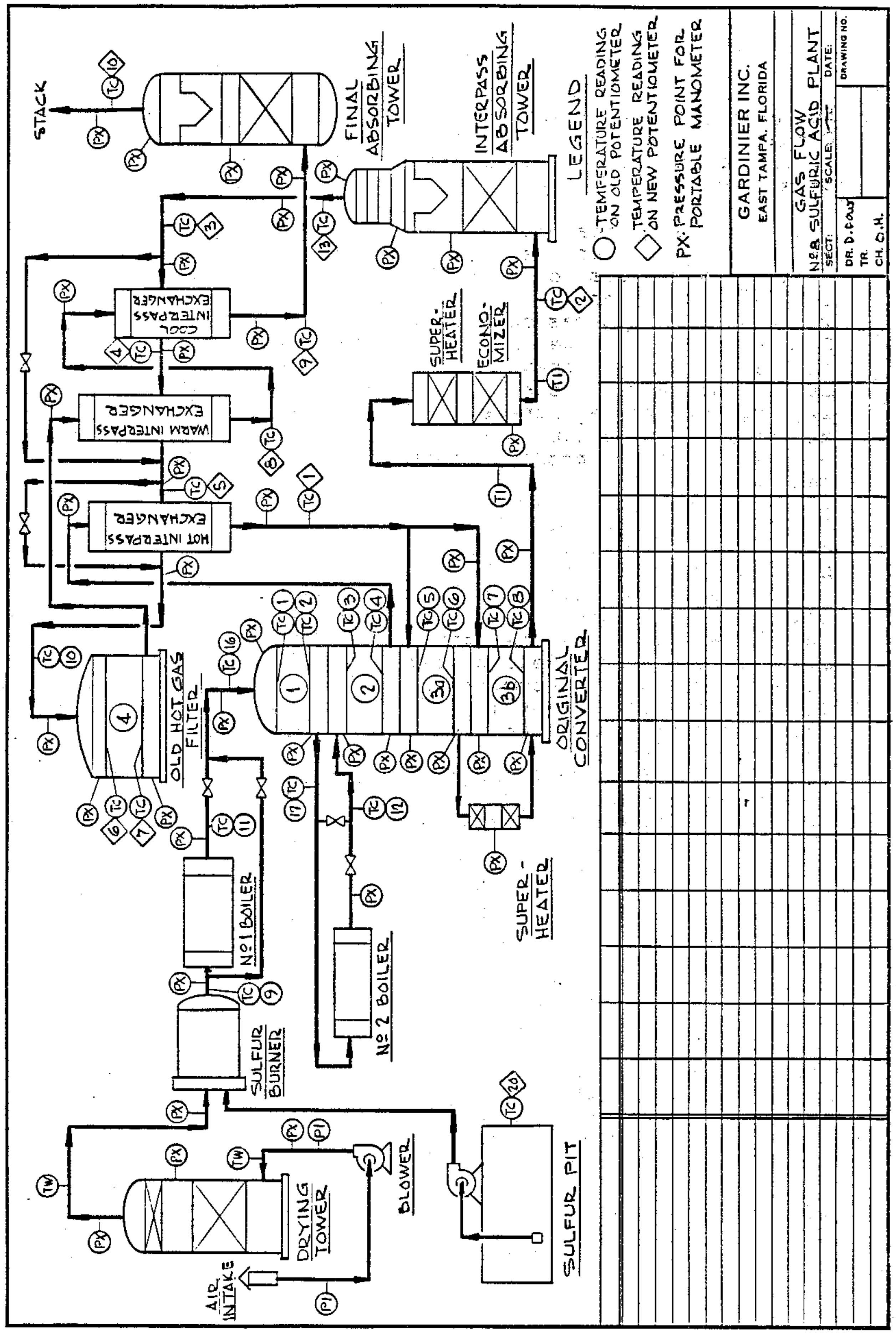
STACK
FINAL ABSORBING TOWER
INTERPASS ABSORBING TOWER
LEGEND
-TEMPERATURE READING ON OLD POTENTIOMETER
-TEMPERATURE READING ON NEW POTENTIOMETER
PX: PRESSURE POINT FOR PORTABLE MANOMETER
GARDINIER INC.
EAST TAMPA, FLORIDA
GAS FLOW
No 8 SULFURIC ACID PLANT
SECT:
SCALE:
DATE:
DRAWING NO.
TR.
COOL INTERPASS EXCHANGER
WARM INTERPASS EXCHANGER
HOT INTERPASS EXCHANGER
SUPER-HEATER
ECONO-MIZER
OLD HOT GAS FILTER
ORIGINAL CONVERTER
No 1 BOILER
No 2 BOILER
SUPER-HEATER
SULFUR BURNER
DRYING TOWER
BLOWER
AIR INTAKE
SULFUR PIT
TAMPA BLUE PRINT CO.

TABLE ONE

EQUIPMENT LIST:

1. Sulphur burner
2. Sulphur Sprays
3. Sulphur pumps
4. Sulphur flow control valves
5. Sulphur pit.
6. Dry tower acid pump
7. I.P.A.T. - 98% acid pumps
8. F.A.T. acid pump
9. Product acid pump
10. Dry and IPAT acid circulating tanks
11. FAT acid cooler
12. Dry and IPAT acid coolers
13. FAT acid recirculating tank
14. Product acid tanks
15. Main blower
16. Main blower' turbine
17. Feedwater heater
18. Boiler Feedwater pumps
19. Boiler Feedwater pump turbine
20. Boiler Feedwater pump motor
21. Boilers:
    a) Drum
    b) No. 1 boiler
    c) No. 2 boiler

22. Dry tower:
    a) Packing
    b) Distributor
    c) Spray catcher

23. Interpass Tower:
    a) Packing
    b) Distributor
    c) Mist eliminator
    d) Mesh pad

24. Final tower:
    a) Packing
    b) Distributor
    c) Mist eliminator

25. Converters: 1,2,3,4,5, masses

26. Gas to gas heat exchangers
27. Superheater exit 3A mass
28. Superheater exit converter
29. Economizer
30. Boiler feedwater storage
31. Gas damper valves
32. Boiler feedwater make-up system (offsites)
33. Control valves:
    a) Dilution water - Dry, Ipat, Final
    b) Superheated steam export
    c) Saturated High Press. steam export
    d) 50 psi. steam export
    e) Deareating heater steam make-up
    f) Product acid and flow meter

34. Electrical transformer for plant supply
35. Instrumentation
36. Gas duct sizing
37. Acid pipe sizing

TABLE 2

OPERATING DATA - GAS FLOW PRESSURE DROP

	Before Modification 1981	After Modification 1985
Production rate (STPD 100% H_2SO_4)	1750	2050
Blower RPM	3100	3080

<u>PRESSURE SURVEY (in. H_2O) :</u>

	Before Modification 1981	After Modification 1985
Blower discharge pressure	165	177
First Mass inlet pressure	137	135
First Mass pressure drop	4.5	5.0
Second Mass pressure drop	9.25	9.75
Third Mass inlet pressure	104	99.5
Third Mass pressure drop (3A)	8.0	3.0
Superheater pressure drop	7.75	1.0
Fourth Mass pressure drop (3B)	10.0	4.0
Fourth Mass exit pressure	78.25	94.25
TOTAL PRESSURE DROP (from Inlet to the 3rd. or 3A Mass, to the Exit of the 4th. or 3B Mass)	25.75	5.25

TABLE 3

OPERATING DATA - TEMPERATURES

	Before Modification 1981	After Modification 1985
Production Rate (STPD 100% H_2SO_4)	1750	2050
SO_2 Concentration exit burner - % SO_2	10.6	10.9
SO_2 Emissions - (lbs./daily ton.)	2	2.9

	TEMP. F	TEMP. F
Ambient Air	80	29
Burner Exit	1855	1875
Temperature Rise - First Mass	334	317
Second Mass	178	125
Third Mass (3A)	61	83
Fourth Mass (3B)	19	83
Fifth Mass (4th.)	29	45
Temperature Exit the Second Mass	986	935
Entrance 3A Mass	--	830
Exit 3A Mass	--	913
Entrance 3B Mass	--	809
Exit 3B Mass	--	892

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