The Umm Wu'al Phosphoric Acid Plants – A Success Story

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Prepared for

AIChE 2019

Clearwater, Florida

June 7-8, 2019

Abstract:

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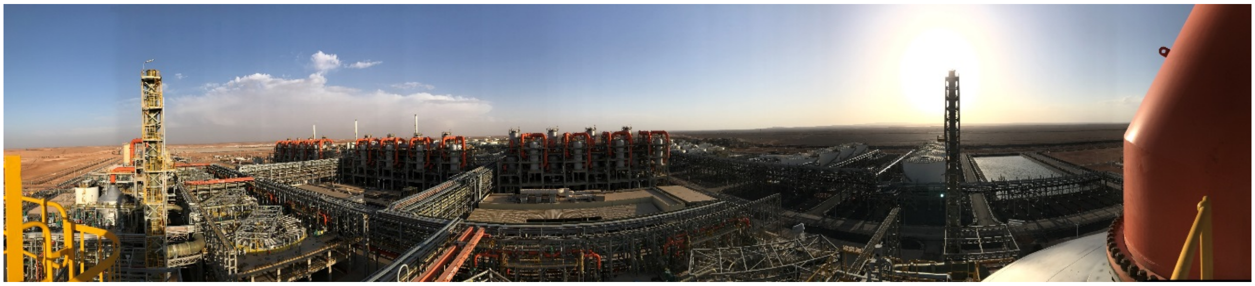
As a part of the overall Umm Wu'al Chemical Complex in Saudi Arabia, three phosphoric acid plants were constructed and are currently in operation. Ma'aden and Mosaic joined together to spearhead the project management and develop a world-class phosphate operation. Jacobs was selected to provide the technology for the phosphoric acid plants and perform Basic Engineering. As a part of the overall strategy, Hanwha was awarded the EPC contract to include Detail Engineering with support from Jacobs and as managed by the joint team from Ma'aden and Mosaic. This model of project execution resulted in some of the best operating plants in the world. All three plants met all performance parameters within a short period of time after start-up. This presentation describes the project execution from Basic Engineering through construction and culminates with Process Performance Test results.



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Introduction

Ma'aden's second large scale phosphate project is centered around the Turaif area of northern Saudi Arabia. The complex is large and contains several world scale plants. Within this complex resides three phosphoric acid plants, which are the focus of this paper.

Ma'aden Phosphate Company (MPC) which operates the first Ma'aden phosphate project was a joint venture between Ma'aden (75%) and Sabic (25%). In contrast the Ma'aden Wa'ad Al Shamal Phosphate Company (MWSPC) team, comprised of Ma'aden, Mosaic, and Sabic with an interest of 60%, 25% and 15%, respectively. The Mosaic involvement was a significant change from the first project.

Ma'aden decided to evaluate other phosphoric acid technologies rather than copy the hemi-hydrate (HH) technology that was used in their first project. After the evaluation Ma'aden decided to proceed on the basis of di-hydrate (DH) technology for the MWSPC project.

Jacobs was selected as the licensor for the phosphoric acid plants (PAP). The Jacobs team worked closely with the project team throughout the engineering and construction phases and the result was some of the best operating plants in the world. Since their start-up in 2017, the plants have been resilient and consistent in producing at or above design parameters. This paper discusses the project processes that made this project successful and shares the respective performance guarantee results.

Keys to Success

Jacobs was selected to provide the Process Design Package and perform Basic Engineering. It is critical to any project that design decisions be made earlier rather than later as early decisions have a greater influence on the project direction and outcome.

For the PAPs, Jacobs was able to maintain the core team throughout the entire life cycle of the project. This provided consistency in direction for a schedule driven project. That direction was communicated with and agreed to with project management throughout all phases of the project. In fact, one of the key points was the support Jacobs received from the project team for all matters involving process guarantees, of which there were many. This is not to say the client had no input to the project, but they consistently listened and acted appropriately when it was determined process guarantees were a consideration.

It was not only the Jacobs core team that remained throughout the project, the project team also had consistency in their management. This helped foster a team approach spanning several companies where everyone was working towards a common goal.

The project team also had a well-defined structure between multiple companies. The direction, responsibilities, and execution from the team was consistent over time making everyone's roles definitive. It cannot be emphasized enough, the team presence between all stakeholders was key to making this project a success.

Project Scope

As is typical in a large-scale world-class project, the project phases were segregated into the PDP, basic engineering, detail engineering, construction, commissioning and startup concluding with performance testing.

Jacobs was selected as the licensor for the phosphoric acid plant and was also awarded the FEED and Bankable Feasibility Study (BFS) for the entire project. The FEED and BFS where managed from the Jacobs Reading office in the UK. However, the phosphoric acid PDP and FEED where executed in the Jacobs Lakeland, Florida office where the technology expertise resides.

Because the project was schedule driven, pilot plant testing was done concurrently with the PDP and finalized during basic engineering. Pending test results, a conservative approach was taken in design. But throughout basic engineering, the results of the pilot plant were used to confirm design parameters to ensure the process guarantees.

Design Basis

The design basis was for 1.5 million tons of P_2O_5 produced annually. The design had to be robust to take into account the environment, limited support services equipment procurement scheduling for spare parts and a transient multi-lingual workforce. Ease and flexibility of operation were critical considerations in the design of the plant. It was decided early in engineering that the nameplate capacities would be 1,615 TPD for each of three trains. This would allow for catch-up in production if unanticipated downtime occurred, such as power outages or other influences outside of the control of the plant.

All weak acid was to be converted to Merchant Grade Acid. This is due to the transportation requirements for moving all acid by rail to Ras Al Khair, approximately 1200 kilometers away where the DAP plants where located. The facility was also designed for zero-discharge with an integrated design to take advantage of a higher asset utilization. Product quality FSA was required, and wet gypsum stacking was selected.

A Jacobs reactor was designed specifically for the source ore and production rate. Each reactor was associated with one flash cooler with a pre-condenser for heating filter wash water and a silica removal system in the vapor ducts.

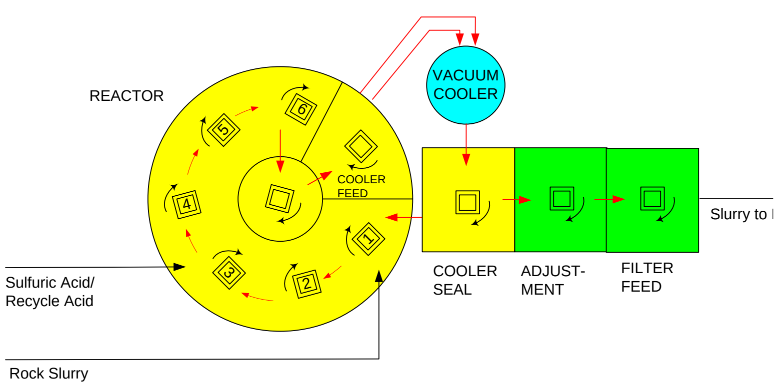

Figure 1: Jacobs Reactor

Figure 1: Flash Cooler

Two tilting pan filters were designed at 70% of the total rate to take advantage of additional production during weekly washes, provide a means to handle fluctuations in the concentrate feed, and to provide a layer of reliability should one filter go down unexpectedly.

Figure 3: Tilting Pan Filter

Because the location is arid and water sources are scarce, the water balance was a critical parameter in the plant design. Heat loads had to be accounted by utilizing non-contact cooling towers. This was done to prevent the cooling towers from becoming point sources for fluorine emissions and to protect the water from scaling ions. Consequently, the water balance is unique and multi-faceted including a dedicated vacuum pump cooling water loop, means to recover P_2O_5 in wash waters and spills, and accounts for other miscellaneous water inputs. Further, ion segregation was a primary driver in water handling to minimize scaling of critical equipment.

Cross flow scrubbers were designed specifically for the systems to include all ancillary tanks and products. They were integrated into the FSA recovery system which results in the facility complying with World Bank Standards for fluorine emissions for a phosphate facility.

Project Management

Ma'aden oversaw all plants and technologies along with assistance with Mosaic's technical expertise. The technical team from Mosaic teamed with the technical team from Jacobs to come to design decisions for the betterment of the project. This occurred in the late stages of basic engineering, but the collaboration was strategic and resulted in a team synergy that carried through the rest of the project.

At the end of basic engineering, RFP's for LSTK bids were prepared. Both Jacobs and Mosaic vetted the bidders from a technical perspective through a formal process managed by Ma'aden. This process brought to light the bidders which were the best fit for this project.

Hanwha was selected as the lump sum EPC bidder and detail engineering was performed in their offices in Seoul, South Korea. The EPC contract required Hanwha to employ Jacobs to oversee critical technical aspects through the rest of project execution. The team in Seoul consisted of Hanwha, Mosaic and Ma'aden. While the Mosaic, Jacobs, Ma'aden team remained intact, it did not take long for the Hanwha team to integrate to form a well-functioning team.

Even though this was Hanwha's first phosphate project, Hanwha is a world renown and capable EPC contractor. By integrating the technical assistance from both Jacobs and Mosaic, Hanwha was able to perform detail engineering to a high level.

All decisions were team based and the process structured to ensure the best outcome occurred. Ultimately, the Ma'aden and Mosaic team made all decisions. Where process guarantees were concerned, both Ma'aden and Mosaic backed the positions from Jacobs

Construction

Hanwha was responsible for construction on site in Saudi Arabia. Mosaic constructed a camp at site and was resident in construction oversight. Commissioning teams were supported by both Mosaic and Jacobs. The Mosaic and Jacobs team also supported the start-up.

A perfect start-up has likely never occurred in a phosphoric acid plant, but this one was close. Minor issues were identified and solved during start-up. The feed from the beneficiation plant was variable and lower quality than the design basis, but the robust design of the PAP ensured full production rates were met within one week of startup of each train.

Because of the integrated design, the Performance Tests were independently conducted on the front end and back end of the plants. Because the plants had relatively minor issues at start-up, the Performance Tests were conducted shortly after start-up.

There were many process guarantees but every guarantee was easily achieved. Some select parameters are shown in the table below.

			A Train	B Train	C Train
	Unit	Guarantee	Actual	Actual	Actual
P_2O_5 Production Rate ex filter	t/d P_2O_5	≥ 1,615	1,621	1,665	1,628
P_2O_5 Production Rate ex concentration plant	t/d P_2O_5	≥ 1,615	1,696	1,673	1,712
Reactor & Filter P_2O_5 recovery	% P_2O_5	≥ 95	96.26	96.45	96.31
Evaporator P_2O_5 recovery	% P_2O_5	≥ 99.7	99.99	99.98	99.99
P_2O_5 content of acid ex filter	% P_2O_5	27-28	27.2	27.2	27.5
P_2O_5 content of acid ex concentration plant	% P_2O_5	≥ 54	54.9	55	54.5
FSA Quality- P_2O_5	% P_2O_5	≤ 0.1	0.07	0.08	0.06
FSA Quality- % H_2SiF_6	% H_2SiF_6	≥ 22	24	23.2	23.2

Conclusion

The success of the plant is ultimately judged by the performance of the plant after startup. As can be seen from the test results above the plants are running excellently and have continued to do so since the performance tests. No plant is without its challenges, but these plants have exceeded expectations. From comments that we have received from site the operators are delighted with the robust design and the ability to handle variable feeds.

The key to success was teamwork between multiple offices and multiple companies and we want to place on record our thanks to all involved in the project.