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CZECHOSLOVAK PROCESS OF NP AND NPK FERTILISER  
PRODUCTION BASED ON DIRECT COOLED CONTINUOUS  
CRYSTALLIZATION

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Severočecké Chemické Závody, national enterprise, (SCHZ) at Lovosice in cooperation with CHEMOPROJEKT Praha have developed a new method for the application of the ODDA process. This method takes the advantage of direct heat transfer for the crystallization of calcium nitrate tetrahydrate from the slurry obtained by nitric acid attack of phosphates. White spirit - commonly applied in the painting industry - is used as the heat transfer medium insoluble in the slurry for the direct cooling of the crystallization bath. In comparison to the classical ODDA process, the direct cooled crystallization reduces to a large extent the necessary crystallization volume and it works fully continuously with minimum demand on process supervision. In addition the process enables to achieve a very high degree of calcium ion separation, making possible the production of fertilizers corresponding to those based on wet process phosphoric acid.

Applying the results of the SCHZ research works a production unit was constructed at Lovosice. Its capacity is 180,000 t of fertilizer having the composition of 13-19-19 with 60% water-soluble  $P_2O_5$ .

In cooperation with BAMAG AG another NPK plant has been brought into operation in Spain. The crystallization of this plant has been carried out in two stages to achieve a very high degree of water-soluble  $P_2O_5$ . Obtained calcium nitrate tetrahydrate is converted to ammonium nitrate by the carboammoniation according to the licence of Chemisch Fabrik Kalk, Köln. The licence was granted by BAMAG AG.

The crystallization of calcium nitrate tetrahydrate from slurries obtained by the nitric acid attack of phosphates is a process that enables to produce complex NP and NPK fertilizers without any need for phosphoric acid. This fact is of real importance especially for plants producing nitrogen fertilizers. Such plants, consuming large amounts of nitric acid for the production of nitrogen fertilizers - mainly of ammonium nitrate - have now the possibility to utilize with advantage the acid for the phosphate decomposition at first and then to convert the separated calcium nitrate tetrahydrate into desired nitrogen fertilizer.

A number of studies have already confirmed that the production costs of NPK fertilizers produced in such a way are 12 to 15% lower than those of comparable fertilizers based on wet phosphoric acid. One sometimes objects that the ODDA process is less flexible from the viewpoint of nutrient concentration of the product than processes using phosphoric acid. By our crystallization process it is however possible to produce NP as well as NPK fertilizers in a wide variety of composition. Research works of SCHZ tend to obtain fertilizers in all respect comparable to those based on the ortho-phosphoric acid.

First of all it is necessary to recall the basic process, i.e. direct cooled crystallization of calcium nitrate tetrahydrate.

Apatite or calcined phosphate rocks are decomposed by a determined and suitable excess of nitric acid - concentration of which may vary between 50 and 60% by weight. The efficiency of the attack is 99% at minimum. Most of insoluble is separated from the acidulation slurry mechanically by decanter centrifuge. After precooling to the temperature slightly above the crystallization point, the acidulation slurry enters to the crystallizer where it is contacted with undercooled white spirit (Fig.1). Being in steady motion at lower temperature the crystals grow and after reaching an adequate size they are continuously separated on filtration centrifuge. The crystals are of uniform size so that after washing they retain 0.2 to 0.3% of occluded  $P_2O_5$  only.

In a single stage crystallization a degree of Ca-ions separation up to 70 per cent may be obtained; above this value it is necessary to perform the crystallization in two stages. The second crystallization stage is quite similar to the first one. Mother liquor from the centrifuge is preheated by acidulation slurry, separated from possible traces of entrained heat transfer medium and after adjusting the N to  $P_2O_5$  ratio by adding the ammonium nitrate solution - if required - it is neutralized with gaseous ammonia. The reaction heat is utilized for the evaporation of water, i.e. for the concentration of the neutralized slurry and possibly for the melting of crystals.

When a less concentrated nitric acid is used, it may be necessary to incorporate an evaporator to the process scheme to achieve the concentration of the slurry required by the chosen granulation technology.

According to the desired formula potassium salt is added and the obtained slurry is granulated with dried recycle in a pug-mill. Fertilizer granules are transported into the drum drier and after lowering the moisture content up to 1 per cent they are screened. The oversize is crushed and recycled to the granulation together with the undersize and with the dust from cyclones. The product-size fertilizer granules (2 - 4 mm) are cooled by means of a fluidized bed cooler and leave the unit.

All gaseous as well as dust pollutions are washed and the recovered products are returned into the process. (Fig.2)

## Outstanding features and merits of SCHZ process :

### 1. Direct heat transfer

The crystallization connected with quick fouling of heat transfer surfaces by crystals presents the main problem of the original ODDA process. Heat transfer surfaces are quickly covered by an insulating layer of crystals and they ought to be cleaned by heating of surfaces and melting of crystals at short intervals. In the SCHZ process the heat transfer is performed directly by the insoluble heat transfer medium and therefore the difficulties due to the fouling of heat transfer surfaces are completely eliminated.

### 2. Simplicity of the process

The whole unit i.e. crystallization, separation of tetrahydrate crystals and its melting, works completely continuous. The process is stable and the adjustment of technological parameters is to be performed practically with the change of raw materials or of the required product formula only.

### 3. Crystallizer capacity

As mentioned above, the high intensity of heat transfer enables to reach a specific output of the crystallizer as high as 1.7 t of  $P_2O_5$  /m<sup>2</sup> daily. This figure exceeds by several times the values obtainable in the classical ODDA process. At present crystallizers with the output of 50 and 75 t  $P_2O_5$  in mother liquor per day are in operation. Further increase of the crystallizer capacity is under consideration.

### 4. Safety of the process

Lacquer petroleum - white spirit - of high boiling range and with a flash point above 35 deg. centigrade is used as the heat transfer medium. As all operations are performed below the flash point temperature the white spirit behaves like nonflammable liquid. For instance according to U.S. regulations - the US National Electric Code - no explosion-proof electric installation is required in such areas.

### 5. Flexibility of the process

It is possible to obtain a CaO separation degree up to 85-90% i.e. up to approximately 90 per cent of water soluble  $P_2O_5$  in the product. It is easy to understand that the high possible degree of CaO extraction enables to produce fertilizers with different N to  $P_2O_5$  nutrient ratios. Up to 50-60% water-solubility. (a single stage crystallization is used; higher water solubilities require the two stage crystallization process).

### 6. Investment

Investment costs are lower by about 35% in comparison to the classical process. They are influenced partly by saving of 50% of the cooling surface partly by lower need of the crystallization volume. It is possible to use efficient continuous centrifuges for the separation of tetrahydrate crystals and finally the equipment can be placed advantageously into an open roofed construction.

## 7. Raw materials

Practically Kola-apatite as well as any calcined phosphate may be treated as raw material. From the economical point of view the most advantageous are phosphates with the lowest CaO/ P<sub>2</sub>O<sub>5</sub> ratio. The concentration of nitric acid may vary between 50 and 65% by weight. The optimal concentration lies between 56 and 60%. Lower concentrations require lower crystallization temperatures for reaching the same CaO crystallization degree. Higher concentrations enable to perform the crystallization at higher temperatures, bringing however an unfavourable influence on the viscosity of slurry at the crystallizer outlet due to the lower ratio of the solid and liquid phase. This unfavourable influence may be eliminated by a suitable excess of nitric acid.

An important quality factor of calcined phosphate rocks is the calcination temperature an optimum of which lies between 950 and 1000°C. The settling properties of fine insolubles as well as of SiO<sub>2</sub> in slurries prepared from phosphates calcined at above mentioned temperatures are improved in such a way that the crystallization performs quite identical as in the case of Kola-apatite. It was stated that some calcined phosphate rocks form during crystallization an emulsion of flocculated residue and SiO<sub>2</sub> with the white spirit. This emulsion is destroyed only slowly and it is influencing the crystallization course after a definite period. Analyses have proved that these phosphates had not been calcined properly as they showed up to 2 per cent of calcination loss (CO<sub>2</sub>, crystalline water, organics). In such cases it is necessary to take measures for additional destroying of the emulsion.

## 8. Crystallization process

Crystallization process which has a decisive influence on the quality of mother liquors and finished products obtained is for a given raw material drawn in form of a diagram and the whole process is designed according to this. An example of such a diagram is given on the Fig. 3.

- Curve A - shows the content of P<sub>2</sub>O<sub>5</sub> in mother liquor
- B - shows the content of CaO in mother liquor
- C - shows the CaO/P<sub>2</sub>O<sub>5</sub> ratio and
- D - shows the degree of CaO crystallization.

All curves are drawn as a function of temperature.

## 9. Utility consumption

The consumption of utilities - mainly of electric power - depends on the required crystallization degree as by, increasing this, the utility consumption grows too. Plants producing nitrogen fertilizers and using the mentioned technology have a possibility to utilize economically the evaporation heat of liquid ammonia used in gaseous form in other production units of the plant. The crystallization degree shows greater influence on the consumption of electric power and water due to its higher specific consumption at lower crystallization temperatures. The steam consumption depends linearly on the amount of crystals only.

## 10. Calcium nitrate tetrahydrate

Calcium nitrate tetrahydrate is separated from the slurry after crystallization in a very pure form. In this process, it forms an analogy to the gypsum by-product in the wet phosphoric acid process. There exists however an important difference as the gypsum forms a very difficult waste complicating the whole production of phosphoric acid whereas calcium nitrate tetrahydrate may be converted into a range of products i.e. mainly to :

- calcium nitrate
- ammonium nitrate by carboammoniation with  $\text{CO}_2$  and  $\text{NH}_3$  - a basis for the production of calcium ammonium nitrate as well as of ammonium nitrate fertilizer. Precipitated calcium carbonate is by-produced in this process. However it presents a product required by farmers; thus as a matter of fact no waste exists in this process at all.
- urea-nitrate with molar proportion of 1:4
- nitrogen oxides (nitric acid) and  $\text{CaO}$  by thermal decomposition. This process - not realized in industrial scale till now - is solved especially for the economical evaluation of nitrate in the uranium industry. In the future it may appear important for the described process too.

### Quality of products

Informative quality parameters of fertilizers produced by the SCHZ/CHP process are shown in the enclosed diagram (Fig.4).

Depending on Ca ion separation degree (scale A) following values for Kala-apatite (K) and for calcined Morocco phosphate 77/79 BPL (M) may be determined :

- scale B - content of water soluble  $\text{P}_2\text{O}_5$  in the fertilizer
- scale C - N to  $\text{P}_2\text{O}_5$  ratio in the basic fertilizer, i.e. a product  $\text{P}_2\text{O}_5$  without any further adjustment of nutrient content.
- scale D - content of  $\text{P}_2\text{O}_5$  in the basic fertilizer
- scale E - content of  $\text{P}_2\text{O}_5$  in the fertilizer after correction of nutrient ratio to 1:1:0
- scale F - content of  $\text{P}_2\text{O}_5$  in the fertilizer after correction of nutrient ratio to 1:1:1
- scale G - amount of nitrogen<sup>(t)</sup> in separated calcium nitrate tetrahydrate for 1 t  $\text{P}_2\text{O}_5$  in the fertilizer.

By adding ammonium nitrate it is possible to obtain a product with any higher N to  $\text{P}_2\text{O}_5$  ratio than may be estimated on scale C. The content of  $\text{K}_2\text{O}$  in the product may be adjusted in any extent too. It is evident that the offered process may assure a wide range of products according to the requirements of customers.

### Economy of the process

The phosphoric component forms a decisive factor in the economy of complex fertilizer production. In the production of wet phosphoric acid - which is one of the most important intermediate products for the manufacture of phosphatic fertilizers - there are certain problems in the dislocation of sulphur sources in the world. A lot of states have to import the sulphur from far distance and on the other side after using it in the phosphoric acid production they have - and that relates mainly to the inland ones - serious problems with the waste gypsum disposal.

As mentioned in the introduction the nitrogen fertilizers producing plants have the possibility to produce phosphatic fertilizers by the aid of nitric acid as well consumed for nitrogen fertilizers and to eliminate completely the need for the phosphoric acid. Economical advantage of this process has been studied not only by us, but by significant foreign experts as Slack and Professor Ewell from USA and others too. All of them came to the conclusion that the production costs of NPK fertilizers based on the ODDA process are by 12 to 15% more advantageous than corresponding fertilizers based on the wet phosphoric acid. Only fertilizers prepared from ammonium phosphate and urea having a nutrient content of 58 per cent compensate this difference in production costs under the condition that the fertilizers are transported to a distance of 300 miles at minimum. Similar results were obtained by our economical studies.

A plant with a capacity of 1000 t/day of a fertilizer containing 13% N, 19%  $P_2O_5$ , 19%  $K_2O$  and 60% water soluble  $P_2O_5$  i.e. the fertilizer corresponding to the SCHZ product has been chosen for the clear comparison of NPK production based on the ODDA process and of nitro-phosphates based on the utilization of phosphoric acid.

Kola apatite with about 39% of  $P_2O_5$  has been used as the raw material for the ODDA process. The calcium nitrate tetrahydrate is subtracted from the raw materials costs as the value of nitric acid lowered to 70% of the original one. This evaluation compensates the price of ammonium nitrate fertilizer to the level of a product prepared by direct neutralization of nitric acid with ammonia. Phosphoric acid for nitro-phosphate process has been calculated at the level of production costs of a unit with the capacity of 220,000 t/year.

Following consumption values for 1 t NPK were used : 148 kg  $H_3PO_4$ , 46 kg Kola apatite (as  $P_2O_5$ ), 98 kg  $NH_3$ , 223 kg  $HNO_3$  and 320 kg  $KCl$ .

As it may be seen from the following tables the ODDA process production costs are lower by 9.5%.

Literature

Kotisek, Hellmer : Nitrophosphate process using direct cooled continuous crystallization.  
Paper presented at II. International Fertilizer Symposium, Kiev, USSR, 1971.

Batra : Phosphoric acid obtained by the nitric acid attack of phosphates.  
Paper presented at INCHEBA, Bratislava, CSSR, 1972.



ECONOMICAL COMPARISON OF 13-19-19 NPK  
FERTILIZER PRODUCTION BY THE ODDA AND BY NITRO-PHOSPHORIC  
PROCESS

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	ODDA	Nitro-Phosphate
Raw materials	73.00%	84.40%
Utilities	3.59	3.30
Labour	0.35	0.29
Depreciation	2.50	2.35
Other costs	20.56	19.16
Production costs	100.00%	109.50%

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SPECIFIC CONSUMPTION FIGURES FOR  
1000 t OF 13-19-19 NPK PLANT - ODDA PROCESS

Raw materials per t NPK

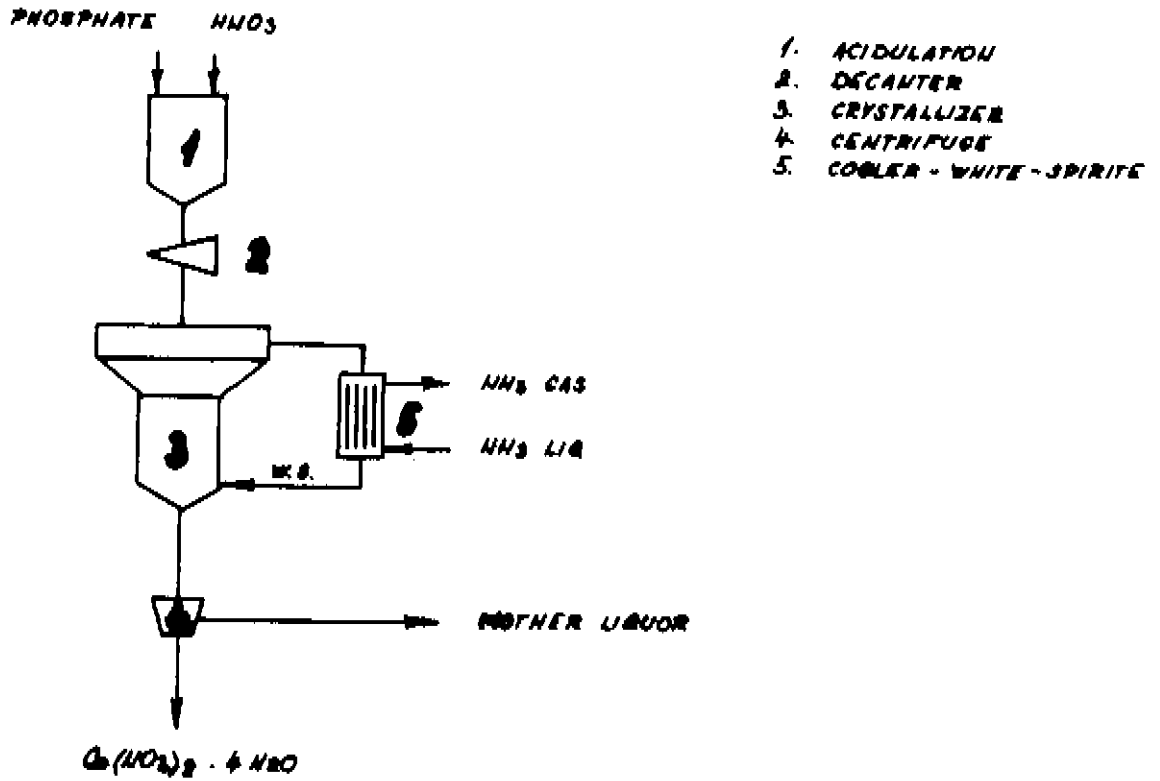
Kala apatite (as $P_2O_5$ )	kg	194
$NH_3$	kg	98
KCl	kg	320
White Spirit	kg	3
$KNO_3$ (100%)	kg	653
By-product from crystallization		
$Ca(NO_3)_2 \cdot 4 H_2O$	kg	780

Utilities per t NPK

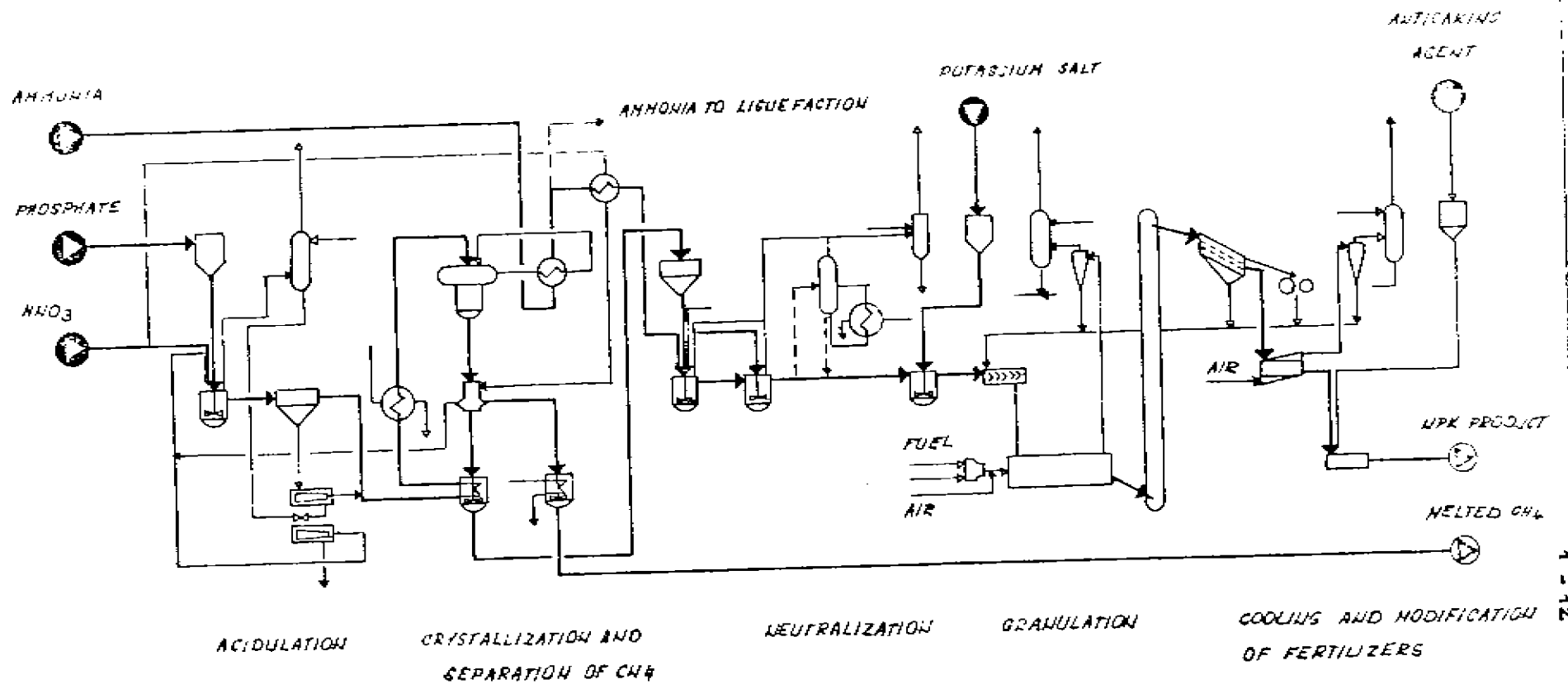
Electric power	KWh	83
Fuel oil	kg	25
Steam	Gcal	0.2
Cooling water	$m^3$	17

ESTIMATED INVESTMENT - 10<sup>6</sup> DM

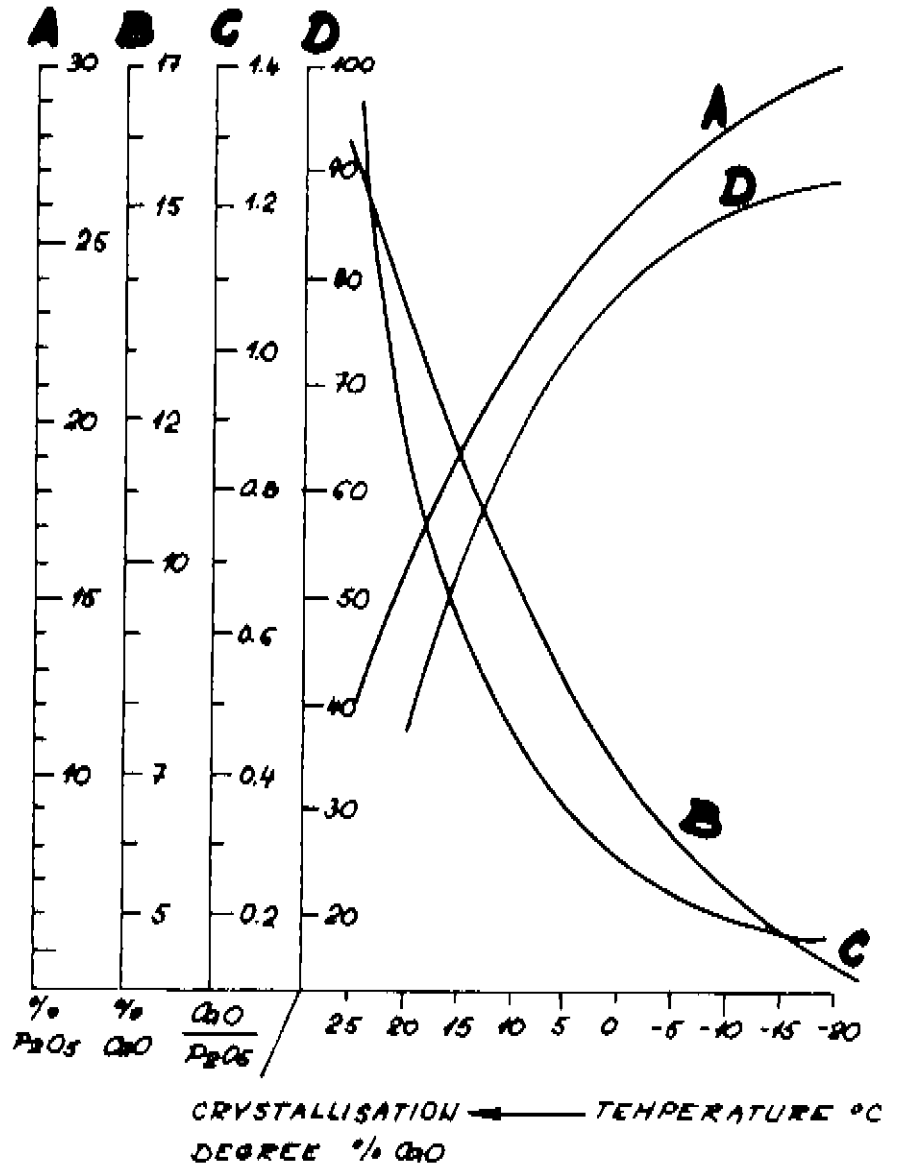
	10 <sup>6</sup> DM	%
NPK unit incl. transport and storage.	16.6	44.4
Offsite, utilities	8	21.4
Miscellaneous - buildings, distribution network, railway siding	12.8	34.2
TOTAL	37.4	100.0



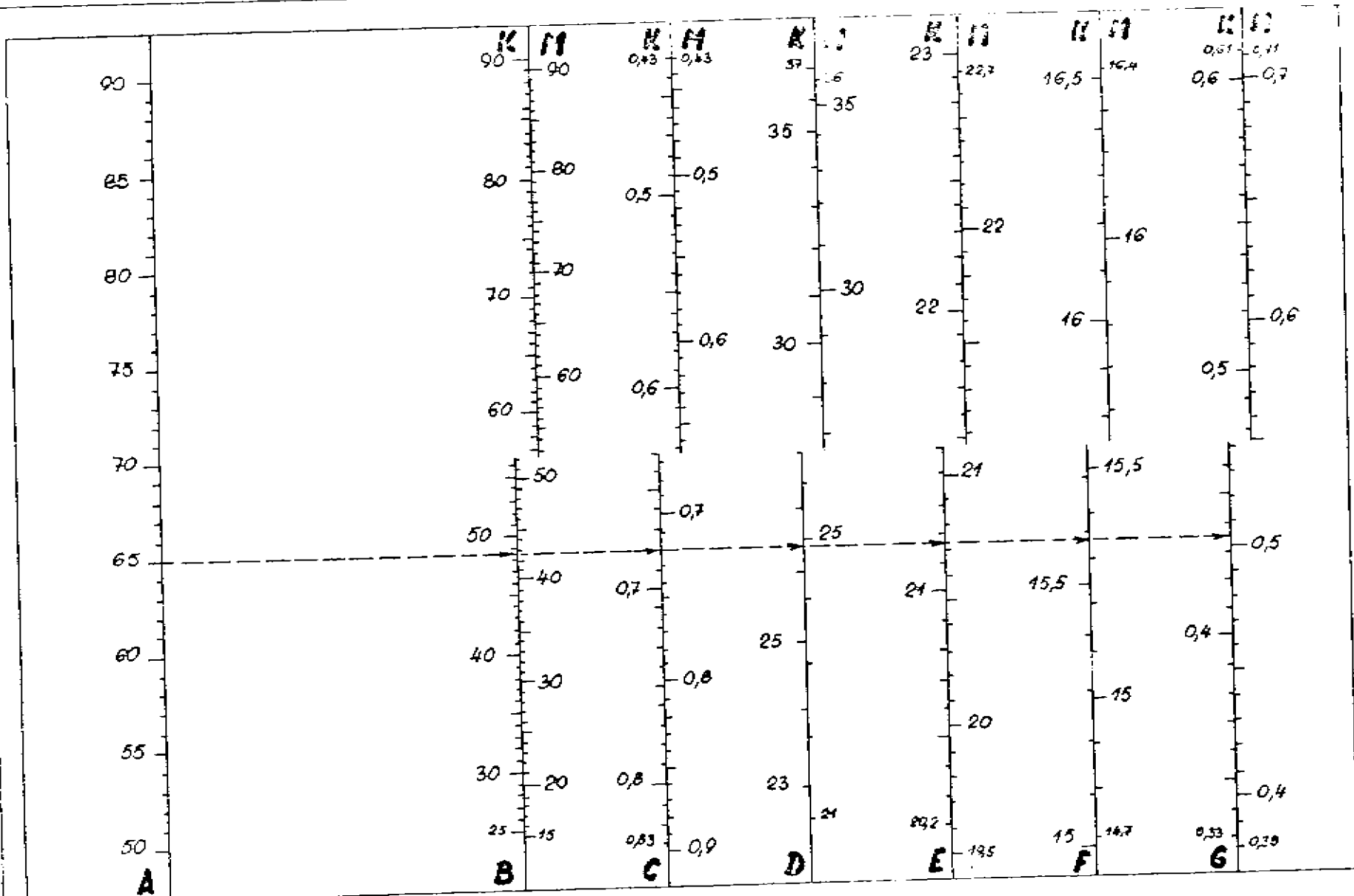
**FIG. 1 FLOWSHEET CONTINUOUS CRYSTALLISATION**



**FIG. 2 FLOWSHEET OF NPK PRODUCTION PROCESS SCHZ-CHP**



**FIG. 3 TYPICAL CRYSTALLISATION COURSE**



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**EFFECT OF THE Ca-ions SEPARATION DEGREE ON FERTILIZER QUALITY** FIG. 4

SCHZ - GHP CONTINUOUS CRYSTALLIZATION PROCESS

DISCUSSION

Mr R. BARTLA (Severocecke Chemické Závody, Czechoslovakia)

Lovosice Chemical Works, in cooperation with Chemoprojekt, Prague, have developed a new method for the application of the Odda process. The process involves direct cooling by means of white spirit. As any Odda process variation, this process is important for nitrogen works as it allows to manufacture complex fertilisers without using phosphoric acid.

In that process calcined phosphates or Kola apatite are reacted with nitric acid, at a concentration ranging from 50 to 65 % with 3.5-5 % excess acid in relation to all the cations contained in the phosphate. The reaction solution must be clarified by static or dynamic decantation. At Lovosice we use continuous centrifugation and about 85 % of the insoluble residues, which are very corrosive, are separated. The clarified solution after cooling down to 3-4° C about crystallization point is fed continuously to the crystallizer. White spirit, cooled to the desired temperature, is added to the solution. White spirit is distributed by a special system. It mixes with and cools the solution. It is then separated at the top of the crystallizer and returns to it. Mother liquors of calcium nitrate crystals are continuously discharged and separated in continuous centrifuges. Separation is a high efficiency process, about 97 %. Crystals are very regular and particle size varies from 0.6 to 0.7 mm. There remains about 0.3-0.4 %  $P_2O_5$  in the crystals. Calcium nitrate crystals are used for manufacturing nitrogen fertilisers. Mother liquors are used for making complex fertilisers according the conventional flowsheet (slide). After crystallization the mother liquors are ammoniated, evaporated, then granulated with addition of potash salts, dried, cooled, screened and coated. The process is quite flexible because CaO can easily be separated as calcium nitrate. The investments in the crystallization stage are reduced by about 35 % owing to a saving in the exchange area required, of about 50 %, and of the crystallization volume.

The process is guided by the curves (slide). Curve A shows the  $P_2O_5$  content in the mother liquor. These curves apply to calcined Morocco phosphate 70BPL and 56 % nitric acid.

Energy consumption is influenced by the nitric acid concentration and by the  $P_2O_5$  water solubility required. With Kola apatite 65 % water solubility is obtainable and in a single stage crystallization about 50 % with calcined phosphates. When a higher solubility is required, a two stage crystallization is necessary.

As other advantages of the process the direct heat exchange does not induce complications with calcium nitrate crystals choking the surface of the exchanger. The process is simple, automatic and continuous. The specific output of the crystallizer is very high 1.7 t  $P_2O_5/m^3$  of crystallizer per day due to good heat transfer. Safety is also a question raised by customers. White spirit, which a portion of distillate obtained between 140 and 220°, ignites at 35-40° C ; since the temperatures used are lower, there is no risk of ignition.

The fourth graph (slide) shows the great flexibility of the process. Scale A gives the CaO rate of separation, scale B  $P_2O_5$  content in fertiliser water.



Mr KNUDSEN (Superfos A/S., Denmark)

The process presented in this paper deserves attention for at least two reasons. Firstly, it is a process for making NPK based on low-cost raw materials. Secondly, the process is operated industrially so that its merits and demerits can be demonstrated in a full-scale production unit.

The use of low-cost raw materials is an outstanding feature of all processes using nitric acid attack of phosphate rock, the oldest and best-known one being the original ODDA process. A number of alternative processes using nitric acid attack have been developed during the last few years, and such processes attract increasing interest every time the sulphur prices are rising, such as they are for the time being. The present process is a variation of the classical ODDA process in one respect; it uses direct cooling based on white spirit as a heat transfer medium insoluble in the nitrophosphate slurry, and the author very clearly accounts for the merits that can be obtained by this improvement.

Based on this background it seems obvious to place two questions to the author. Firstly, since it is a major advantage of any process based on nitric acid attack that it uses low-cost raw materials, it seems to be a drawback for this process that it can only use high grade calcined rock. This fact may be considered particularly regrettable in the present phosphate rock situation, which calls for processes than can treat low grade rocks. So, the first question is: What is the lowest grade phosphate rock you have actually used with good results in your plant - and do you see any possibility of solving the problems in using low grade uncalcined rocks in your process?

The second question relates to the economics. You state that a number of studies have confirmed that the classical ODDA process can produce NPK fertilizers at 12 to 15 % lower costs than those of fertilizers based on phosphoric acid, and that you have obtained similar results by your economical studies. Your process is to be considered an improvement of the classical ODDA process, among other things it requires considerably less investment costs. However, as far as I can see, in the tables in your paper you compare the ODDA process (your or the classical one?) with a conventional nitric-phosphoric acid process and get to 9.5 % lower costs. Since your process is an improvement of the classical ODDA process it would be interesting to see also these two processes compared, and so my second question is: Have you made any economic comparison regarding how many percent your process is more economic than the classical ODDA process?

Finally, I should like to congratulate the author on a very clear presentation of a process which in my opinion will have a good chance of becoming a great importance in the fertilizer industry at today's raw materials conditions.

Mr BARTLA

The first question refers to the quality of phosphate rock which can be used for manufacturing complex fertilizers by the ODDA process. The profitability of phosphate fertilizer production always depends upon the quality of the phosphate.  $P_2O_5$  concentration of phosphate has always an impact on the investments

and on the production costs. The ODDA process gives products comparable with those obtained in the phospho-nitric processes or when phosphoric acid is used. These fertilizers are always highly concentrated and highly watersoluble. For low grade phosphates calcium nitrate separation has a great influence on the investments and largely increases the cost of the whole unit. At Lovosice we use Kola apatite which is an excellent raw material for that production. In the pilot plant other calcined phosphates such as 80 BPL Florida and 78-80 BPL Morocco have been tested. In addition the Boukhra phosphate from Spanish Sahara is a very important product for the ODDA process. When a high  $P_2O_5$  water solubility is required, beyond 35 %, normal grade phosphate rock can be used but these phosphates must always be well calcined.

Regarding the second question, as I indicated in my paper, the advantages of the SCHZ-ODDA process is a saving on the exchange surface, approximately 50 %, which reduces the investments costs which are also decreased by the smaller crystallization volume, about 5-7 times less than in the case of the conventional ODDA process. Then the automatization, simplicity of the operation, is quite important. I think that the answer to that question will be given by the visit which the delegates will make at our works where there will be able to compare our process with the conventional ODDA process.

Mr MEJDELL (Norsk Hydro, Norway)

I have found this paper on a crystallization process with liquid/liquid heat transfer very interesting, and I should like to give a few comments on your paper.

I fully agree with you that it will be difficult, if not impossible, to design a true continuous high capacity crystallizer with solid cooling surfaces for this NPK process. Your method of using direct cooling with liquid white spirit thus appears to be an excellent way of solving this problem.

I would, however, have expected that you by this method should obtain higher capacities than those reported. If I have understood you correctly, the figure of 1.7 t/m<sup>3</sup>/h refers to single stage operation giving 50-60 % water solubility of the product. If you then aim at solubilities of 80-90 %, where two stages will be necessary, I suppose that your overall capacity will be almost cut in half. This means that you get the same capacity figures as in the Norsk Hydro process where single stage discontinuous crystallizers with stainless steel cooling coils are used for obtaining the same high degree of water solubility. Am I incorrect, or is there any explanation for this ?

I also want to ask a second question : What is happening to the 3 kg white spirit you loose per t NPK. Will it follow the products, or is it a pollution problem ?

Mr BARTLA

1st question. The specific output applies actually to single stage crystallization.

2nd question : the losses amount to 3 kg white spirit per ton of product ;

these losses occur during storage and crystallization. The white spirit circuit is closed and the losses are only due to the impurities remaining in the frozen solution. These impurities contained in the white spirit remain in the frozen solution and are directly introduced into the first ammoniation stage. After ammoniation the frozen solution contains no white spirit and, hence, nor does the product. The very small impurities on the calcium nitrate crystals are also eliminated during evaporation and, before carboammoniation. We made quite a number of tests - ammonium nitrate does not contain white spirit. Ammonium nitrate produced normally contains slightly more organic matter than in the case of ammonium nitrate solution produced by carbo-ammoniation.

Dr RAISTRICK (Cramer and Warner, U.K)

I understand from the answer to the first question that you do not use uncalcined rock in this plant. So my question is : What aspect of the behaviour of the uncalcined rock don't you like ; what are the behaviours which make it impossible to use uncalcined rock in your plant ?

Mr BARTLA

The problem with uncalcined phosphates is that calcination is necessary to change the physical properties of the insoluble residues coming from the phosphate or reduce or eliminate organic matter. It is absolutely necessary, owing to calcination the fine insoluble material agglomerates with the larger particles and thus decantation is quicker than in the case of uncalcined phosphate. Then during crystallization with white spirit, fines are floated by white spirit drops and this is the main problem with uncalcined phosphate. At present, in our research department, we try to minimize this problem to be able to use different types of rocks but we realize that the direct cooling process might be slightly modified in respect of the contact between mother liquore and white spirit.

Mr QMBERG (Norsk Hydro, Norway)

To get high water solubility you have to crystallize in two stages. Do you have to install equipment for removing the calcium nitrate between the two stages or do you centrifuge out all the calcium nitrate after the second stage ?

Mr BARTLA

To obtain a water solubility exceeding 50 % in the case of phosphorites and 65 % in the case of Kola apatite a two stage crystallization is necessary. In each stage about 50 % of the total amount of crystals is separated, according to the curve shown here. Thus crystal separation is split into about two halves. The reason is that otherwise the solid/liquid ratio would be too high.

Mr MORAILLON (Générale des Engrais, France)

The process includes a separation of the insoluble material after the reaction with nitric acid. I would like to know how these insoluble used in order to avoid nutrient losses.

Mr BARTLA

After reaction the insoluble material is separated and the insoluble sludge is returned in the ammoniation tanks.