"A RETROFIT ENERGY ENHANCEMENT PROJECT CAN IMPROVE YOUR PROFIT PICTURE"

PRESENTED AT CENTRAL FLORIDA AND PENINSULAR FLORIDA SECTIONS OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS JOINT MEETING

MAY 1982

AUTHORS

D. P. BIGGERSTAFF, P. R. MINBIOLE, AND J. R. SHAFER

MONSANTO ENVIRO-CHEM SYSTEMS INC.

ST. LOUIS, MISSOURI

Most major new phosphate fertilizer complexes being built today include a turbogenerator for cogeneration of electrical power. The reason is cogeneration provides a significant opportunity to improve the economics of producing phosphate fertilizers. For example, Monsanto Enviro-Chem has participated in projects for International Minerals and Chemical, Occidental, U.S.S. Agri-Chem and W.R. Grace, all involving new sulfuric acid plants with a turbogenerator. Currently we are constructing a 2000 STPD sulfuric acid plant that will support a phosphoric acid plant and a 13 kilowatt turbogenerator. At $0.05/KWH the electrical power from this operation represents a savings of about $24/ton of sulfur consumed or looking at it another way, a reduction of about the same amount per ton of P_2O_5 in the cost of manufacturing phosphoric acid. With savings of this magnitude, cogeneration probably represents the best opportunity for the fertlizer manufacturer to fight the tough squeeze in profit margins brought on by spiraling manufacturing costs and depressed fertilizer prices. As mentioned, most new fertilizer complexes are taking advantage of the benefits that can be derived through cogeneration. However, it is realized that not every fertilizer company has a new plant under construction, and unfortunately probably will not for some time to come. Therefore, the purpose of this paper is to give some insight as to the potential for existing plants to take advantage of this opportunity.

Before proceeding with this subject, it may be of value to briefly discuss why cogeneration is economically viable today. There are two major reasons: one is the relative escalation of energy costs versus capital costs, and the other is recent federal regulations.

Appendix I is a plot of escalation versus time for new plant construction capital costs and for energy costs. Using 1972 as a base year, we see that capital costs have almost doubled in eight years. During this same time frame, energy costs have increased almost fivefold. This means the value of energy has increased at a significantly higher rate than capital. As an illustration, let's take a hypothetical 15,000 kilowatt turbogenerator project. In 1972, the capital cost may have been $5M. By 1982, as we've seen, the cost has doubled to about $10M. The electricity produced by the 15,000 KW was worth approximately $700,000 per year in 1972 and by 1980 it increased nearly 5 times to $3.3M per year. Thus, in 1972, our project would have had an unattractive payout of 7 years. But by 1980, the project becomes viable with a 3 year payout. This illustration clearly points out that the economics of energy related projects has improved dramatically in the last 8 years, and the experts predict that this trend will continue into the 1990's.

The second factor effecting cogeneration today is the federal government. In 1978, Congress passed the Public Utilities Regulatory Act or PURPA. In 1980 the Federal Energy Regulatory Commission (FERC) promulgated PURPA regulations. The intent of this legislation was to stimulate cogeneration in private industry. The term cogeneration means using an energy source for both process needs and to produce electricity. A sulfuric acid plant fits this description. PURPA requires utilities to do three things:

(1) Connect in parallel. This allows the cogenerator to tie into the local utility's power distribution system.

(2) The utility must supply standby power. That means when a cogenerator's facility goes down the utility must supply his needs.

(3) The utility must purchase excess power produced by the cogenerator at its avoided cost.

PURPA also exempts qualifying facilities from utility rules and regulations, such as the Federal Power Act, Public Utility Holding Company Act and laws concerning rate schedules.

Simply stated, PURPA obligates local utilities to cooperate with private industry on cogeneration projects. This key principle has remained intact following challenges to the PURPA laws in the courts. It should also be noted that PURPA applies to cogeneration projects in existing facilities as well as grass roots projects.

We have now seen why cogeneration is economically viable today, so it is time to look at the technical side of cogeneration in a phosphate fertilizer complex. Generally speaking, with sulfur as a fuel source, there is a net excess of energy in a fertilizer complex in the form of steam. At many existing sites this net excess is simply being vented to the atmosphere, as there is not sufficient quantity to support a turbogenerator. The key then is to modify the operations to increase the steam production in the sulfuric acid plant and/or reduce the site steam consumption (in the sulfuric acid plant as well as in the phosphoric acid plant and related operations). In other words, the objective is to optimize the existing equipment based on today's economics. For this, a good starting point is to look at the technology that is being implemented in new plants.

It is beyond the scope of this paper to review in detail the entire list of energy-efficient design features that fall in this category, however, some of the major ones will be highlighted.

Increasing SO_2 gas strength is one of the more lucrative items as it has the double-edged advantage of increasing steam production as more energy can be recovered from the gas stream and reducing steam consumption of the main compressor turbine as the gas volume is reduced. Operation at up to 12% SO_2 is now possible. Of course catalyst is the key to operating at this high gas strength. Monsanto Enviro-Chem has expended considerable effort in this area and confirmed that our catalyst can achieve the required overall conversion while maintaining normal safety margins.

Another design approach is to recover more energy from the gas stream prior to the absorption towers. Plants historically have recovered some of this energy through the use of economizers and superheaters, but recovery was limited due to potential acid condensation and resulting severe corrosion problems. Here again Monsanto Enviro-Chem has developed low temperature economizer technology to allow reliable recovery of much more energy. For example, in one recent modification for a plant using bright sulfur, a design temperature of 270°F to the absorption tower was successfully demonstrated. This modification represents a 15% increase in steam production.

Operating at higher steam pressures and superheat levels provides an opportunity to increase the efficiency of the turbogenerator. Normally these conditions have been set at comparatively low levels since the phosphoric acid plant requires only low pressure steam. However, with a turbogenerator on site, operating pressures up to approximately 800 psig and superheat up to 900°F can be justified.

Another design feature is a suction drying tower. This refers to having the main compressor downstream of the drying tower as opposed to a pressure drying tower where the main compressor is upstream. The suction drying tower is a more energy efficient design because the heat of compression of the main compressor can be converted into steam. Monsanto Enviro-Chem has developed a new mist eliminator specifically for this service -- the CS-I. It not only provides improved protection of downstream equipment, but it also provides higher reliability and longer life than mesh pads. Suction drying towers are not new as they have been our standard due to process requirements for metallurgical and spent acid regeneration plants. With today's economics the incremental capital cost of a suction drying tower is now justified in sulfur burning plants.

The major energy consumer in a sulfuric acid plant is the main gas compressor. With rising energy costs, a capital expenditure of $20,000 is now typically justified to save one inch of water column gas side pressure drop on a 2000 T/D plant. The inherent pressure drop of commercial vanadium sulfuric acid catalysts have been gradually reduced over the last several years. The most recent new products are the Monsanto Enviro-Chem LP (low pressure drop) series of catalysts, LP-120 and LP-110. These new catalysts can be used as liter-for-liter replacement for existing high-activity Monsanto catalysts. Their outstanding advantage is their inherent pressure drop characteristics which are 30-60% lower than the previous Monsanto products. Low pressure drop catalysts save energy in the form of electrical power or high pressure steam, whichever is used to drive the main gas compressor. In addition, these high void fraction catalysts have more dirt-holding capability and thus the acid plant will be able to operate with longer intervals between shutdowns to screen the catalyst and remove dirt accumulation.

These examples highlight energy enhancement features for new plants. The question is whether such features be incorporated into an existing plant in a retrofit mode to help justify a turbogenerator. Certainly the economics of a new plant might be different than the economics of modifying an existing plant in terms of capital costs. With this in mind, a case study was conducted. The study was based on two 2000 STPD sulfuric acid plants and a corresponding 1400 TPD phosphoric acid plant. For this study a list of more than 100 enhancement features were considered in both the sulfuric and phosphoric plants. This list was reviewed and screened using an investment equivalent of $1500/KW. This means that it is economically justified to invest $1500 capital for each incremental KW of power produced. $1500/KW equates to a simple payout before taxes of 3 years and $0.06/kilowatt hour electricity. For the case study, capital cost and the corresponding energy produced were determined for each energy enhancement feature. Also the incremental capital cost for the incremental turbogenerator capacity was established and added to the capital cost of each feature. Each feature was then compared to the $1500 investment equivalent to determine viability.

The case study resulted in the following retrofit energy enhancement project:

Scope: Low temperature economizers, increased steam superheat level, mechanical vacuum pumps for phosphoric acid attack tank cooling, suction drying tower, low pressure drop catalyst, increased SO_2 gas strength and a turbogenerator.

Capital Cost: $11,000,000

Electricity Produced: $5,500,000/Yr.

Payout (Before Taxes): 2 Years

This case study indicates that there is an outstanding potential for economical retrofit energy enhancement projects in existing fertilizer complexes. Of course every specific site is different in terms of the number and size of sulfuric and phosphoric acid plants, age and type of the units, and product mix.

These factors are the classical difficulties where the design basis can be well defined from an engineering standpoint. Because of the constraints and variability encountered when performing retrofit projects as compared to grass root projects, care must be taken in developing the scope for a retrofit energy project. If a site is complex in terms of multiple number of units, a suggested program is to first perform a preliminary evaluation of the specific site to determine the potential for such a project. If the results look encouraging, then a detailed evaluation is recommended to define the project scope and economics with sufficient accuracy and confidence level to make a decision to proceed with the project. By developing the project in this manner, there are two opportunities to review the scope and economics before committing major capital for the project.

To this point the discussion has addressed cogeneration retrofit projects. There are also locations in which the existing sulfuric acid plant does not export enough steam to satisfy site steam requirements. Consequently the steam supply must be supplemented with fuel fired auxiliary boilers. These locations also offer an opportunity for retrofit energy projects. By increasing steam production from the sulfuric acid plant, the fuel for the auxiliary boiler can be reduced or possibly eliminated. The economics for this type of project can be extraordinarily attractive since the project does not carry the capital burden of a turbogenerator.

To summarize, escalating energy costs and federal cogeneration regulations have influenced the development of new technology and subsequently the design of fertilizer complexes being built today. These complexes have been optimized to cogenerate electrical power and thus are realizing a significant reduction in manufacturing costs. Further, the combination of cogenerator regulations, energy costs, and new technology also provides an outstanding opportunity for existing fertilizer complexes. This opportunity has been quantified in a case study and in many site-specific studies, demonstrating that a retrofit energy enhancement project is economically attractive in most phosphate fertilizer complexes.

/rm/G30i

Appendix I

PURCHASED ENERGY

vs

PLANT CONSTRUCTION