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THE CONTINUOUS MANUFACTURE OF SUPERPHOSPHATE IN ROTARY DENS – HISTORY AND RECENT DEVELOPMENTS

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Over the last twenty years the continuous manufacture of superphosphate has almost everywhere replaced the old batch production installations. A number of engineering firms have developed various types of continuous dens which have all been proved satisfactory. There is, however, one type of plant which, despite its virtues, is still little known and little used. We refer to the rotary den, essentially comprising a cylinder on an almost horizontal axis.

At the ISMA Technical Meetings in Cambridge, in September, 1953, Mr. J.T. Procter related his experience of an apparatus of this type. The Cie. de Saint-Gobain, for its part, has been interested in this process for a very long time. It is with the history of the rotary den and with its recent developments that we propose to deal in the present paper.

HISTORY

The idea dates back to 1907, but it was only in 1912 that the first cylinder, 80 cm in diameter and 4 to 5 m long, was experimentally used. It gave a regular production of 4,200 kg/hr of dried superphosphate, for according to the customary practice at this time the superphosphate issuing from the dens was subjected to a drying process, in a rotating cylinder for example.

In 1914 we designed for the factory at Rouen a plant to produce 300 tons per 24 hours, comprising a rotary den and a drier. Contracts were given and part of the equipment was delivered. The war prevented its construction.

After the war, the practice of delivering undried superphosphate became widespread. Lacking a knowledge of the

performance of the rotary den under these new conditions, we gave up the idea of installing it.

In 1927, the factory at Chauny was confronted with the problem of manufacturing a product called "activated phosphate" or again "neutral phosphate", which was nothing other than an under-acidified superphosphate, containing only half its P205 i available form. This product enjoyed some favour in France at the time. Thus we decided to install the rotary den at Rouen, and the results were satisfactory.

It was only in 1933 that this first industrial rotary den was used with success for the manufacture of superphosphate proper.

As the fineness of the phosphate rock used was relatively poor and the reaction was consequently slow, agitated containers called "thickeners" were inserted between the mixture proper and the rotary den.

In 1935 this apparatus was replaced by a new, larger rotary den in the shape of a truncated cone, and this allowed us to dispense with thickeners. The anticipated advantage of the truncated cone shape, with its diameter decreasing from top to bottom of the line of flow, was to further the progress of the product by virtue of the inclined axis of rotation, even if the lower plane of movement was almost horizontal in order to inhibit the flow of the slurry introduced at the top end.

This equipment gave a production of 22 tons/hr. Since 1935 all the superphosphate produced at Chauny has issued from this cylindrical den which is still in service.

After the second world war, it was decided to replace in several of the company's factories the old deteriorated batch installations by continuous systems. The rotary den was not used to refit these works. It was alleged - wrongly as we shall see later - that the rotary den gave the product a less attractive appearance than the Broadfield or Moritz dens, with a higher moisture content and containing granules (the presence of the latter being considered at the time as a serious defect). It was not realised that this physical appearance, which was considered inferior, had nothing to do with the rotary den itself, but resulted from the characteristics of the raw materials used and from irregularities in the feed system. The phosphate grinding system, which was very old, could not exceed a fineness of 80% through a mesh of 200 microns. The chamber sulphuric acid was often very dirty (tank washing). The working of the continuous phosphate rock weigh-feeder, which certainly represented a remarkable invention, unique of its kind at the time at which it was conceived, was not above all reproach: the extent of the oscillations of the throughput were sometimes as much as 10%. All these reasons provide an ample explanation of why the quality of the superphosphate was not always perfect, and this would have been exactly the same with any other type of continuous den.

When some years later, in 1953, modern phosphate grinding apparatus was put into service at the Chauny factory, the rotary den proved that it could produce a product of the highest quality.

By taking samples from different points along the cylinder

during its working, it was also established that its length of 12 metres was considerably more than sufficient.

It was not until 1954 that an opportunity arose to construct a second rotary den for a factory in Italy. The truncated cone shape was conserved, but its length was reduced to 6 metres. It commenced production in March, 1955, and, from the beginning, produced material of a remarkable quality, drier and more broken up than that obtained previously in any other continuous den.

Since then, six new rotary dens have been installed, four in France, one in Spain and one in the Philippines. We have given all these dens a cylindrical shape, which facilitates their construction and increases the internal volume for the same load, but which, on the other hand, presupposes a careful adjustment of the inclination. Four of these dens are six metres long, and two are eight metres long.

ACCESSORY EQUIPMENT FOR THE ROTARY DEN

The speed of rotation can be adjusted according to manufacturing conditions by means of a simple and relatively cheap speed control.

To prevent congestion of the internal wall of the den, it is provided with a very simple and very effective decrusting device.

The plant at Chauny initially comprised a large two-shafted mixer. The slurry from this fell into a cast-iron sphere centred on the axis of the cylindrical den, in which paddles turning around a horizontal shaft perpendicular to that of the den propelled the slurry into the interior of the cylinder whilst simultaneously raking its walls.

When finely ground phosphate rock became available, a small vertical high speed mixer was installed. This had certain disadvantages and was finally abandoned.

The present solution consists of a very short horizontal mixer with a single shaft approximately coaxial to the den. The design of this apparatus has been improved on several occasions in order to facilitate cleaning it and to limit the waste of phosphate rock carried off in the gases evolved.

The phosphate rock is fed in by means of a continuous belt weigher of the type giving a constant weight per unit length of belt. The regulator is governed by the weigh-roller and acts either on the speed of rotation of a rotary distributor or simply on the position of a damper which limits the height of the phosphate stream. In the latter case, to make absolutely sure of avoiding avalanches of finely ground phosphate, the plant feed system should be operated under very closely defined conditions.

To regulate the continuous flow of sulphuric acid, various systems are used in our factories: variable speed scoop wheels; constant level container and adjutage, the outlet volume of which can be adjusted by moving a central conical shaft; and a simple manual sluice operated under constant pressure, the outflow being indicated by a rotameter or by a calibrated glass level fixed above an adjutage.

All these devices are satisfactory.

The superphosphate issuing from the den can either be sent directly to storage or passed through a simple crumbler which makes the granule size more uniform and promotes the evaporation of water.

PRESENT PERFORMANCE OF THE ROTARY DENS

Using North African or Florida phosphates to produce ordinary superphosphate, the rotary dens with a length of 6 metres regularly produce 30 tons per hour, and those with a length of 8 metres, 40 tons per hour.

The production of the veteran den at Chauny is at present limited to some 30 tons per hour by the raw materials feed system.

As in all other systems, the physical quality of the superphosphate produced depends on the nature and fineness of the phosphate rock and on the acid concentration. The experience we have acquired in using different types of mixers a both continuous and batch dens has, in fact, shown us that this quality is practically independent of the type of apparatus used: it is purely a function of the raw materials.

The rotary den is very well suited to the manufacture of ordinary superphosphate with concentrated sulphuric acid (93%) without preliminary dilution or cooling of the acid. One has only to add the necessary quantity of water into the mixer at the same time as the acid.

We also have experience of manufacturing triple superphosphate in this type of den. Production capacity remains the same but, in order to avoid the formation of lumps caused by the rapidity of the setting, it is advisable to increase the speed of rotation. The product obtained is mostly in the form of hard granules.

By using mixtures of sulphuric and phosphoric acid superphosphate of intermediate grades can also be manufactured.

Finally, it is possible to produce NP binary fertilisers or NPK ternary fertilisers according to the method described by Mr. P. Dondin in an excellent paper presented at the ISMA Technical Meetings in 1959.

In all cases, the product issuing from the den can be immediately granulated in a granulation plant of classic design.

One can thus have a very compact plant fed with phosphate rock and sulphuric or phosphoric acid, and producing completely granulated superphosphate ready for despatch after a few days of curing.

CONCLUSION

The horizontal rotary den continues to be proved satisfactory under very varied conditions. As compared with other processes, it has the advantage of simplicity, compactness, relative cheapness of the equipment and of its installation, low energy consumption and, above all, greatly reduced cost of maintenance. The latter is limited to the periodic replacement

of mixer blades and of those parts of the decrusting apparatus which sustain heavy wear: about every 30,000 tons where Moroccan phosphate is used.

From the point of view of production capacity, the extrapolation of the apparatus is easy. Having exceeded 30 tons per hour, we see no difficulty in constructing a rotary den of 100 tons per hour.

It is surprising that, despite its advantages, this process is not more widespread. Apart from the eight rotary dens mentioned above, there are, indeed, at least a dozen dens of similar design installed by an Italian company and perhaps some others in England. But on the world scale their total number remains low, fertiliser manufacturers being generally ignorant of the process.

Despite the present decline in superphosphate, old installations continue to be refitted and new factories are even constructed. We consider that those responsible for a project would be well advised to examine closely the possibilitie of the horizontal rotary den before choosing any particular process.

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