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Revamp of the Ultrafertil Phosphoric Acid Plant

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L’atelier d’acide phosphorique d’Ultrafertil a été conçu pour produire 250 tonnes par jour de P205 avec du phosphate de Floride 66ù BPL. L’atelier a été conçu par Dorr-Oliver et comportait un réacteur annulaire et un filtre Bird-Prayon de 45m2.

L’atelier a démarré en mai 1970 et a passé un test de performance en juillet de la même année.

En 1982 on a changé de phosphate pour du phosphate igné brésilien 80% BPL de Golasfertil et Tapira. La capacité de l’atelier a été réduite à cause de la plus faible filtrabilité du phosphate brésilien. Pour surmonter cela, en 1994 on a installé un filtre à bande Eimco avec 60 m2 de surface active. Les caractéristiques de l’atelier étaient typiquement de 380 tonnes par jour et alors l’atelier a été limité par refroidissement et on a eu un entraînement excessif du refroidisseur sous vide.

En 1999 a eu lieu une réhabilitation majeure pour débloquer et moderniser l’atelier. L’opération à comporté :

- Elimination de l’ancien refroidisseur et installation d'un refroidisseur sous vide à bar niveau Prayon.
- Une nouvelle pompe à flux axial Ensival de 5450 m3/h
- Installation d’un précondenseur nouveau et remplacement par un condenseur barométrique.
- Une pompe à vide pour remplacer l’éjecteur de vapeur
- Un nouveau séparateur d’entraînement sur l’unité de concentration.
- Adjonction d’une unité de concentration de rechange .
- Amélioration des instruments de pneumatiques à un système DCS.

L’unité a redémarré en août 1999. Des informations seront fournies sur l’approche engineering employée pour ce projet, des détails sur le dessin de l'atelier et la performance opératoire.

1. Summary

Ultrafertil’s Phosphoric Acid plant was designed to produce 250 tpd P_2O_5 from 66% BPL Florida rock. The plant was designed by Dorr-Oliver and consisted of an annular reactor and a 45-m2 Bird-Prayon filter.

The plant started up in May 1970 and passed a performance test in July of that year.

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In 1982 the rock source was changed to 80% BPL Brazilian igneous phosphate from Goiasfertil and Tapira. The capacity of the plant was reduced because of the lower filterability of the Brazilian phosphate. To overcome this, in 1994 an Eimco Belt Filter was installed with 60m^2 active area. Plant rates were typically 300 tpd P_2O_5 and now the plant was limited by cooling and there was also excessive carryover from the flash cooler.

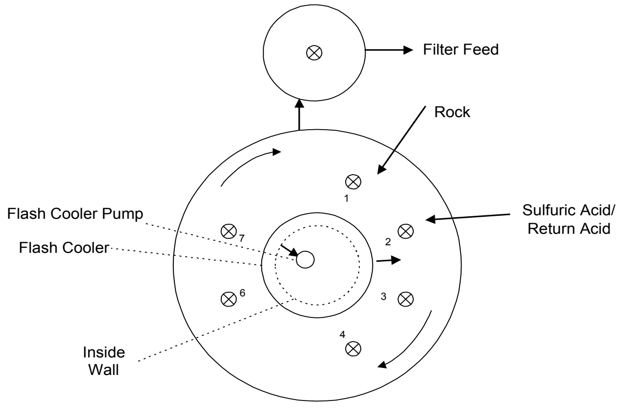
In 1999 a major revamp took place to debottleneck and modernize the plant. The revamp comprised:

- removal of the old flash cooler and installation of a Prayon Low Level Flash Cooler
- a new 5450 m^3/h Ensival Axial flow pump
- installation of a new pre-condenser and replacement barometric condenser
- a vacuum pump to replace the steam ejector
- new entrainment separator on the concentration unit
- a "spare" concentration unit added
- upgrade of the instruments from pneumatic to a DCS system.

The plant was started up in August 1999. Information will be provided on the engineering approach employed for this project, details of the plant design, and operating performance.

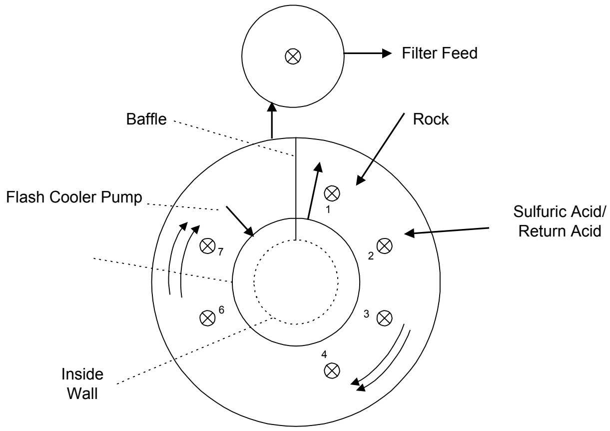
2. Original Dorr-Oliver Plant

The original Dorr-Oliver reactor consisted of an annular reactor with six agitators. The flow around the annulus is induced by the rotation of the agitators. The reactor is cooled by a flash cooler mounted above the reactor. Slurry is pumped from the reactor by a mixed-flow pump mounted in the center of the reactor. Cooled slurry overflows from the flash cooler between agitators 2 and 3. Rock is added near the No. 1 agitator and sulfuric acid and return acid near the No 2 agitator. Slurry overflows from the reactor between agitators 7 and 1 to a filter feed tank.



3. 1999 Revamp

The purpose of the revamp in 1999 was to remove the cooling restriction by adding a large flash cooler with a design cooling capacity of 500 tpd P_2O_5, to reduce P_2O_5 losses from the flash cooler, reduce energy costs, and to modernize the instrumentation system



3.1 Prayon Low Level Flash Cooler

The old flash cooler limited the capacity of the plant to about 300 tpd P_2O_5. If the plant was pushed over this rate there were several unfortunate consequences:

- the high temperature drop of the slurry through the flash cooler caused excessive scaling
- there was excessive carry-over of P_2O_5 from the flash cooler and the barometric condenser had to be cleaned every six days

To mitigate these problems a higher circulation rate and a new flash cooler with less carryover were required.

The existing flash cooler had a bottom vertical slurry inlet and a side overflow outlet. The vertical slurry inlet and small flash cooler diameter both led to high carry-over.

The new Prayon Low Level Flash Cooler has the following features:

- larger diameter
- more disengagement height
- slurry entry parallel to the floor of the flash cooler (only slightly inclined upwards from horizontal

The reactor was partitioned to provide a defined flow of all the reactor circulation through the flash cooler.

Because the flash cooler acts as a siphon, the pump only has to overcome entrance and exit losses and the line losses in the short circulation piping. This means that a high flow can be obtained with low energy input.

It was intended to lift the old flash cooler in one piece – the weight had been estimated at 140 tons empty. However, the flash cooler was not empty but contained over 60 tons of scale. The old cooler was cut into pieces and lifted out. The new flash cooler was fabricated in São Paulo and transported to site for rubberlining. After lifting into place on a new support structure, it was brick-lined.

3.2 Ensival Axial Flow Pump

The new Ensival Axial flow pump has a capacity of 5450 m^3/h at less than 1 m TDH. The pump operates at only 252 rpm and uses a 75 kW motor. The pump has performed well with no problems.

3.3 Pre-condenser

A pre-condenser was installed between the new flash cooler and barometric condenser. The purpose of the pre-condenser is four-fold:

- to heat cake wash water
- to reduce the load on the barometric condenser (reducing its size and cooling water requirement)
- to recover any P_2O_5 losses from the flash cooler and return them to the filter as cake wash where they can be at least partially recovered
- to entrain some of the non-condensables from the vapor from the flash cooler

The pre-condenser acts as a partial condenser of the steam from the flash cooler and heats the cake wash water to the saturation temperature (about 60 °C) at its operating pressure.

3.4 Barometric Condenser

A new barometric condenser was installed. The previous barometric condenser had complicated internals – it plugged easily and was difficult to clean. The new barometric condenser has a single cooling water spray nozzle and no internals.

3.5 Vacuum Pump

The steam ejectors were replaced by a vacuum pump.

3.6 New entrainment separator on the concentration unit

The concentration unit had a conventional barometric condenser and steam ejector but no entrainment separator. P_2O_5 carryover losses had been high. In the revamp project an entrainment separator designed by KEMWorks was installed.

3.7 "Spare" concentration unit added

Ultrafertil wished to increase the operating factor of the concentration system but did not need to increase the instantaneous capacity. Previously, the fouled heat exchanger was removed for washing off-line and a spare exchanger installed in its place. To reduce downtime a "spare" evaporator body, circulation pump and heater were constructed tying into a common entrainment separator and barometric condenser.

The barometric condenser was designed to withdraw non-condensables through the downleg, thus eliminating the need for a steam ejector or vacuum pump.

3.8 Upgrade of the instruments from pneumatic to a DCS system

The instrumentation upgrade proved to be the most challenging part of the project. The old pneumatic system was completely changed to a Foxboro I/A DCS system during the six-week turnaround. There were over 750 I/Os in the system.

A centralized control was built for the sulfuric acid and phosphoric acid plants. There was some initial resistance to this change because of the distance to the plants and because the control lab stayed in the old control room inside the phosphoric acid plant.

The plan to convert the entire instrumentation system to a DCS at one time proved to be perhaps over ambitious. Problems with the I/O cards meant that the DCS system had to be bypassed completely and the plant started up in manual from the local phosphoric acid plant control room. In retrospect, it might have been better to do the DCS conversion in phases.

4. Engineering Approach

Ultrafertil decided to use technology from Prayon-Rupel Technologies with engineering from KEMWorks Technology. While KEMWorks would usually supply basic engineering only, Ultrafertil found that the complete detailed engineering supply from KEMWorks was at a lower cost than could be obtained locally.

Some lessons were learned in this project in the differences between engineering approaches in the US and other countries, and in particular in this project in Brazil regarding “Detail Engineering” and “Structural Detailing.” Common practice in the U.S. assumes the engineering firm takes the drawings to a point that a qualified fabricator may make appropriate shop details from the information given on the engineering drawings. In Brazil it is expected that the engineering company is responsible for these details.

5. Capital Cost

The capital cost of the project was approximately US $4 million which included the DCS conversion for the phosphoric acid and sulfuric acid plants, a new centralized control room and new MCC.

6. Benefits

6.1 Extra Production

Average plant rates have been increased from 300 tpd P_2O_5 to consistently over 400 tpd P_2O_5. The on-stream factor has been increased from 81% to 88%, because of reduced downtime to clean the barometric condensers, longer filter cycles and generally improved reliability.

6.2 Reduction in Operating Costs

Operating costs have been reduced because of higher production steam savings (from vacuum pumps replacing steam ejectors and use of the pre-condenser to heat cake wash).

6.3 Better Control of Reactor

Operators have claimed that the reactor is easier to control. The standard deviation of the sulfate has remained at around 0.2% despite the large increase in plant rate.

6.4 Lower ΔT in Flash Cooler

The flash cooler ΔT has been decreased from 6 - 7°C at 300 tpd P_2O_5 to 3°C at 500 tpd P_2O_5.

6.5 Heat recovered from Pre-condenser to heat cake wash water

As well as saving steam, less cooling water is required for the Flash Cooler Barometric Condensers because of the new pre-condenser.

7. Future Work

The cooling capacity of the plant is now in excess of 500 tpd P_2O_5. Usually it is necessary to operate only the Eimco Belt filter to achieve rates up to 500 tpd P_2O_5 and there is sufficient additional filter area in the Bird Filter to achieve rates of over 700 tpd P_2O_5. [The plant has actually been run at rates up to 624 tpd P_2O_5 on one filter.] The restriction is now reactor volume. The lack of volume has been made more of a problem by the rock feed becoming coarser after “ultrafines” were removed for use on the slurry route SSP Plant. Concentration capacity is also limiting and the reactor strength is now maintained at over 32% P_2O_5.

Appendix

Table 1- Rock Analysis

	66% BPL Florida	**Goias**	**Tapira**	**Ultrafertil**
P_2O_5	32.65	38.16	35.53	36.5
CaO	48.38	51.42	50.26	48.5
R_2O_3	2.06	2.69	1.90	2.70
MgO		0.25	0.84	0.78
Al_2O_3		0.36	0.39	0.32
Fe_2O_3		2.33	1.51	2.38
TiO_2		1.08	1.48	
F	3.93	2.35	1.40	2.26
SiO_2	4.05	1.85	1.08	2.36
H_2O	0.74			8.81

Table 2 - Rock Feed

Tyler Mesh	**66% BPL Florida**	**Goias**	**Tapira**	**Ultrafertil**
-65	92.0	92.0	98.0	94.9
-100	77.6	77.4	93.3	78.4
-150	60.2	60.2	82.0	53.2
-200	41.0	41.0	64.6	35.3
-325	27.3	27.3	40.4	12.2

Table 3 - Performance Test Results

	66% BPL Florida	**Goias**	**Tapira**	**Ultrafertil**		
				Oct/98	April/00	May/00
Production, t P_2O_5				10128.20	1390.58	10593
Hours				662	70	654
Production, tpd P_2O_5	261	250	228	367	477	389
Efficiency – Reaction		97.93	97.45			
Efficiency - Reaction & Filtration	96.73	96.35	95.45	94.31	92.35	92.31
H2SO4 / t P_2O_5				2.359	2.335	
Rock / t P_2O_5		2.591	2.790	2.911	2.968	3.027
Rock % P_2O_5				37.08	36.40	36.37
DBS t / t P_2O_5				0.0007	0.0007	
kWh / t P_2O_5				135	165	175
Reactor Conditions						
P_2O_5		27.18	27.78			
SO_4		3.04	2.83			
Solids		24.00	25.75			
Reaction Volume, m^3	560	560	560	560	560	560
Specific Reaction Volume, tpd P_2O_5 /m^3	2.15	2.24	2.46	1.53	1.17	1.44
Filter area, m^2	45	45	45	60	60	60
Specific Filtration Rate, tpd P_2O_5/ m^2	5.80	5.56	5.07	6.12	7.95	6.48