SULFURIC ACID PLANTS FOR
THE 1980's

BY

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In previous papers presented to this group, we have discussed corrosion, sulfuric acid cooling, and energy recovery from sulfuric acid plants. This paper will discuss sulfuric acid plant design in general but is aimed specifically at the role of the sulfuric acid plant in the typical phosphate fertilizer site one finds in central Florida.

The fertilizer industry in central Florida is a major generator and consumer of energy in a State with a growing population and no indigenous energy resources. The industrial sites and the individual processes were also developed and the plants designed in times when (a) energy costs were low; (b) energy was readily available, and (c) when keeping such plants as sulfuric and phosphoric on line was a major challenge in itself.

The seventies brought a number of changes industrially of which environmental pressures and a changing energy scene were the key changes. Both of these factors as well as the availability of newer materials and equipment has forced companies to re-examine their operating practices and see if better economies could be obtained on their production sites.

If one reviews site practices, the sulfuric acid plant as an energy source feeds an energy consuming site with the phosphoric acid plant being the prime consumer. Steam generated in the sulfuric plant is initially at high pressure allowing a letdown to either 50 psi for low pressure uses or to condensing conditions where there is more available than is required as LP steam. The bulk of the steam is typically used to evaporate water from the phosphoric acid.

Some simple basic facts which may be of interest:

(1) In manufacture of one ton of sulfuric acid, approximately 5,000,000 BTU's of heat are evolved which is equivalent to the net heating value of 1 barrel of oil now worth about $30. This value corresponds to a value of $6 million of BTU's vs $3-4 cited in most references and discussions in the past.

(2) One ton of sulfur makes three tons of sulfuric acid and releases 15,000,000 BTU's. The fuel value of the sulfur is thus signicant in terms of its total cost, with the fuel credit ranging as high as $90/ton vs its present value of around $100 F.O.B. Tampa.

(3) A typical sulfuric acid plant throws away 40 to 45% of this energy as low grade heat in the associated acid cooling system. The remaining heat is recovered in the form of high pressure superheated steam.

If one wishes to improve the overall sulfuric acid plant energy balance, it is necessary to:

(a) Increase the amount of energy in the steam system;

(b) Decrease the consumption of energy in the sulfuric acid plant itself.

Two ways by which more energy can be fed to the steam system are (a) improvements in economizing heat from the SO_3 gases and (b) locating the blower such that the heat of compression goes to the sulfur furnace and not to the acid cooling system.

On improving the economizing, two sources are available, the SO_3 gas going to the primary absorber, and the SO_3 gas going to the final absorber. Limitations on the extent to which one can economize are set by the need to avoid condensation of sulfuric acid vapor on the heat exchange surface and the resulting corrosion. Recoverable energy by better economizing in a 2000 TPD plant is in the order of 20,000,000 BTU/hr. and involves only use of extra heat transfer surface.

Traditionally in sulfur based sulfuric acid plants, the blower has been placed before the drying system so that it can handle ordinary air and the pressure developed by the blower has been maximized so that the plant equipment size and cost could be decreased. Neither the location nor the decision to accept a high pressure at the blower discharge make economic sense today and they make even less economic sense for the future.

Relocation of the blower to handle dry air instead of ordinary air offers the opportunity to save the compression energy used to cause the air to flow through the process, a saving in heat of 12,000,000 BTU/hr. in a standard 2000 TPD plant. As well, the heat rejected from the acid cooling system and the cost of the acid cooling system are reduced. The sole risk is one of damage by acid carryover which has been proven in both metallurgical and sulfur burning plants to be quite manageable.

A further and more significant area of improvement in the main blower energy consumption is also available on consideration of the pressure requirements of the process. Present plant designs are based on a blower discharge pressure in the range of 200" of water (7psig). The power requirement in such a typical plant in the main blower alone is close to 5000 HP. Redesigned plants with a pressure rise of 120" are clearly feasible and would offer a reduction in power requirement of one third, without a substantial penalty in plant cost.

Combining the improvements already cited, the plant heat input to the steam system has been increased over 10% with a decrease in the cooling system heat load of 25% and at the same time, almost 1500 HP have been saved in the acid plant itself.

A further potential saving in energy is possible within the steam system itself where steam is now used to heat water and to strip out dissolved oxygen in the deaerator. Waste heat from the plant could be used for this purpose, thus saving low pressure steam.

Summarizing the acid plant of the future as a result of the changes already discussed, we have the following table:

2000 TPD H_2SO_4 Plant

		NOW	FUTURE
1.	Heat to Steam System (BTU/hr.)	240,000,000	278,000,000
2.	Internal Power Use (HP)		
	- fixed users	2000	2000
	- main blower	4500 (200"WC)	3200 (120"WC)
		7000 HP	5200 HP
3.	Heat rejected in Acid Cooling System	160,000,000	122,000,000 BTU/hr.
4.	Energy Gain	-	(1800 HP + 38 x 10^6 BTU/hr.)

All of the previous work has been based on a thermal value for energy, an assumption which is not true in most of the Florida fertilizer sites where there is already sufficient steam from sulfuric acid manufacture to allow the phosphoric acid plants to run. To be of value, extra steam must (a) replace fuel; (b) generate power, or (c) allow an increase in plant capacity or flexibility. Let us consider the potential improvements in terms of high level energy and low level energy.

Identifiable uses for high quality energy include (a) generation of mechanical power such as in the main blower, or (b) generation of electricity in extraction or condensing turbo-alternator sets or conceivably (c) use of such steam to heat air for dryers where solid products are made e.g. DAP or MAP.

Evaporation of water at high temperature could also fit in this category. The first two uses are well known to most acid plant operators although (b) is undoubtedly more economic as the size of the site increases. Use (c) clearly does not require any massive innovation but the best of my knowledge has not yet been used in the U.S. industry. Obviously, steps which increase the quantity of steam available and steps which minimize the internal use of high pressure steam will improve this power generating capability. The changes (shown in the previous table) for instance, result in over 2500 KW extra power now worth close to $900,000/year.

For low level energy from the circulating acid that is now rejected to cooling water or air, there are a number of potential users, some of which have already been discussed. Generally, the best use of such energy is to free up higher quality energy. It is also possible to pass such energy through low level Rankine cycle systems to generate power. One such system is in existence in a sulfuric acid plant on a pilot plant scale. The efficiencies of such systems are relatively low.

Summarizing, the following uses are either proven or practical for energy from the acid cooling system.

(1) Heating of boiler feedwater or condensate.

(2) Generation of sub-atmospheric pressure steam (possibly with subsequent compression to more useful pressure levels). Both of these steps are proven industrially.

(3) Use in a Rankine cycle to generate power - not yet well proven on an industrial scale in sulfuric acid plant.

(4) Production of hot water for process or heating duty e.g. buildings, town heating. Such energy recovery schemes are well proven but not very likely in Florida.

(5) Process heating in phosphoric acid plant including:

   - preheating of the phosphoric acid feed to the evaporators;
   - heating of wash water.
   - as a replacement for LP steam in the evaporative section, and
   - heating of pond water.

(6) Heating of ammonia and phosphoric acid prior to reaction to form MAP or DAP as a means of cutting hot air and fuel requirements in product drying.

Which of the recovery systems will fit a given site requires detailed study of the individual site to determine benefits and return on capital invested in energy recovery.

Energy Utilization Comparison

	PRESENT	PROPOSED
Steam Generation Rate (lbs./hr.)	200,000	232,000
Steam Use (lbs./hr.) at LP conditions		
- sulfur	15,000	15,000
- phosphoric plant	130,000	20,000
	145,000	35,000
HP Steam Available for Power (elect. or mech.) (lbs./hr.)		
- (a) 600 psi to 50 psi	145,000	35,000
- (b) 600 psi to condensing conditions	55,000	197,000
	200,000	232,000
Total Power Generation (KW)	11,800	19,900
Internal Consumption in H_2SO_4 Plant	4,700	3,900
Net Power Available KW	7,100	16,000
Net Gain (KW)		8,900

Combining the previous work on energy availability with the assumption that most of the low grade heat will be used, a comparison has been made between what I would classify as conventional practice and the technology I expect to see in the middle and later part of the 80's. The evaluation suggests around 10 MW more electrical energy available per 2000 ton sulfuric acid operation. The overall power availability per plant would be in the 15 - 20 MW range, a change which ought to go a long way towards making the fertilizer sites almost independent of grid power. Such a change would represent a significant overall energy saving as well as improving the competitive position of the industry.

BIOGRAPHY

GORDON M. CAMERON, who earned his B.Sc. at Queens University, Kingston, Ontario and a Ph.D. from the University of Delaware, has been Technical Manager of Chemetics International Ltd. since 1975. Prior to this appointment, he was Process Engineer and Technical Superintendent at the Copper Cliff Works in Sudbury, Ontario.