Cooling MAP with the Bulk Flow Heat Exchanger at Fosfertil, Brazil

Summary

Fosfertil installed a new, more efficient pipe reactor during the 1993 annual shut down to increase their granular MAP capacity and improve overall process efficiency. However, the company's long term goal was only partially fulfilled. In order to equally improve their product quality for a new breed of "privatized", more demanding end user the granular MAP product needed to be cooled to approximately 50°C before being sent to storage.

After careful analysis of today's available cooling technologies Fosfertil S.A. chose to install two parallel Cominco Bulk Flow Heat Exchanger Units to cool 70 t/h of granular MAP from 85°C to 50°C. Installed and commissioned in December 1994, the new Cominco Coolers, eliminated caking in storage resulting in high product quality.

Introduction

The granular MAP unit installed at the Fertilizantes Fosfatados S.A. (Fosfertil) site at Uberaba, Minas Gerais, Brazil was designed and engineered by Badger/Gulf design and detailed by Natron S.A., in the late 1970's. The plant was commissioned in 1981.

This plant was the subject of a paper titled "Design Start Up and Operation of a 70 t/h MAP Pipe Reactor, at Fosfertil, Brazil" given at the 5th Fertilizer Latin American Conference, in April 1994. This paper described the changes which took place in the granulation process and the pipe reactors, and touched briefly on the other operations in the production unit. This included a reference to the high product temperature and the need to provide additional cooling.

This year's presentation will concentrate on the need for a Bulk Flow Heat Exchanger(BFHE), and a description of the installation, start up and operation of this system.

Fosfertil's Granular MAP Unit

The original Badger/Gulf design for this unit had the following characteristics:

- liquid feeds, ammonia and phosphoric acid were added via spargers in the rotary granulator
- a typical 3:1 recycle ratio, with a nominal design rate of 42 t/h
- the unit had neither a recycle or product cooler

The original scrubbing system consisted of two separate loops. The first serving the granulator, used dilute phosphoric acid, which was used both to recover the ammonia and at the same time was used to dilute the remainder of the 52% P_2O_5 phosphoric acid to 47% P_2O_5 before being fed to the granulator sparger.

The second system received the gases from the dryer and equipment cylones. This used process water as the make up and the recycled MAP solution as the process fluid, being fed to the venturi scrubber and the sprays at the inlet of the cyclonic separator. The overflow of this system was fed to the seal tank of the granulator scrubber, diluting the phosphoric acid. The system was designed to operate in balance, without any liquid effluents.

It was never possible to operate the system as designed, there always being a bleed of effluent to the phosphoric acid cooling pond.

When the granulation process was converted from spargers to a six inch diameter pipe reactor, it used 50-52% P_2O_5 phosphoric acid. With this, the granulator scrubber was converted to use pond water, as was the dryer-equipment scrubber. This water was recirculated until it became saturated and returned to the pond system.

The introduction of the pipe reactor and the use of the more concentrated acid permitted the production rate to be increased to 60 t/h. It also made the system autothermal; that is the process no longer required an external heat source to dry the product so the air heater (burner) was deactivated. The heat of reaction was such that even with the dryer being operated as a co-current cooler the product outlet temperatures were very high, 100-110°C, at the outlet of the MAP plant and 90-100°C in the storage bays. At this temperature the product rapidly caked, and caked very badly. Even when Fosfertil used a policy of removing the product with pay-loaders from one storage bay to another in the first 12-18 hours, the caking was severe. It was only possible to carry out this removal procedure during the first few months of the year. Unfortunately the Brazilian fertilizer market is very seasonal; this meant that Fosfertil, as a primary producer, was forced to build up stocks during the winter while waiting for the peak deliveries in the spring. At the higher stock levels it was not possible to carry out this removal procedure. The results were storage bays of "single lumps" of 12,000 t which had to be broken down by bulldozers. The resulting "product" had to be screened before being loaded into the trucks and sold to the "bulk blenders". The negative effects on the product quality were obvious. The rejected material from this screening had to be reprocessed. It represented about 5% of the total production. This reduced the plant's capacity.

In January 1993, a second larger pipe reactor was installed. This increased the production rate to 75-80 t/h and at the same time reduced the temperature of the product leaving the MAP plant to 80-90°C which meant a temperature of 70-80°C in the storage bays. This pipe reactor was the subject of last year's presentation.

The product's caking problems were reduced but they were still very serious. In order to avoid heat set and product caking it is necessary to limit the storage temperature to 52°C (125°F).

The new owners of Fosfertil S.A.-Fertifos are among other things the main client for the granular MAP which is used in their bulk blending operations and they needed to improve the product quality. They knew it would be necessary to cool the product before it was sent to storage.

Therefore, the various options on product cooling were studied and evaluated. These included the classical rotary drum, the newer fluid bed system and the CESL "Bulk Flow Heat Exchanger", BFHE. The great advantages of the BFHE is that it does not use vast volumes of air to cool the product which has to be cleaned. Therefore there are no associated cyclones, bag filters or wet gas scrubbers required.

Figures 1 & 2 show a schematic flow diagram of the Fosfertil MAP unit before and after the addition of the two Cominco coolers.

Pilot Testing

In the early part of 1993 CESL brought to Brazil a small scale pilot plant unit. This was used to test the system on both the granular MAP and granular TSP plants at Fosfertil, Uberaba. The results were very good, but the duration of the tests was short and the equipment small scale.

To confirm the results of these initial tests, Fosfertil carried out a second series of longer term tests with a larger pilot unit. This test work was completed in September 1993 with good results. Based on this test program, Fosfertil decided to proceed with the project to install BFHEs in February 1994.

Priority was given to the MAP unit as it had the most problems with product quality.

One of the early results of the pilot testing was a build-up of MAP fines on the cooling plates. This was caused by the humid air entrained with the product condensing on the plates forming a wet build up of fines. The problem was solved during testing by purging the feed with dry air (instrument quality) to lower the dew point of the entrained air below the plate temperature.

The experiences of the start up and the initial results from the operation of these coolers are the main topic of today's presentation.

Commissioning and Start-up

The start up and commissioning period of the two MAP Cominco Coolers was scheduled for December 1994 and actually started Friday, December 16, 1994. A two-man engineering team from Cominco Engineering Services Ltd. of Calgary, Alberta was present at the Fosfertil, Uberaba site to assist with the start up and commissioning of the units.

The MAP coolers were fitted with dry dilution air spargers to prevent possible condensation formation on the cooling plates and subsequent caking problems.

The unit's control system is configured to maintain a constant product level (set point) in the top hopper as the flowrate changes (the cooler is designed to operate with the plates always covered with product to prevent condensation). The controller continuously detects the difference between the process signal from the level transmitter and the set-point. The output signal is a function of the difference and is transmitted, after being converted to a proportional pneumatic signal, to the actuator's positioner. This controls the opening of the gate and hence the material flow rate.

A schematic of the Fosfertil's BFHE control layout is show in Figure 3.

Originally, the level controllers intended for and supplied with the two coolers were local pneumatic controllers. Fosfertil replaced these with a panel mounted multi-loop digital electronic controller installed in the control room for ease of operation.

A great part of the commissioning exercise consisted in correctly calibrating the capacitance probe and level transmitter so that the controller can maintain the desired level set-point.

It was necessary to repeat the calibration procedure several times in order to obtain the desired result.

Some of the problems encountered during the calibration procedure were temporary loss of feed and oversize particles leading to pluggage of the unit.

Since Fosfertil's MAP unit uses conventionally formed agglomerate granulation, the produced granules are much more irregular than prilled or fluid bed granules. Also the Tyler "Hummer" screens used in the MAP unit are a high throughput/large size cut type screens and will need to be upgraded as a result of the increased capacity.
The oversize product crushers will also need to be upgraded to handle the higher throughput.

As a result of receiving larger than design particles, the discharge gate openings were readily plugging, creating bridges and restricting the flow of material through the unit. The problem was solved by increasing the gate opening to a maximum aperture of 11/4"

A parallel solution was the installation of vibrators on the outside of the discharge hopper walls to help dislodge the wedged oversize particles and prevent bridging. This was immediately experimented with but the installed vibrators were found to be too large and had to be removed. Fosfertil has since installed correct size vibrators with good results.

Another item which was identified as a potential problem was the size of the exhaust vent line. This line was designed to remove the entrained moist process air and dust entering the cooler in order to improve flowability. The constant build up of moisture inside the top hopper during commissioning led to the conclusion that the vent line size and suction pressure were undersized.

The vent lines were changed from a 4" IPS to an 8" IPS and the location of the discharge was moved, from upstream of the dryer cyclone to between the cyclone and the dryer scrubber in the dryer fan system, resulting in a much higher suction pressure (approx.250mm H_2O).

Since Fosfertil had made the decision to install the BFHEs in both the granular MAP and granular TSP systems, the main cooling water loop was designed and installed for both plants. The system has a return bypass when only one plant is operating. As such, balancing the cooling water system for the existing coolers has proven to be an operational challenge. The system should become less complicated when the TSP product cooler is on-stream.

Operation

The two product coolers have been operating since start up, December 16, 1994.

The principal operating difficulty has been the occasional cleaning required due to product build up on the plates. For the start-up of the coolers there was only a limited quantity of dry air available. Part of the scope of the commissioning was to determine how much dry air would be required so that a new dry air system could be sized.

This problem is being addressed by increasing the dry air purge and improving the air distribution. This has extended the interval between cleaning.

The cleaning cycle has also been extended by increasing the size of the vent line and its suction pressure as well as introducing a higher dry air quantity(250 Nm^3/h). The resulting increased moist air removal capacity and increased removal of fines has helped in maintaining good mass flow and efficient operation for prolonged time periods.

We are optimistic that with the various changes planned, cleaning of the units should be rarely required.

Fosfertil has recently completed a 5 day, 24 hour performance study to accurately evaluate the operational efficiency of the MAP coolers.

Table 1 gives the initial design criteria for the MAP coolers. Table 2 lists the data gathered during the performance study.

It can be seen that the coolers operate at or better than design. However the excessive cooling is not necessarily desirable since product temperatures much below 50°C lead to moisture migration in the storage pile and possible caking. As such, water flow is regulated in an effort to maintain a relatively constant outlet product temperature.

Fosfertil is very pleased with the performance of the Cominco coolers since their installation. The product quality has visibly improved and shifting the storage pile is no longer a requirement.

Conclusions

The two Cominco Bulk Flow Heat Exchangers installed as product coolers in Fosfertil's granular MAP unit have made an important contribution to the company's bid at enhancing product quality and improving operating efficiency.

Since their installation and start up in December 1994 they have met all of the client's expectations:

- higher product quality
- better than design cooling performance
- shifting of storage pile no longer required
- higher operating capacity through elimination of storage recycle
- energy savings

Fosfertil are now planning the next phase; to install a BFHE in their TSP process.

References

J. Sinden & L.F. Quirino Loureiro, "Design, Start-up and Operation of a 70 t/h MAP Pipe Reactor at Fosfertil, Brazil", 5th Fertilizer Latin America Conference, April 1994

N.P. Jordison, "A Simple Way to Cool Nitrogen Fertilizers", 5th Fertilizer Latin America Conference, April 1994

Fig 1: MAP Process Flow Diagram

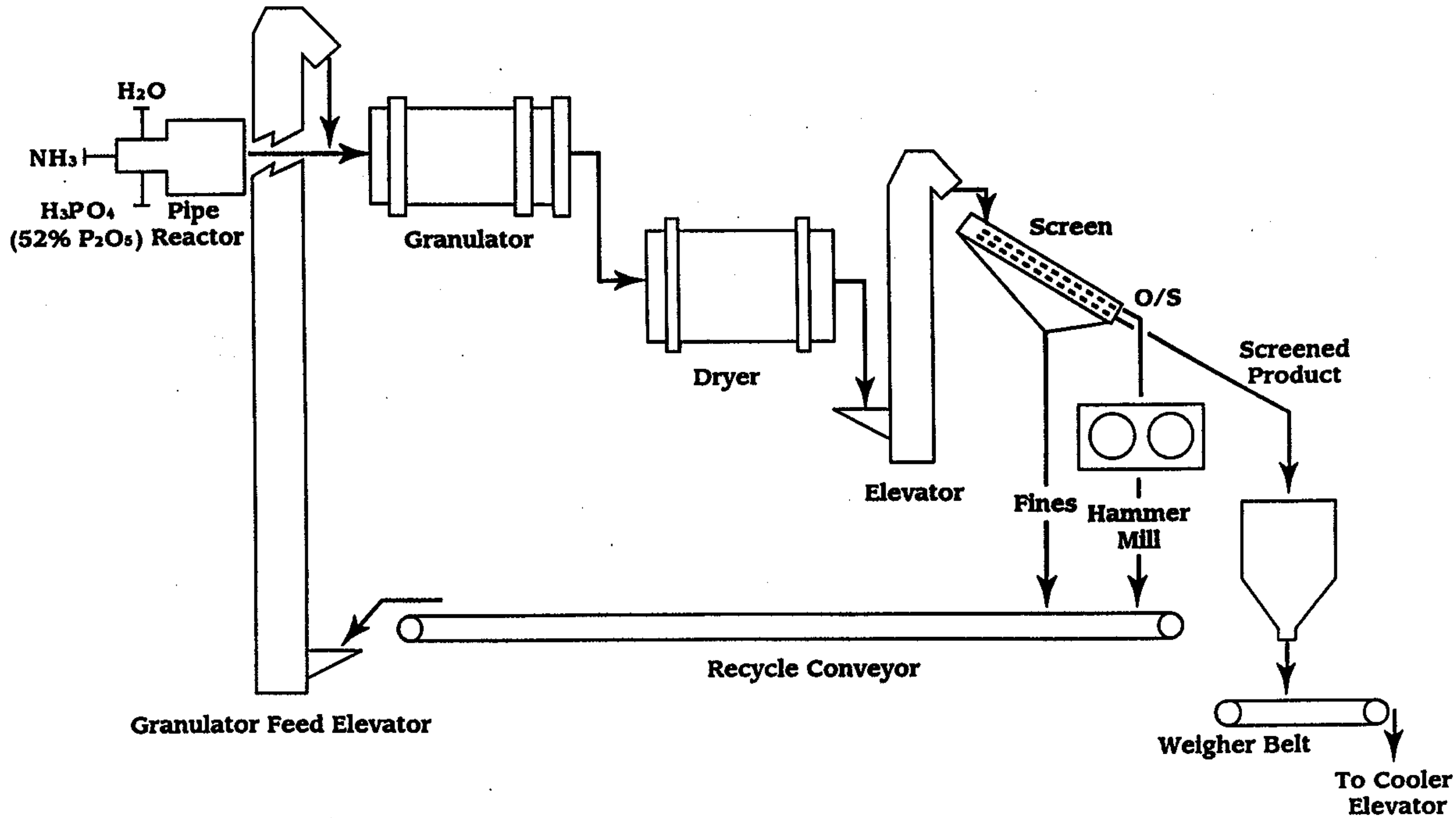

Fig 2: Bulk Flow Heat Exchanger Installation

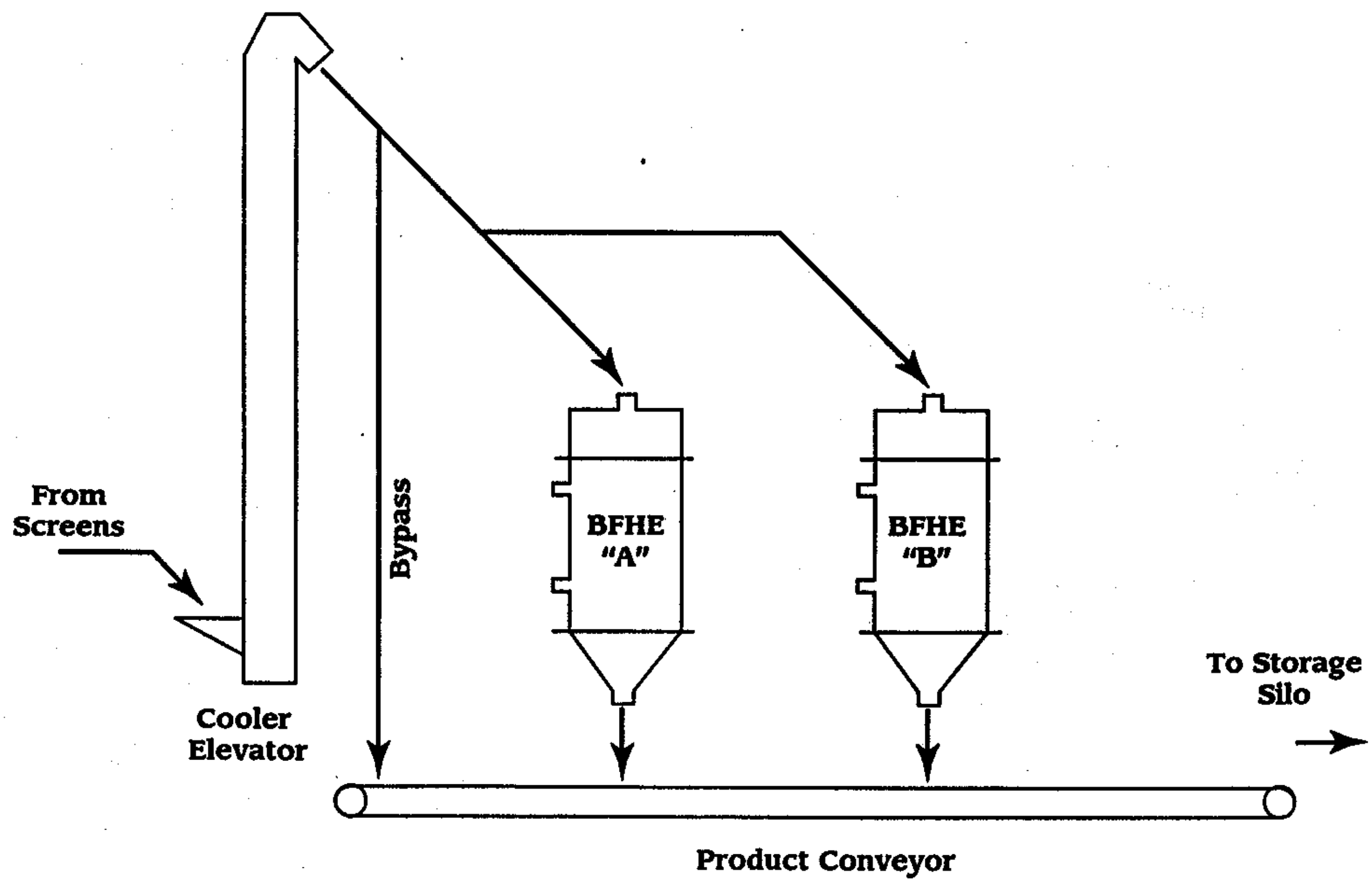

Fig 3: Bulk Flow Heat Exchanger Control Schematic

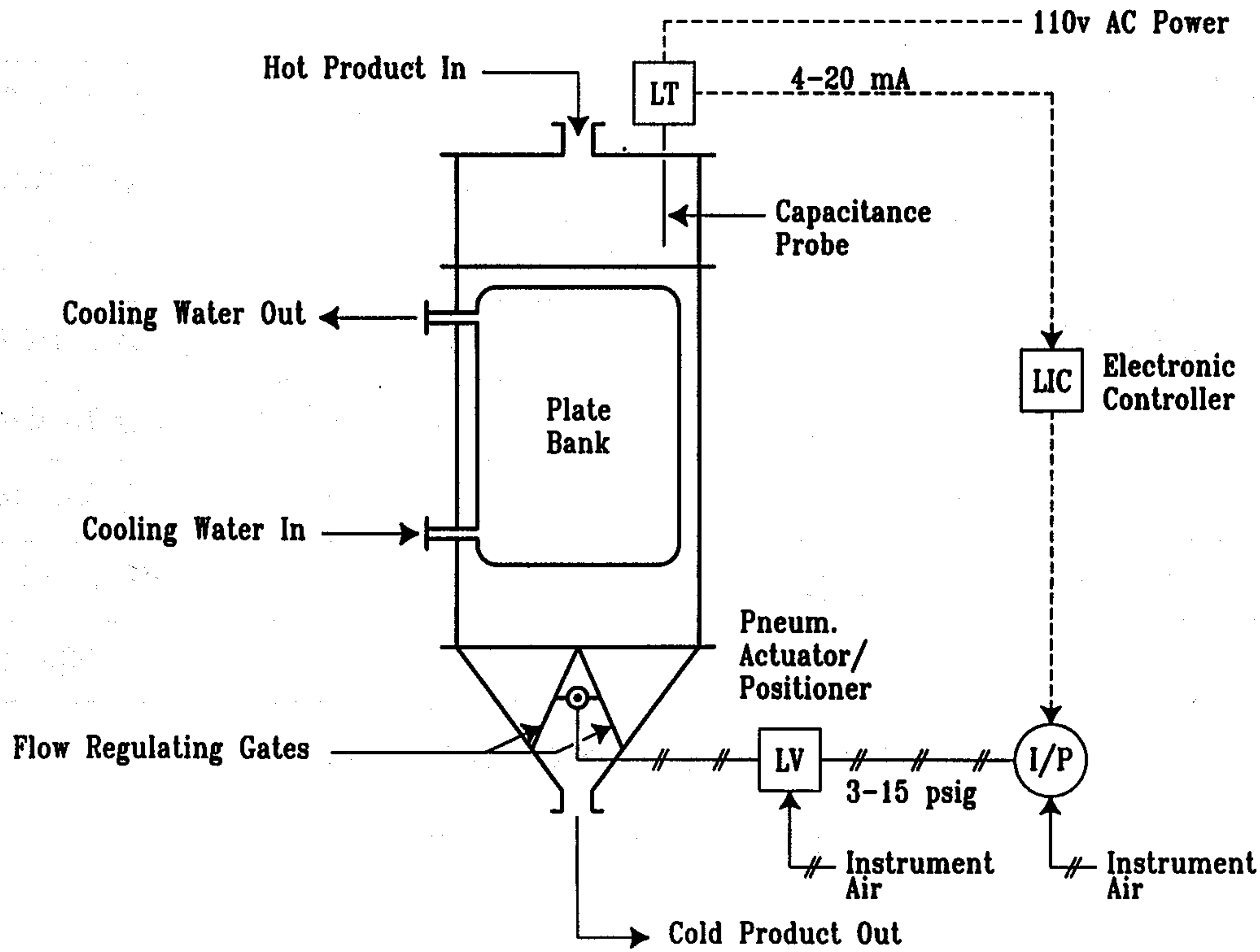

Table 1: MAP Cooler

Process Design Conditions

Material:	MAP
Design Feed Rate:	70,000 kg/h (77 T.P.H.)
Product Inlet Temperature:	85°C (185°F)
Product Outlet Temperature:	50°C (122°F)
Product Bulk Density:	800 kg/m^3 (50 lb/ft^3)
Cooling Water Supply Temperature:	28°C (82°F)
Cooling Water Discharge Temperature:	31°C (88°F)
Cooling Water Flow Rate:	252 m^3/h (1112 USgpm)

Table 2: MAP Cooler

Performance Study Data

(March 6 - 10, 1995)

Date	GRANULAR MAP			COOLING WATER		
	Flow (t/h)	Inlet Temperature (°C)	Outlet Temperature (°C)	Flow (t/h)	Inlet Temperature (°C)	Outlet Temperature (°C)
March 6, 1995	72.0	95	49	299	32.0	35.6
March 7, 1995	69.4	91	45	288	31.5	34.3
March 8, 1995	78.7	92	49	250	31.5	35.0
March 9, 1995	87.8	86	47	240	30.5	34.0
March 10,1995	83.6	80	46	252	30.4	33.0

Notes:

1. Temperatures and flows represent daily averages.
2. Outlet product temperature is measured at product belt.
3. Water flows are calculated from a heat balance.