

## **Foscálcio 2700 Dicalcium Phosphate Plant**

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## **Introduction**

In early 1997, Serrana De Mineração Ltda. asked JEATech and KEMWorks Technology, Inc. to prepare a basic engineering package for a dicalcium phosphate plant capable of producing 28 mtpd of product. The new operation would use the existing rotary dryer, elevator and screen but would require a new limestone milling and transport section, phosphoric acid storage and handling, reactor and material conveying equipment. The key to the process would be the SPINDEN<sup>TM</sup> reactor which permits agglomeration of the reactants with a low solids recycle ratio. In early 1998, prior to start-up, Serrana ordered a second basic engineering package increasing the production rate by 25% to 270,000 mtpd.

## **Existing Facilities**

Dicalcium phosphate was produced in the Serrana plant in Cajati, Brazil by mixing powdered limestone with defluorinated 50-52% phosphoric acid and depositing it on a slow moving covered conveyor belt (den). At the end of the belt, the damp grainy material was transferred by conveyor belts to holding bins in a storage building. After aging, the reacted mix was fed by payloader to a hopper feeding a conveyor which dropped the material into a rotary dryer fueled by wood chips. The dryer discharge emptied into an elevator and onto conveyor belts to bagging and storage. A large amount of dust was generated and the dust from the dryer and the conveying equipment was captured by cyclones and baghouses.

Production was 165,000 mtpd.

## **New Operation**

### **Limestone Preparation**

The limestone feed is delivered by front-end loader onto the conveyor belt that originally fed the dryer. A new conveyor was installed directing the material outside the building to the new milling structure. It is received in a hopper, which feeds the mill by means of rotary valves.

The limestone (40% on 100 mesh and 70% on 200 mesh) is ground in a ring roller with a vane-type separator. The fine material is blown out of the mill and into a cyclone separator. The cyclone overhead is recycled back to the suction of the fan. A purge stream is taken off the discharge of the fan sent to a baghouse to remove those particles that escape the cyclone. The discharge of the cyclone and the baghouse feed a dense phase pneumatic transfer system which takes the dust to a silo holding 2.5 to 3 hours of reactor feed. The silo is mounted high in the production building to allow flow by gravity to the reactor.

## **Reaction Section**

The SPINDEN<sup>TM</sup> reactor is a proprietary unit used to agglomerate solid raw materials with a minimum amount of liquid present. The design and operation result in a very low recycle rate. In this case, the recycle is less than two times the product stream. This is the fifth reactor of this type although this is the largest one to-date.

The SPINDEN<sup>TM</sup> has a flexible casing to avoid the effects of build-up that occurs when agglomerating thixotropic compounds. An agglomerator with a rigid casing uses excessive power and at the same time is limited to relatively low tip speeds on the paddles. With the SPINDEN<sup>TM</sup>, the thixotropic compounds only build up to a certain thickness before the movement of the casing causes the build-up to break off. This keeps the unit operating with low power requirements.

The reactor has a variable drive that allows a fairly high tip speed. The D<sub>50</sub> particle size is inversely proportional tip speed and the traditional blungers tend to produce a D<sub>50</sub> of 2 to 4 mm whereas the SPINDEN<sup>TM</sup> produces a size of 0.8 to 3.5 mm depending on the speed.

The SPINDEN<sup>TM</sup> has hybrid pin-paddles with a special angle of attack to maximize the effects of compression and coalescence. These paddles are directly responsible for the agglomeration of the raw materials. The combination of paddles with the liquid distribution system and the proper size particles result in a low recycle ratio. Since the reactor effluent is close to product size, only a small amount of oversize needs to be crushed and recycled.

The feeds to the SPINDEN<sup>TM</sup> consist of the powdered limestone, phosphoric acid and recycled fines. The two streams of solids enter through screw feeders on opposite sides of the unit. The phosphoric acid enters through nozzles in the top of the reactor. The acid is controlled at about 42% phosphoric acid by blending a purge stream from the scrubber system with 52% acid. The acid feed is ratio-controlled to the limestone fed to the reactor as measured by a weigh belt. The recycle flow is measured but not controlled.

Vapors from the SPINDEN<sup>TM</sup> reactor consisting of dust, phosphoric acid and carbon dioxide are vented out of the end to the scrubber system.

The reactor product discharges by gravity into the existing rotary drum dryer. The combustion chamber is fueled by wood chips. The product for the initial operation at 28 mtph contained less than 2% moisture. With the 25% increase in capacity, the dryer discharge will contain 6% moisture.

## **Product Sizing – 28 mtph**

For the first phase of production, the dryer product feeds an elevator that in turn feeds the rotary screen. The product falls to a series of conveyor belts that lead to the storage and bagging area. There is a diverter that allows the operator to also send the product to a truck-loading silo.

The over-size material enters a screw conveyor that feeds a chain mill with the crushed discharge being recycled back to the dryer elevator.

The fines drop to a recycle belt conveyor along with the dust collected in the various baghouses. This discharges into a screw conveyor that supplies the feeder on the SPINDEN™ reactor. The flow rate is measured by a belt scale.

### **Product Sizing – 35 mtpH**

With the 25% increase in throughput, the dryer product will increase from 2% moisture to 6%. A second rotary screen will be added to handle the flow. The added volume and the extra height require that the existing dryer elevator be replaced with a bigger, higher one. The elevator discharge will go through a diverter, which will divide the flow to the two screens. The product will need further drying and will be conveyed by screw conveyors from the screens to a new fluid bed dryer/cooler. This will be a horizontal oil-fired unit that will first heat the product to remove the water and then cool it back to the 70°C that it was when it entered the dryer/cooler. The product will enter the relocated elevator that was formerly the dryer elevator. This will feed the product belts leading to the storage and bagging area.

The dust from the dryer cooler will go to a new baghouse, which will discharge to the recycle belt.

The oversize material from the new screen will go to a mill and then back to the dryer elevator. The fines will fall to the recycle conveyor belt.

### **Scrubber System**

The vent stream from the SPINDEN™ reactor is ducted to a pair of venturi cyclonic FRP scrubbers. It is drawn in series through the scrubbers by a fan which discharges to a new stack. The make-up water to the second scrubber is by level control. The scrubber liquor is recycled to each scrubber from seal tanks by horizontal centrifugal pumps. The liquor overflows from the second seal tank to the first. A side-stream from the recirculation stream on the first scrubber goes to dilute the phosphoric acid as required by production rate.

### **Start-Up**

The first phase of production (28 mtpH) was scheduled for start-up in late March. The limestone mill was to be checked out first, followed by pre-operational checkout of instruments and other equipment. Feed was initially scheduled for March 21 but delays in other areas of the plant and in construction held up the start-up by several weeks.

Initial operation of the mill produced good quality powdered limestone and the pneumatic transfer system performed as it should. Unfortunately the feed to the mill hopper was not completely protected from the weather and a hard rainstorm left some damp material in the rotary valves that feed the mill. These had to be cleaned out and plans were made to improve the weather protection.

As it turned out, the quality of the basic engineering package was good and the detail engineering effort was therefore held to a minimum. The lack of follow-up review during detail engineering allowed several design errors to remain undetected until start-up. Several screw conveyors kicked out during initial operation and it was discovered that the incline of the conveyor had not been considered when sizing the motors.

The chain mill supplier was apparently inexperienced and provided a drive with only 800 rpm and a resultant 5% efficiency. The result was an accumulation of oversize material in the undersized screw conveyor. This was addressed by speeding the mill up to 1200 rpm.

Another problem surfaced when it was discovered that the venturi cyclonic scrubbers were made with 6 “ nozzles instead of the specified 8” nozzles. The increased vacuum pulled a high vacuum on the reactor and pulled large amounts of dust into the scrubber. A vacuum control was installed at the discharge of the reactor.

Start-up was made more difficult since it came during a plant turnaround in the phosphoric acid plant and the feed acid was cold rather than at the design temperature of 70°C. This can normally be counteracted by diluting the acid but the acid concentration was marginal already because of water left in the line from instrument testing.

### **Acknowledgements**

We would like to acknowledge the cooperation and assistance that we received from the plant owner, Serrana de Mineração, Ltda. and in particular the Production Manager, Mr. A. C. Roncolato. Their hospitality at the site was outstanding.



Figure 1

OLD DICAL  
MIXER



Figure 2

BELT DEN

Figure 3

AGING BINS



Figure 4

CONVEYOR TO AGING  
BINS



Figure 5

FEED HOPPER



Figure 6

FRONT END  
LOADER





Figure 7

FEED CONVEYOR



Figure 8

DIVERTER



Figure 9

LIMESTONE  
BELT TO  
MILL





Figure 10

MILL FEED  
HOPPER

Figure 11

MILL





Figure 12

MILL  
CYCLONES  
AND  
BAGHOUSE



Figure 13

DENSE PHASE  
CONVEYING



Figure 14

SILO



Figure 15

SPINDEN

Figure 16  
SCRUBBERS



Figure 17  
SEAL TANK



Figure 18  
SCREEN

