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THE FERTILIZER INDUSTRY

Background Paper

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THE FERTILIZER INDUSTRY

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FERTILIZER INDUSTRY

1. INTRODUCTION

When one considers the installation of fertilizer plants in the context of today's developments whether it is Nitrogenous-Ammonia, Urea etc. or phosphatic - phosphoric acid, ammonium Phosphate, triple superphosphate etc. or potash - potassium chloride, Sulphate etc. one thinks of very large capacity (Ammonia 1000 tons per day or more) and the most sophisticated technology. This is because it is essential to get maximum economies of scale and adopt well proven technology in use in developed countries.

Whereas such large plants and sophisticated technologies are appropriate for some developing countries which have reached high levels of development and others which have large internal markets or those which have export potential based on large and cheap resources of raw materials, there are many developing countries particularly less developed land locked or island countries where such scales and technologies are not appropriate. Further, even in large developing countries which build 'Jumbo' size plants using modern technologies there is scope for dispersed end product fabrication units using appropriate technologies.

To quote the Aide Memoire for this meeting "It is imperative, that very close interlinkage is ensured between the modern and the dispersed sectors, which should be viewed as integral parts of industrial growth processes. Unless an integrated two-fold approach is adopted concentrating both on the modern and dispersed or decentralized.

industrial sectors, the industrial growth pattern would continue to be confined to small pockets of industrial concentration located in small urban enclaves and providing only limited benefit to the large rural communities in these countries.

"The concept of appropriate technology needs to be considered both in the context of processes and techniques in the most sophisticated industrial sectors in these countries and in respect of a wide range of goods and services which can be produced through a more dispersed industrial sector, where manufacturing processes could be more directly related to meeting basic socio-economic needs and requirements of rural communities.

Technological needs for the decentralized or dispersed sector could vary significantly from those of the modern sector, though the basic principle of suitability and appropriateness would be equally applicable. In the two sectors, production scales and unit investment outlays would tend to be different according to local factor conditions, including human skills. In the dispersed sector, appropriate production processes could take the form of more labour-intensive techniques or production technology either used formerly in industrialized countries or presently in developing countries or which may need to be developed through R and D processes. The identification of such processes and techniques would necessitate a systematic search for appropriate production technology in specific sectors or the development of such techniques through research efforts.

This paper examines possibilities of dispersed end product production fertilizer plants using intermediates or products from local 'Jumbo' plants or from imports. Such dispension will help in participation of rural population and making available timely inputs for agriculture. The experience even in developed countries such as U.S.A., U.K., France and others has proved that dispersed bulk-blending **and liquid fertiliser formation** plants have helped a great deal in dispersion, greater usage and as bringing appropriate technology to rural areas.

2. 'JUMBO'PLANTS

Developing countries should not be isolated from the main stream of technological innovations and developments, Ten years ago very large ammonia plants of capacities of 1000 tons per day and above were mostly built in developed countries. But during last ten years many such plants have been built in developing countries in single streams. The concept of centrifugal compressors, Naphtha or natural gas reforming furnace technology, gas purification systems, the ammonia loop modifications ammonia reactor design itself and other innovations have been adopted in developing countries and operated successfully. But there is still room for development of appropriate technologies peculiarly suited to developing countries especially energy conservation systems, air-cooling methods, simple instrumentation techniques etc. processes which do not affect the environment particularly in phospharic acid, sulphuric acid and nitric acid production should be wel-comed.

These process innovations and technologies are more attuned to large scale production plants, for example centrifugal compressors need a minimum amount of synthesis gas to be handled which determines the minimum capacity. Total energy concept is also best possible in ammonia plants of capacities above 600 tons per day. Thus large scale plants and appropriate technologies some time go together.

There is need and scope for such 'Jumbo' Plants in many developing countries. They are located either market oriented or raw materials oriented. Thus where natural gas is flared and can be obtained cheaply "Jumbo" ammonia plants could be built for export purposes. Other in-frastructure facilities should also be available. Naphtha, fuel oil or coal based plants could be built in countries where there is a large market. In both cases the locations are mostly close to urban areas where in-frastructure facilities and technical man-power are available. Thus the tendency in countries with large markets or with abundant and cheap sources of raw materials is to isolate themselves from rural and consuming areas. This isolation leads not only to migration of workers but also tends to minimise dispersion of industries. But many countries are now making a concerted effort to disperse even 'Jumbo' plants to rural areas.

3. MODEL APPROACH

To overcome such difficulties it is recommended that such 'Jumbo' plants should be used to feed satellite and product fabrication units located in the rural areas. We shall examine the mechanism of setting up such units, the advantages of this approach and its effects on economic and industrial developments in country concerned.

Even if intermediates or finished products have to be imported in bulk, such end product fabrications plants located in rural consuming centres have certain advantages.

Central 'Jumbo' plants should participate in setting up such units. If a 300 mile radius is one economic distance to move finished on intermediate materials, such units could be set up within these limits. For example, a 'Jumbo' plant could select a potato growing region, a paddy (rice) growing region, a coffee growing region so as to build satellite units. Intermediates or finished products could be moved in bulk and bulk-blended to produce appropriate N:P:K mixture for potatoes, paddy-rice and coffee. A more advanced approach will be to make liquid fertilizers and help in their direct application.

'Jumbo' plants should also make available to their satellite units technical know-how and appropriate technologies not only in bulk-blending and liquid formulations but also in soil analyses, extension services, application procedures, crop protection, post-harvest storage credit, marketing supply of seeds, water and plant protection chemicals. Thus rural areas benefit from the vast technological, marketing, extension services and other skills available in a 'Jumbo' project and in turn benefit from better sales.

Multiplier and demonstration effects of such schemes are obvious. A village or district benefitting from such satellite units and improving output and general conditions of living will automatically show to neighbouring districts on villages the advantages.

Many others will voluntarily opt for coming into such arrangements as will build such satellite plants in co-operations. Above all the input/output ratio has to be advantageous for such schemes to work

5. PROCESS DESCRIPTION AND EQUIPMENT NEEDED

Let us now discuss the physical facilities required for such satellite units.

BULK STORAGE Capacity of the bulk-blending and bagging plant is 30,000 tons per year.

With a storage capacity of 3,000 tons of bulk materials, a horizontal storage system is clearly indicated, and as at least three different materials will have to be accommodated, individual storage bins will be practical. The cost of bin walls capable of withstanding the pressure of bulk materials rises sharply with increased storage height; a storage height of 4 m at the bin ends is recommended. The maximum storage height, in the middle of the building may be 8 m. To bear the extra pressure, the bin partition walls should be tied together with steel rods. At these storage heights, there should be no difficulties in reclaiming the materials and no tendency for the materials to harden unduly.

In order to accommodate 3,000 tons of bulk materials with an assumed density of 0.9 t/m^3, about 3,300 m^3 of space will be needed. With a minimum angle of repose of 27°, a bin length of 22 m gives a material cross section of 143 m^2, bins of the same size is recommended giving a capacity of 3,150 tons. The bulk-storage building for the plant will therefore occupy an area of (22x25 = 550) m^2.

The building should have a concrete floor high enough to prevent entry of run-off water. As wood is impervious to fertilizers and also is relatively cheap in most developing countries, a building construction based on 5 20-cm wooden studs with plywood sheathing on the inside and asbestos sheathing on the outside is recommended, as are wooden rafters across the bins, covered with plywood and asphalt shingle or asbestos sheathing. For countries where wood is scarce or too expensive, a building construction with steel structures covered with asbestos sheathing may be advantageous.

RAW MATERIALS RECEPTION AND STORAGE

As the raw materials will be delivered by trucks or railway cars a receiving and input capacity of 30-60t/h is considered sufficient. Trucks should dump from a 0.5 m high ramp onto a portable under-car belt conveyor that feeds a bucket elevator located outside the short side of the storage building. The bucket elevator feeds through the top of the side wall to a belt conveyor under the peak of the roof. This conveyor runs the length of the building and is equipped with a tripper carriage, feeding a transverse-shuttle belt conveyor that can be shifted from bin to bin. Each end of the shuttle conveyor should be equipped with a plow-type spreader to split up the stream of material, and in its outer position the conveyor should feed to tube chutes, also equipped with spreaders that carry the material further out to the bin ends. This relatively complicated arrangement is considered necessary to prevent segregation in the long bins, as the filling point can be shifted over most of the bin length. In this way it will also be possible systematically to reblend materials that segregated during previous handling, and the spreaders will further prevent degradation and dust generation with brittle materials, such as urea prills. The alternative of using telescoping fill-pipes from a central shuttle-conveyor is impractical with the large bins in question.

To prevent moisture absorption during storage, the pile surface should kept covered with plastic sheeting e.g. polyethylene(PE)film 0.15.20 mm thick. Two rolls of film with a width corresponding to width of the bins should be suspended under the central conveyor in each bin. After filling, the PE film can be pulled out all the way to the bin ends. During emptying, the rolls can be gradually rewound. The storage building should be made as tight as possible to eliminate draughts of humid air.

RECLAIMING OF RAW MATERIALS

Bin ends should be equipped with openings about 3 m square. During filling, these openings are closed by horizontal wooden boards, mounted a certain distance above each other. This arrangement prevents the materials from running out of the bins; to reclaim, the boards are taken out one by one, starting at the bottom. To prevent dust from escaping during filling and moisture being absorbed during storage, the openings should be covered by roll curtains of plastic sheeting that can be operated manually.

Reclaiming should be done using a 1.5-2 ton diesel forklift truck equipped with a hydraulic tilting shovel with a capacity of about $0.8m^3$. This size truck has ample capacity for either plant and can also be used in maintenance, repairs etc. A forklift with shovel is cheaper and has a more compact turning circle than a small front loader.

Blending

In the blending operation, a system consisting of a lump crusher, a bucket elevator, clustered holding bins, weighing scales and a horizontal, one-way rotating mixer is recommended.

Conveyors should stand above floor level to facilitate clean-out and maintenance, and a capacity of 50 t/h is recommended, corresponding to the discharge rate from the mixer, so that no surge bin is necessary. A lump crusher is considered necessary. It should be located over the intake of the bucket elevator a small hopper above it being fed by the shovel truck. From the bucket elevator, a swivel spout feeds any of four compartments in a cluster hopper with a capacity of (4x5=20)tons. To prevent segregation and degradation, the hopper inlets should be equipped with simple plow-type deflectors, and the four outlets should be together in the pyramidical part so that each compartment has an eccentric outlet, equipped with hand-operated clam-type outlet gates. There should be a light-signal system to inform the truck driver which material is needed. The ingredients of each batch are successively let down into the hopper of the weighing scale situated under the cluster hopper, and the reading of the scale is observed. A batch size of 1 t is considered suitable for both plants. After being weighed, the batch is dumped via a chute into a one-way rotary mixer of 1-t capacity. With a batch cycle time of 3 min.capacity will be 20 t/h, enough for the plant.

In order to eliminate undue amounts of dust in the blending and bagging building, air should be exhausted by a centrifugal blower from the tops of both bucket elevators, from the lump crusher etc., the dust-laden air being fed to a cyclone and, if necessary, to a simple bag filter.

The mixer should have a system for adding up to 1% of mineral oil to each batch by means of a spray nozzle fed by a small gear pump. For correct metering of the oil, the operating time of the gear pump should be pre-set on a timing device. About 0.5% of a mixture of light and heavy fuel oil or used motor oil has proved to be very satisfactory for suppressing dust, both in mixing and in subsequent operations.

With this system, anti-caking agents or micronutrients may be added at will in the mixer as fine powders. It may also be possible to feed some of the dust collected in the cyclone back to the mixer. Segregation of fines in the bagging hopper will be reduced and the bagged products will have less tendency to cake in storage.

The mixer should discharge onto an inclined belt conveyor that takes the product upto the bagging hopper. This conveyor should have a capacity to match the discharge rate of the mixer i.e. 50 t/h.

Bagging

Only one size of bag should be used: 50 kg. With that size the necessary production capacity of 7 t/h corresponds to a bagging rate of 2.5 bag/min. Furthermore, the bags should be of the open-mouth style, valve bags being more expensive and requiring complicated bagging equipment. Depending upon the bag strength necessary and the supply available locally, different bag types could be used, such as jute or woven polypropylene outer bags with inner PE liners, or plastic-film bags, preferably made from PE. A simple fixture made of steel tubing and plywood is used for proper and quick insertion of PE liners into woven bags. The inner liner should be closed by tying, the outer bag being stitched on a simple sewing machine. Film bags should normally be closed by heat sealing, but if such bags are used only occasionally, stitching may also be permissible, provided that a paper or plastic-film strip is folded over the bag top before sewing (stitch-over tape).

As mentioned above, the products are transferred by a belt conveyor to one/two bagging hopper(s) situated over the packers. Each hopper should have a capacity of 1.5 t. As prevention of segregation is particularly important after blending, the hopper should be designed with special care. It should be equipped with internal baffles, dividing the area into nine partitions. When bagging straight materials, e.g. urea and DAP, these should be taken directly from the second elevator to the inclined conveyor by means of a chute. In this way the dustered hoppers, weighing scales and mixer are by-passed, avoiding unnecessary degradation and dust formation.

Bagging is done on the simple "volumetric" bagger, developed for example by Norsk Hydro AS, is easy and inexpensive to make and maintain, and the attainable accuracy of ± 0.5% (250g in 50 Kg) is considered good enough for the purpose.

The fertilizer to be bagged is measured by volume instead of being weighed as is normally done. The receptacle is filled from a small overhead hopper. Then a bag is placed underneath the spout and the handle on the valve plate is lifted, thereby simultaneously closing off the hopper at the top and opening the spout at the bottom, so that the measured quantity runs down into the bag. After the bag is filled, the handle is pushed down, closing the receptacle at the bottom and opening it at the top, so that the receptacle fills while the full bag is taken away and an empty one placed under the spout.

The volume of the receptacle can be changed to adjust for different bulk densities by pushing a displacement cylinder more or less into it. Tests have shown that a bagging rate of 5 bags/min can be kept up with one unit, which compares favourably with many automatic mechanical scales on the market. A manually operated checkweighing scale is needed, however, to adjust baggers properly and to check filled-bag weights periodically.

This simple bagger can be adapted to different levels of mechanization. In the simplest, the bagger may be placed at the circumference of a bulk heap, its hopper being kept full by workers with shovels or buckets. The bags are carried to other workers, who close the inner and outer bags by hand. A normal gang would then consist of about 12 workers. At the other extreme, as in the plant described here, one or more units could be placed under a hopper filled by mechanical means, and the bags could be taken to electric stitching machines by belt conveyors. In this way a gang size of 4-5 workers may suffice.

Filled bags are taken to the tying station, the sewing machine or the heat sealer on a bag conveyor and finally to the product storage area(described in the next section) on hand trucks where they are lifted on to a portable belt conveyor with adjustable slope, so that bags are brought up to the stack top by mechanical means. When loading outgoing trucks, bags can be slid down polished wooden boards and lifted to the truck bed by a smaller portable conveyor.

Storage of bagged products

To hold a half-month's production, the product storage buildings must have a capacity of 1,500 tons. Since unskilled labour is likely to be readily available, storage of loose bags as opposed to palletized storage is recommended. Assuming a loading height of 4 m and allowing an extra 20% for aisles, an area of 500 m^2 is needed. In peak seasons, bags can be piled outside and covered by tarpaulins. For the storage of empty bags etc. an area of about 100 m^2 will be needed. About 50 m^2 will be needed for bleading, 50 m^2 for bagging and about 50 m^2 for maintenance, laboratory etc. The total comes to about 750/1, 150 m^2. Using a building length corresponding to that of the bulk-storage building i.e. 25 m, and a width of 3 x 10 = 30 m, the total required floor space comes out to be 750 m^2.

Laboratory:-

The plant should have a laboratory capable of checking the quality of incoming raw materials and of intermediate and finished products. The laboratory should therefore contain equipment for sampling, sample splitting, sieve analyses, nutrient and water-content determination, soil analyses etc. It is recommended that a skilled agriculturalist should manage the laboratory, spending most of his time as a consultant to farmers.

5) LIQUID FERTILIZERS

A more sophisticated approach to locate satellite plants in villages and districts will be to initiate production and use of liquid fertilizers. In the U.S.A, it is reported that nearly 50% of all fertilizers applied to the soil are in the form of liquids. The advantages over solids are as follows:-

1) 10 - 20% saving of costs in production, storage and distribution, and application of liquids to the soil.
2) more efficient use by plants.
3) production in satellite units and centralized application techniques.
4) less use of energy.
5) high nutrient contents.

Disadvantages are:-

1) Liquids are more expensive and require specialized aquipment for storage and application.
2) more economical only for use in large farms.
3) changes in composition if stored for long periods of time.

Conditions which are particularly favourable for the growth and use of liquids:-

1) Large farms with crops, with the necessity of intensive application of fertilizers.
2) spread of demand throughout the year.
3) presence of primary fertilizer or mother plants which can supply intermediates.
4) good rail, road or water transport facilities.
5) technical skills in storage, application and operation and maintenance of farm equipment.

Types of liquid fertilizer:-

1) **Clear liquids** such as anhydrous or aqua ammonia, ammonium phosphate, urea and ammonium nitrate solutions.

2) **Suspensions**
Stabilized suspensions of triple superphosphate and di-ammonium phosphate.

3) **Slurries**

Raw materials required:-

1) Nitrogen (N) in the form of anhydrous or aqua ammonia, D.A.P, A.N, urea, etc.

2) Phosphates (P) in the form of phosphoric acid, T.S.P, etc.

3) Potash (K) potassium chloride, sulphate, phosphate or hydroxide.

4) Clay for stabilizing suspensions.

5) Water.

Compositions:-

1) N-	anhydrous ammonia	82%N
	aqua ammonia	15 - 25% N
	urea	48% N
	ammonium nitrate	30% N
2) P-	phosphoric acid	54% P_2O_5
3) K-	potassium chloride	62% K_2O

4) N - P_2O_5 - K_2O in different proportions as needed by crops and soils and made up of components which are mutually compatible such as:-

Ratios of N:P:K	N:P:K
1:1:1	15:15:15
1:2:1	7:14:7
1:2:3	4:8:12
1:3:1	6:18:6

Types of plants and equipment:-

1) Hot mix plants - these can be continuous or batch-operated.

Continuous type

a) reaction tank of S.S, equipped with agitator and with cooling coils.
b) pipe reactor, T.V.A type.
c) storage tanks.
d) pumps
e) piping
f) instruments
g) weighing equipment

Batch type

a) reaction tank
b) storage tanks
c) pumps
d) piping
e) instruments
f) weighing equipment

2) Cold mix plants - these are simple mixing units to make clear liquids or suspensions.

Plant costs and economic viability

Investment costs for a plant of capacity 15 tons/hour using the wet process phosphoric acid and making a grade of 10-20-20, will be about $ 835,000.00 in the U.S.A.

Personnel requirements

Manager	1
Shift supervisors	4
shift operators	4
others unskilled	8
Total	17

Consumption of raw materials and utilities

For a 20 ton batch of product, analysing 9-9-9, theoretical requirements are as follows:-

Phosphoric acid (54% P_2O_5)	3.34 tons
Aqueous ammonia (25% NH_3)	2.92 tons
Urea	2.61 tons
Potassium chloride (60% K_2O)	3.00 tons
Water	8.13 tons

Utility requirements

Power 1000 kW

6) FINANCIAL IMPLICATION

Estimated Investment Cost:

The list on the next page summarises the investment estimates (in thousands of Dollars) for the plant. Note that Land and Off-Site utilities are not included, nor are office buildings and equipment, labour and staff facilities and maintenance equipment.

	(30,000t/a)
Mechanical equipment	115
Electrical Equipment	17
Laboratory Equipment	4
Subtotal, equipment ex-works	136
Export crating, delivery, freights, 30% of above	41
Erection and installation	
Mechanical	11
Electrical	9
Subtotal, installed equipment	197.3
Civil engineering, foundations, concrete, floors etc.	28
Site preparation and roads	15
Bulk storage building	105
Blending tower and product storage building	90
Start-up supervision (four months)	8
Total	443.3

These costs are based on experiences in developed countries and could be reduced in developing countries and the buildings and mechanization appropriately adapted.

7) Employment Opportunities.

The following indicates the number of personnel required for such a unit:-

Manager -	1
Chemists -	2
Agronomist -	1
Operators -	4
Fork Lift Operators	4
Truck Operators -	4
Skilled Labour -	12
Unskilled labour -	12
	40

Part-time workers may be used to run the operations.

8) MANAGEMENT AND TRAINING:-

The Chemist and Agronomist could train apprentices who are matriculates in simple analyses of fertilizers, soil analyses etc. The agronomist could train extension workers who could advise farmers on the proper use of fertilizers. Depending on the soil analyses and the crops grown, fertilizer mixtures could be made to suit the soils and crops. Thus farmers have a ready source of plant nutrients near their farms.

9) INPUTS INTO AND PARTICIPATION OF RURAL AND AGRICULTURAL SECTORS:-

With the installations of such a satellite plant in a village of 10,000 population the needs of the farmers and the times and quantities of fertilizers required can be predetermined. The bulk blending plant can have an assured and planned production schedule. If credit facilities can be offered and if farmers can pay back cost of fertilizers when their produce is harvested and sold their participation can be assured. As stated earlier the satellite plant can also make use of seasonal or part-time agricultural labour from the village.

The 'Jumbo' or 'mother' plant should adopt the village and provide know-how and assistance in proper selection of seeds and then treatment, soil management, water management application of fertilizers and pesticides, post harvest storage and co-operative selling. If such services are assured the village farmers will co-operate and benefit from the assistance. Disposal of Industry and extension of appropriate technology to rural areas then will become possible.

10) NATIONAL AND INTER-COUNTRY BENEFITS:-

The idea of satellite plants can also be extended to co-operation between two countries. A country which has large natural resources and raw materials to produce cheap fertilizers can come to an agreement with a country with large market. The two countries can agree on a project for importation of finished or intermediates from the country which can produce cheap fertilizers and put up 'Satellite' facilities, jointly or independently in a country or countries with large markets. In such a scheme the country exporting fertilizers has an assured market and the importing country gets the benefit of cheap fertilizers. The two countries benefit and ultimately the farmer gets fertilizers cheaply and in time. Although such arrangements between countries exist even now, fuller participation of all concerned in an institutional way will be more advantageous and fruitful in dispersion of industry and allowing appropriate technology to reach the rural areas.

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