STATUS REPORT ON OCCIDENTAL'S HEMIHYDRATE PROCESS

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In late 1979 Occidental's Swift Creek hemihydrate process phosphoric acid plant was commissioned and at the 1980 Clearwater meeting we presented several papers on the design, startup and early operation of the Swift Creek Complex. Now, three years later, we are here to present operating data, discuss modifications and improvements and to show that the choice of the hemihydrate process has been amply justified.

The process was selected on the basis of economics derived from the design parameters of the plant, and it now seems appropriate to present comparisons of operating data with those design parameters. So throughout this paper, the comparisons represent improvements made during commercial operation of the plant.

At the outset, it is noted that there were no major design or equipment problems that caused significant downtime or process losses. Such problems were recognized and overcome in developing the smaller prototype plant at Suwannee River Complex in the three years prior to process selection for the Swift Creek plant. This meant that there was reasonable confidence in the design parameters, but the economic justification over the predicted 20-year life of the plant could not allow much conservatism in design, in view of increasing competitiveness in the industry. The design was made on the basis of proven performance of the prototype, and in the economics there was no allowance for future improvements, although they were expected. The expectations have been realized steadily over the three years, and we believe that overall performance will continue to improve. Occidental continues basic research of the process through its phosphate group at Occidental Research Corporation, under the direction of Dr. Fernando Ore. During these difficult economic times when many research programs are being reduced or eliminated, OXY is making a determined effort to maintain its leadership in hemihydrate technology, and the Research program is part of this sustained effort. It is also an acknowledgement by Corporate Management of the success of the process. Dr. Ore presented a paper at the Fertilizer Round Table last October describing this research.

Before going into details, for those who do not know the process or plant configuration, the Swift Creek plant consists of split reaction trains, each side having a rock slurry tank, dissolver and crystallizer, followed by a single filter feed tank and Ucego table filter. The plant was designed for 1433T/D P2O5, or roughly 1 ton/ minute, and operates on wet unground rock. The hemihydrate cake is repulped in pond water and pumped to a stacked settling area. All the product acid is converted to superphosphoric acid, after a purification step by another Occidental proprietary process. Most of the electricity to power the complex is generated on site from steam made available largely by the increased strength of filter acid from the hemihydrate process.

When the plant was built, there were many unknowns concerning the operation; for example, how would the cake disposal system function, especially with respect to hydration? Also, the operation of the first of a line of huge new filters was, of course, untested. It was like a novice bidding 7 no trumps without knowing if the game was played with a joker or not. Bridge experts know that there is no joker, but we had no hemi experts in those days. As it turned out, there was no joker or jinx on the process, and some of the many benefits or improvements reported here result directly from that.

For this discussion, improvements have been divided arbitrarily into five categories for detailed discussion:

1. Learning to operate the plant
2. Coping with variations in feeds
3. Equipment modifications and changes
4. Process improvements
5. Improved cleaning and maintenance

1. Learning to Operate the Plant

One of the 1980 papers previously referred to discussed the training procedures, which were extensive and thorough. Operators and supervisors became familiar with the physical plant during the final weeks of construction. An identical control console and simulator were set up in Occidental's training school for hands-on training. Of course, no amount of simulation can duplicate the real thing; the dynamic responses or the sounds of an operating plant, from which operators learn to allocate their attention for maximum effectiveness. The training program paid off in the remarkably smooth startup of the whole complex. One cannot define the learning process absolutely, because it interacts with every aspect of the operation; but I think it is reasonable to state that a high level of operating proficiency was reached within six months of startup, and is still continuing. Improved operation has come despite unusually heavy labor turnover; only eight of the original 20 hourly personnel, and two of four supervisors are still with the plant. Ten changes resulted from the union seniority rolling procedure during layoffs in other departments. Significantly, not one operator has voluntarily left the hemi area. Also significant is the average age of the operators--only 24 years, with 16 months average experience with Occidental.

In the learning category I include management, because the learning function extends throughout the organization. Every plant has its problems and unknowns, and Swift Creek has benefitted from progressive and responsive management.

The numerical aspects of operation include operating factor and tonnage. The design operating factor was 75%, and with corrections for market constraints, this has been achieved or bettered each year. There has not been a year without marketing constraints, which included the embargo on shipments to USSR, and the overall depressed market conditions, so the plant has not been fully extended. Tonnage produced has increased each year, and in 1982 was 90.3% of design. Again, marketing constraints reduced this figure by an estimated 7%. The actual operating rate analysis is interesting, and for 1982, shows that about 11% of the reactor time was at less than 1000 T/D, much of this being single reactor train operation. With both reaction trains operating, nearly 59% of the time the operating rate was at rates above 1400 T/D, and 27% above 1600 T/D. The highest daily production achieved was 1826 tons (1.27 x design), and 1035 T/D on one train (1.45 x design). Each represents the maximum attainable rate to the limit of pumping capacity. This table shows the areas where improvement is possible by a general shift to the right. For instance, the zero rate on 29 days, which includes turnarounds, extended repair/cleaning days and some market constraints downtime, obviously can be reduced. Extending the periods between reactor cleanouts will reduce total downtime, and because reactor cleanouts are staggered, column two (which is largely single train operation), will be reduced. This improvement, together with removal of market constraint downtime, should bring production up to design, and further operating improvements will allow excess production.

This analysis has been made in some detail to demonstrate that overall operability of the hemihydrate plant is not greatly different from dihydrate plants with which all of you are familiar.

2. Variations in Feeds

The design was based on 68% BPL (dry basis) feed rock, and fresh water filter wash, the latter being chosen as a convenient base for calculation rather than planned operation. In any case we had no prior experience with pond water in a purely hemihydrate based system.

Rock feed variations caused particular problems, especially in the first year or so of operation before in-plant analytical procedures were satisfactorily resolved. Fluctuations up to 3% BPL between shifts were not uncommon, and grade dipped as low as 59% BPL. Moisture variations in the wet rock contributed to control problems, since the automatic moisture compensation was not reliable. It also took some time to recognize that the process responded to subtle changes caused by variations in beneficiation operations, particularly with respect to foaming, which will be discussed later.

Pond water problems are mainly with scale on screens, valves and nozzles. As the pond water concentration built up and stabilized over the first year of operation, these problems became evident, and equipment changes were made, particularly spray nozzles. There is scope for design of equipment that allows individual spray nozzles to be removed and cleaned or replaced without shutdowns.

3. Equipment Changes

Earlier it was stated that there were no major equipment problems that caused significant downtime or losses; this should not be interpreted to imply that everything was perfect. Of the 89 items of major equipment, 26 have been modified or eliminated (excluding small changes such as substituting packing for seals or vice versa). Some changes were relatively expensive, such as switching from hydraulic drives to the more reliable variable frequency drives, converting the filtrate pumps to recessed impeller models, and eliminating the suction side scale removal tanks which were unsatisfactory. Some relatively minor changes were made in agitator speeds and configurations. The original shell and tube wash water heaters were replaced by a single maintenance free direct injection heater. The defoamer pumps were changed, to cope with problems caused by transfer of defoamer from the remote bulk storage tank.

Piping modifications probably number in the hundreds, and range from duplication of the return acid line to change of materials for certain reducers. Included in the piping changes are valve changes, which have been significant. We now have a considerable number of hydraulically operated knife-gate valves, all powered from a single system. The knifegate valves, first used by Occidental in 1979 in a dihydrate process, have overall superiority in many difficult applications. Another equipment change is that the lamella thickener originally installed to reduce solids in the filter acid before evaporation is no longer used, mainly because solids are low and post precipitation is negligible.

The cooperation of many equipment manufacturers and suppliers in working with us on improved materials and designs undoubtedly has contributed to the success of this plant. This cooperation continues but the emphasis is now towards the maintenance function.

4. Process Improvements

This is the category in which the greatest benefit has been realized since startup, particularly with respect to cake losses. In 1982, the losses averaged 6.17%, which is a significant cost saving over design. An area where performance was less than design was defoamer consumption, but late in 1982 a change immediately reduced consumption to about half of the design figure, and other less obvious benefits have also shown up e.g., reduced entrainment. There was one unexpected side effect with the new material, and we now have to add a small amount of defoamer at the cake repulp tank to control foam and avoid gas locking of the cake disposal pumps.

Process improvements have also resulted from improved in-plant analytical methods for sulfate and calcium. The latter is necessary in hemihydrate technology for maintaining the correct range of monocal concentration in the dissolver.

Another process saving recently instituted was in reduction of cake wash temperature, with a steam saving of about 9000 lbs/hour, and no measurable effect on water soluble loss. It is relevant to note that the hemihydrate cake is easily washed, and that water soluble losses average less than 1/2%.

5. Cleaning and Maintenance

Much of the downtime of phosphoric acid plants is necessitated by cleaning, and the hemihydrate process is no exception. This was recognized in the early stages of development, and stabilization of the process was identified as important for reducing scaling and buildup--particularly in the crystallizer circuit, where the energy saving low head agitators are fairly sensitive to flow restrictions, and it is necessary to maintain operating clearances in these vessels. At first, the Swift Creek vessels were inspected and cleaned every three months. Now, with better process control, and new diagnostic techniques for gauging vessel fouling the period between shutdowns has been extended to six months.

Scheduled washing of the Ucego filter has also been extended, to three weeks. In addition, each three weeks one-quarter of the filter is thoroughly cleaned, including cells and cell pipes. Probably most people have heard the horror stories about hemihydrate cake setting up on filters during power or other interruptions. OXY has never had such an experience for two main reasons;

1. The hemihydrate formed in this process is relatively stable, and there has been adequate time to clean the filter manually on the one or two occasions necessary.

2. Swift Creek Complex is not subject to power interruptions or failures of the supply grid, because it is practically self-sufficient in power. During external power interruptions, non-essential use of electricity is shut off, and normal production maintained in most areas.

As one would expect, there are some areas where maintenance cannot be compromised on quality of workmanship or materials. An example is the sulfuric acid injection system inside the crystallizers. Failure of any part of this system will quickly and inevitably lead to shutdowns, and in fact, many of the unscheduled shutdowns have been for this reason. Sensitivity of the process to failure in the sulfuric system is due to the much lower mixing velocities in a draft tube agitated system compared with open tank agitation. This is one negative point compared with the many advantages of draft tube agitation, but it has been successfully overcome with good design and maintenance.

Overall maintenance requirements have been lower than projected, even with most of the modifications in the first three years being charged against maintenance. The dedicated maintenance force has been reduced, and currently consists of 20 fulltime hourly workers, two part-time (crane crew) and three supervisors.

CONCLUSIONS

In three full years of operation, Occidental's large hemihydrate plant has surpassed its original goals and achieved considerable maturity. Process and plant improvements continue, with close ties maintained between plant operations and basic research.

As energy becomes more expensive, the advantages of the hemihydrate process become more pronounced, and we now enjoy the full benefits of the foresight and effort it took to develop the process.

Occidental is now sharing these benefits with the phosphate industry through an active licensing program, developed in cooperation with several leading engineering companies. Pilot plants at White Springs, Florida and at Occidental Research in California are used for evaluating feed rocks and generating data for plant design.

SWIFT CREEK HEMI PLANT
ANALYSIS OF 1982 OPERATING RATES

	Rate While Running T/D						
	0	1-1000	1000-1200	1201-1400	1401-1600	1600+	Total
Days	29	37	31	92	96	80	365
%, Raw Data	7.95	10.14	8.49	25.21	26.3	21.9	100
%, Excluding Zero Days	-	11.0	9.2	27.4	28.6	23.8	100 (336 Days)
%, Excluding 1 Train Operation	-	-	10.4	30.8	32.1	26.8	100 (299 Days)