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ESPINDESA Pipe Reactors, 30 Years Experience in Operation

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"ESPINDESA Pipe Reactors, 30 Years Experience in Operation"

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ABSTRACT: Pipe Reactor is a proven technology for a NPK and DAP production. General overview of the ESPINDESA system and experiences are presented. A reduced recycle ratio has been achieved by using a Pipe Reactor system; thanks to their unique pipe design a granulator without ammonia spargers can be designed even for DAP production.

1. The development of Pipe Reactors

Early in the 70´s it was promoted the idea of simplifying the neutralization of phosphoric acid with ammonia in the simplest reactor that could be imagined: a pipe.

The first Pipe Reactors were exactly what its name suggests: a length of pipe in which reaction takes place. Usually they were T-shaped. The ammonia was introduced at one end of the main pipe and phosphoric acid through the side arm. The length of the pipe was selected to provide sufficient residence time in the pipe for the reaction to be essentially complete before the resultant slurry was discharged into granulator.

The main drawback of those early pipe reactors was the ammonia release from the pipe, that reaches very high values, what limited its use to the manufacture of MAP or polyphosphates.

Considerable efforts ware done in the 80´s to improve the pipe reactor and new designs were developed which achieved neutralization of phosphoric acid up to N/P ratios in the order of 1.4 with reasonable low ammonia release. One important additional advantage of those pipe reactors was the lower recycles ratios achieved (In the order 4:1) due to the low water content of the concentrated slurry of ammonium phosphates which can be produced inside the pipe reactor and the temperature of the slurry as it emerge from the discharge nozzle is considerable above its boiling point at atmospheric pressure, so part of the moisture flashes of in the granulator, remaining water in the slurry is low and the recycle ratio can be therefore reduced.

2 ESPINDESA Pipe Reactor

During 1983, a new process by improving the mix chamber in the pipe reactor as well as discharge nozzles for the manufacture of di-ammonium phosphate, it was developed by ESPINDESA. This process was later incorporated to the ESPINDESA first reference unit for TOROS in Ceyhan (Turkey) where the unit was designed for 600 TPD as DAP and 1000 TPD as NPK.

Other units as Luzhai fertilizer, Guixi fertilizer and Luxi Fertilizer in China, CUFL in Bangladesh and more recently JPMC in Jordan have incorporated ESPINDESA Pipe Reactor.

Figure 1 : Pipe Reactor inside Granulator in Luzhai (China) Unit

The ESPINDESA Pipe Reactor differentiates from other Pipe Reactors that the reaction takes place to obtain DAP completely in the pipe, obtaining DAP in a single piece of equipment, in this pipe reactor the reaction takes place under pressure, in very short time, in such a way all the heat of reaction is evolved inside the pipe, consequently most of the water is vaporized at pipe reactor discharge, which means that lower quantities of material to be need to recycle to the granulator

Figure 1 : Pipe Reactor in Operation in TOROS Unit

3. The ESPINDESA Process

The following summarizes the design of a typical DAP plant designed by ESPINDESA.

The process can be followed according the PFD shown in Drawing 1 below.

A 3-D Layout of the plant can be also shown in Drawing 2 below.

The process consists on several steps:

- Acid preparation section

Fresh phosphoric acid is sent to Dust Scrubber and form the overflow of the scrubber to the Scrubber Circulation Tank (SCT). The scrubber pumps sent liquor from bottom of this equipment either to Dust Scrubber or to Granulator Scrubber from SCT.

In the Granulator Scrubber the acid fixes most of the ammonia lost from the Granulator. The scrubber liquor results partially neutralized and falls by gravity to the SCT.

In the Dust Scrubber the acid fixes most of the ammonia evolved in the Drier and also dissolves the dust of DAP entrained from Drier Cyclones. The acid falls by gravity to the bottom of this scrubber where is mixed with fresh acid and overflows to SCT.

- Pipe Reactor and granulation

From Granulator Scrubber, the partially neutralized phosphoric acid enters in the Pipe Reactor. Here the acid reacts with ammonia under pressure to DAP. No need for further ammonia addition in the granulator bed.

The neutralization reactions are instantaneous and exothermic and the heat of reaction is used to evaporate part of the water of the phosphoric acid fed to the plant.

This water vapour and the un-reacted ammonia are entrained in a stream of air flowing through the Granulator and are end to Granulator Scrubber

The DAP melt produced in the reactor is sprayed over the bed of recycle and by effect of the temperature and of the moisture the melts becomes granulated.

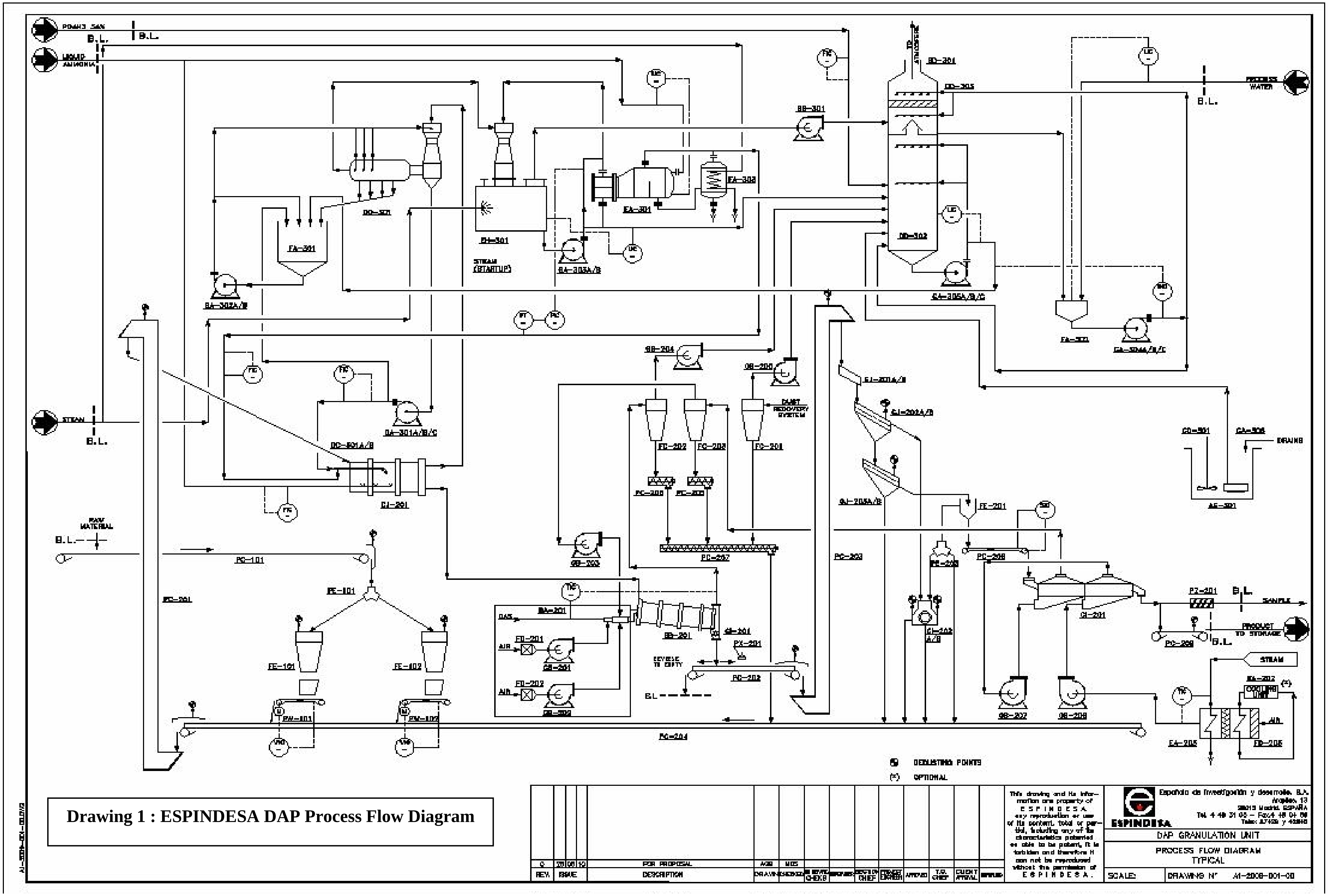
- Solid Handling

The granulated DAP falls into the Rotary Drier where it dries in contact with a co-current flow of hot air coming form Drier Burner.

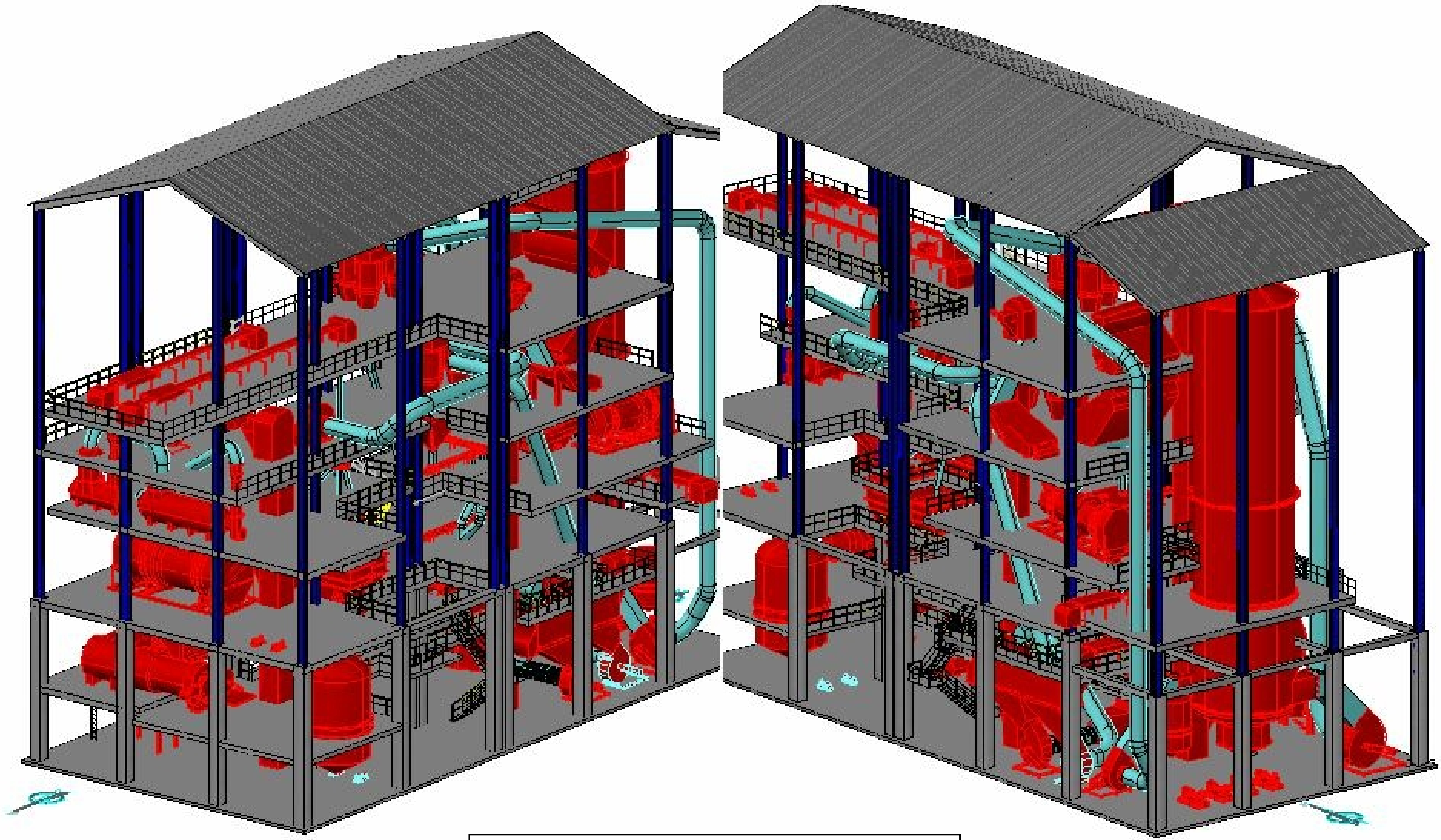
Product leaving the drier is sent, through the Ex-drier elevator, to the top of the screens, where is divided into three streams: The oversize, the on-size and the fines.

The oversize (and some on-size if required) pass into Oversize Pulverisers. Crushed material, fines and the dust collected by cyclones are discharged to the Recycle conveyor.

The on-size product from the Screens falls into a Fluidized Bed Cooler where it is cooled until the desired temperature. Finally the product is sent to storage.



Drawing 1 : ESPINDESA DAP Process Flow Diagram



Drawing 2 : ESPINDESA DAP 3-D Layout

4. Energy efficiency of the ESPINDESA Process

ESPINDESA has developed the process with high energy efficiency thanks to the following key points:

a) To avoid sudden vaporization and ammonia bubbles in granulator, the ammonia is sent to the Pipe Reactor in gas phase. To vaporize the ammonia, a close circuit of warm condensates is used in a contact Condenser. This design helps not only to avoid energy consumption for ammonia vaporization, but also reduces granulator gases temperature that later will help the Fluorides Scrubber and simultaneously remove some fluorides in the Condenser Scrubber.

b) Due to the low recycle ratio all electrical consumption in solid loop is reduced.

c) The air passing from Fluidized Bed Cooler is recycle to drier to minimize natural as or fuel oil consumption in the Drier Burner

5. Process Features

The main advantages of this technology can be summarized as follows:

a) The neutralization of phosphoric acid to DAP is achieved in one step in a single Pipe Reactor.

b) Low recycle ratio, operating below 3:1.

c) Higher solubility of P_2O_5 due to the sort residence time in the reactor.

d) Smaller size of equipment due to the lower recycle ratio.

e) From emissions point of view, all solids and liquids wastes can be reprocessed to the system. Gases achieve European emission standards or World Bank guidelines.

f) Typical consumptions of raw materials and utilities are as follows:

a. Ammonia as (100 % NH_3) 221 kg/Ton DAP
b. Phosphoric acid as (100 % P_2O_5) 463 kg/Ton DAP
c. Electricity 34 kWh/Ton DAP
d. Fuel oil 4 kg/Ton/DAP

6. Safety

DAP unit is a relative safe unit, but special attention has to be taken to the following points:

a) Ammonia is a toxic gas at ambient condition, special attention to leak scenarios has to be taken as well as place equipment with liquid ammonia in well ventilated areas, safety valves must discharge to safe place.

b) Special attention to a Liquid spillages must be taken due to their acidity, segregated areas for equipments processing acid are recommended

c) To minimize dust emission in the environmental areas, low speed recycle belt with cover is recommended as well as good and large design for dedusting system.

d) Liquid ammonia areas as well as Natural Gas areas are according IEC 650079 20 recommended to be classified areas.

e) Start up procedures for rotating equipment including belts and elevators are recommended to operate locally in order to check surrounding of the corresponding equipment

7. References

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e) Routes to the Manufacture of NPK Fertilizers. Beijing Seminar, January 1999.

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