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A NEW METHOD FOR THE CONCENTRATION OF
WET-PROCESS PHOSPHORIC ACID.

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INTRODUCTION

1. Concentration of wet-process phosphoric acid, normally with P_2O_5 content of between 25 and 35% by weight, is usually carried out by means of steam in vacuum evaporators, or by hot gases in spray towers or submerged combustion evaporators.

1.2. The first type typically consists of double-effect forced-circulation vacuum evaporators with graphite tubes. The heating method used is low pressure steam; some plants make use of the heat of dilution of the sulphuric acid needed for phosphoric acid production. This type of plant gives a good P_2O_5 yield but the considerable scaling which occurs lowers appreciably the coefficient of heat exchange between the steam and the acid. The period of continuous operation which is possible is, therefore, limited by the frequent shut-downs which are necessary for cleaning the tubes.

These cleanings, as well as the high water consumption of the pressure condensers, considerably affect the costs of the process. In addition, it is uneconomic to concentrate the acid beyond the not very high limiting values.

1.3. The concentration systems which make use of direct heat exchange with hot gases are characterised by high thermal efficiency and by great simplicity of construction. Their principal disadvantage derives from the appreciable losses of P_2O_5 in the form of fumes, which are very difficult to handle. To reduce air pollution it is often necessary to install electrostatic filters or multi-stage scrubbers to deal with the gases emerging from the concentrators. In some cases, the P_2O_5 is in form of a very dilute solution which it is very costly to recover.

A further draw-back is the high temperature reached by the acid - some 10 to 15°C below boiling point at atmospheric pressure. In these conditions the acid is highly corrosive and it is necessary to use special materials in the construction of plant. By using the submerged combustion system it is possible to produce a more concentrated acid than with the other systems; it is even possible to produce a superphosphoric acid.

reduce the partial pressure of the water vapour lowers the boiling point of the liquid, producing an effect similar to that of reducing pressure. The result is that there is much less corrosion than with other direct exchange processes, and it is possible to use relatively inexpensive materials, as for example plastics, in the construction of much of the unit. Because of the kinetic regime inside the concentrator, scaling is greatly reduced and the plant may be operated for long periods without fear of blockage.

6. DEFLUORINATION OF THE ACID

The high level of turbulence inside the concentrator - quite similar to that in "stripping" towers - facilitates the elimination of fluorine from the acid. For example, if a 30% acid, containing fluorine compounds which give a 2% fluorine content, is concentrated to a level of 50% P2O5 by weight, 75% of the fluorine is eliminated, in contrast with 50% eliminated in other processes. If the concentration is taken up to 64% P2O5, the proportion of fluorine eliminated rises to 90%.

This is of considerable importance when the acid is destined for use in which only a low content of fluorine is tolerated, for example in the production of feed - grade dicalcium phosphate.

It has already been noted that the absence of P2O5 fumes permits a perfect separation of the acid from the gases which contain only negligible amounts of P2O5 on emergence from the concentrator.

Fluorine contained in the outlet gases may be recovered without difficulty and without using special processes, since alkaline solutions of fluorides, or fluosilicic acid with a very low P2O5 content, may be obtained.

7. PRODUCTION OF SUPERPHOSPHORIC ACID

Since an acid of any concentration may be produced simply by varying the temperature of the gases at the outlet of the concentrator, superphosphoric acid, containing 68 to 72% P2O5, may be produced directly.

In contrast to what happens with traditional plants the brief period during which the material remains in the unit is insufficient for the production of the particular types of polyphosphate of iron and aluminium (probably cyclic and long chain) which are insoluble in water and acids.

The formation of these materials inevitably means a loss of P2O5 additional to the P2O5 lost in form of fumes from the concentrator. The polyphosphates mentioned above also cause an abnormal and troublesome increase in the viscosity of the superphosphoric acid, which must be subjected to special treatments.

The comments made earlier about the concentration of ortho-phosphoric acid are also relevant for the production of super-phosphoric acid. The relatively low temperature reached by the acid and the striking advantages which this confers in respect of construction materials, is particularly worthy of note.

In practice, the plant is not very different from that which has already been described for the concentration of ortho-phosphoric acid. Since a gas temperature at the plant outlet of about 200 to 280°C is necessary to obtain superphosphoric acid, the usual practice is to link two units in series as shown in Fig 2. The second unit concentrates the dilute acid of 28 to 30% P_2O_5 to an intermediate concentration, depending on the thermal balance - it is usually possible to reach a level of 45 to 50% P_2O_5 . This acid is carried directly to the first unit where the final concentration to the desired level is carried out. The cyclonic separator at the outlet of the first concentrator may be adjusted so that it does not cause too great a loss of pressure, given that material which may escape separation is taken up again into the second concentrator. Thus, a single high yield separator is needed at the outlet of the preliminary concentration unit.

This system, therefore, permits of high efficiency, both thermal and from the point of view of plant economics.

8. OPERATIONAL DATA FOR A CONCENTRATION UNIT

The operational data given refers to an industrial plant similar in its essentials to that shown in Fig 1. This is a low pressure plant and is equipped with a combustion chamber for heating the gases, and with a series of scrubbers for the recovery of the fluorine content of the effluent gases in the form of 25% fluosilicic acid. The installation is completely automated and requires only periodic supervision by an operator. Because of the particular requirements of the plant which uses the acid produced, the final concentration is not very high and is deliberately limited to about 46% P_2O_5 . The production of the plant to which refer the figures given below was about 65 tons/day of P_2O_5 ; this could be raised appreciably by increasing the temperature at which the gases are introduced into the unit.

8.1. Acid

Dilute phosphoric acid input:

P_2O_5	29.3%
Density at 15°C	1,323 g/l
Output as such	9,180 Kg/hour

Concentrated Phosphoric Acid produced:

P_2O_5	46.3%
Density at 15°C.	1,580 g/l

8.2. Gas Output measured at the stackGas (wet) 21,500 m³/hourDry Gas equivalent 17,500 Nm³/hour8.3. Fuel consumption2.90 x 10⁶ Kcal/hourEquivalent to about 1.07 x 10⁶ Kcal/ton of P₂O₅8.4. Pressure throughout the system:heater inlet 1850 mm H₂Oconcentrator inlet 1500 mm H₂Oinlet to the cyclonic separator 1300 mm H₂Oinlet to the H₂SiF₆ plant 1200 mm H₂Oinlet to the stack 20 mm H₂O

The pressure loss in the concentrator and cyclonic separator is thus limited to 300 mm H₂O.

8.5. Temperatures (averages of long periods of operation)

Gas entering the concentrator 500°C

Gas leaving the cyclonic separator 95°C

Gas at the outlet of the H₂SiF₆ installation 45°C.8.6. P₂O₅ Yield 99.8%

in the water used for scrubbing gases 5Kg/hour

in the H₂SiF₆ 0.6 Kg/hour8.7. Thermal balance (average of a long period of operation)

	<u>Kcal/h</u>	<u>total %</u>
Heat to evaporate the water from the acid	1,960,000	67.5%
Heat for heating the acid	290,000	10.0%
Heat content of the gases leaving the cyclonic separator	450,000	15.6%
Heat losses	200,000	6.9%
Total	2,900,000	100.0%

8.8. Electricity consumptionOverall requirement for concentration and H₂SiF₆ production 100Kwh/t P₂O₅For the H₃PO₄ concentrator alone40Kwh/t P₂O₅

9. THE ECONOMICS OF A LIQUID PHASE CONCENTRATOR COMPARED WITH TRADITIONAL INSTALLATIONS.

9.1. The comparison refers to 100t/day plants which concentrate the acid to 30-50%. The data is for plants in Italy, in a moderately industrialised area, with a certain variability in local air pollution regulations. The following types of plant are considered:

1. Double effect forced-circulation Swenson type, the vacuum obtained by electrically driven pumps. Graphite heat exchangers. Heating by steam at 2 atm.

2. A double-effect forced-circulation type, using the heat of dilution of sulphuric acid obtained from the production of dilute sulphuric acid. Vacuum obtained by electrically driven pumps. Graphite heat exchanger. Steam at 2 atm.

3. Submerged combustion concentration unit. Graphite combustion chamber, the walls of the concentrators clad in neoprene. A certain amount of flexibility in regard to the type of gas scrubber used (medium & high yield) was taken into account.

4. Montecatini-Edison liquid phase plants including units for the recovery of fluorine.

9.2. Although it is possible to obtain data about level of inputs (electricity, steam, fuel, etc.) and plant outputs, by reference to existing plants and to the literature, a number of difficulties arise when an attempt is made to evaluate the costs of a particular given plant. It must be recognised that there are a large number of plant constructors, each of whom offer their particular solution to the problems; additionally, account must be taken of the fact that costly installations may, nevertheless, be cheap to operate, or vice-versa. Furthermore, the costs of the plant depend on the incidence of a large number of factors which appear to be not particularly important when viewed individually - steam pressure, water temperature, transport facilities, local wage-rates, etc.. The various regulations about air and water pollution are especially important. They are particularly relevant for submerged combustion installations, as they affect the costs of scrubber units and fume extraction equipment; in some cases, these costs may even result in a doubling of the overall costs of the plant as a whole. It is also necessary to keep in mind that plants were built or projected at different times, costs being affected by the subsequent depreciation in the value of money. Again, plant sizes vary somewhat as a result of slight differences in power sources, and extrapolation is necessary. Because of these uncertainties it was thought best to show the relationship between the costs of the various types of plant, taking the classical two-stage Swenson installation as the standard. For the same reason, the figures should be viewed only as indicative of order of magnitude, not as absolute values.

TABLE I

AN ECONOMIC COMPARISON OF THE DIFFERENT TYPES OF CONCENTRATORS

Type of Plant	2-stage Swenson	2-stage with recovered heat of H_2SO_4 dilution	Submerged combustion	Montecatini-Edison liquid phase
Capacity = 100 tons/day of P_2O_5				
Initial Concentration = 30% P_2O_5				
Final Concentration = 50% P_2O_5				
Ratio of costs	1	1.8	0.8-1	0.4
Inputs per ton of P_2O_5				
Steam Kg	2 400	610	0	0
Fuel at 10,000 Kcal/kg				
Kg	0	0	125	100
Electricity Kwh	30	40	40-45	100 (1) 40 (2)
Water m^3	80	40	2	4
Average P_2O_5 Yield	99.5-99.7	99.5-99.7	98.5-99.2	99.7-99.9
Fluorine recovery from the acid %	0	0	0	80%

(1) Including the fluorine recovery unit

(2) P_2O_5 concentration only.

10. CONCLUSIONS.

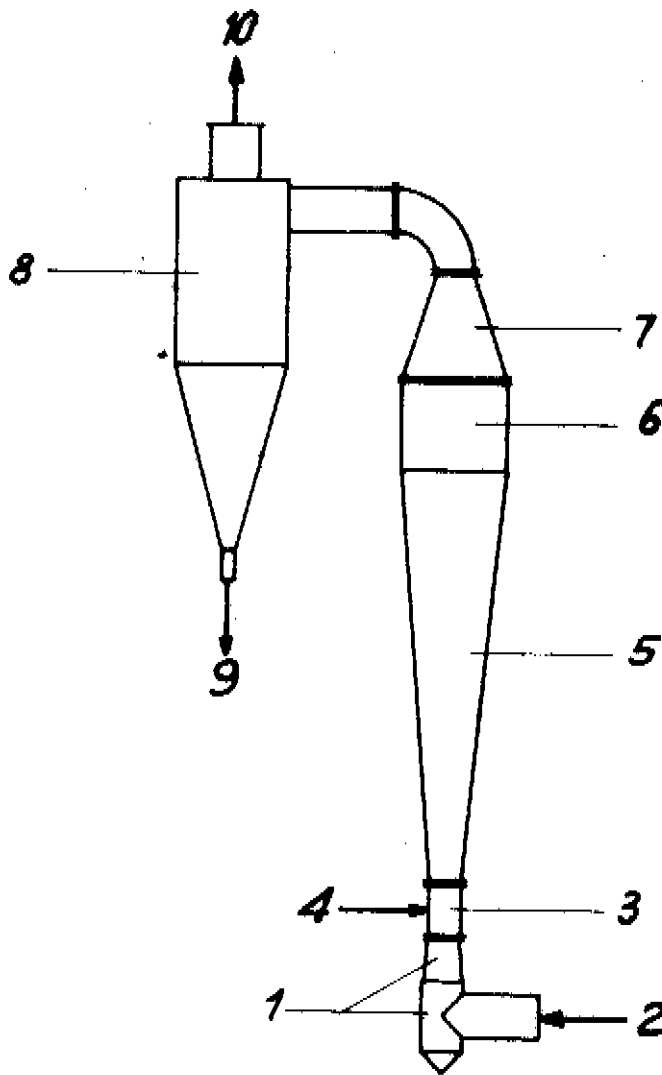
The fluidised layer phosphoric acid concentration plant developed by Montecatini-Edison, has clear advantages when compared with traditional plant, particularly in respect of the cost of installation, continuity of operation and maintenance costs.

As a result of its high thermal efficiency, excellent P_2O_5 yield and the recovery of fluorine, operating costs are appreciably reduced. Because of automation, only periodic supervision by a single operative is required.

The plant has a high degree of flexibility; it may be stopped and started rapidly and the concentration of the product acid may be varied within the space of a few minutes.

As a result of these characteristics, the plant is especially suitable for the production of superphosphoric acid, particularly in the version with two concentrators in series is shown in Figure 2.

FIGURE I

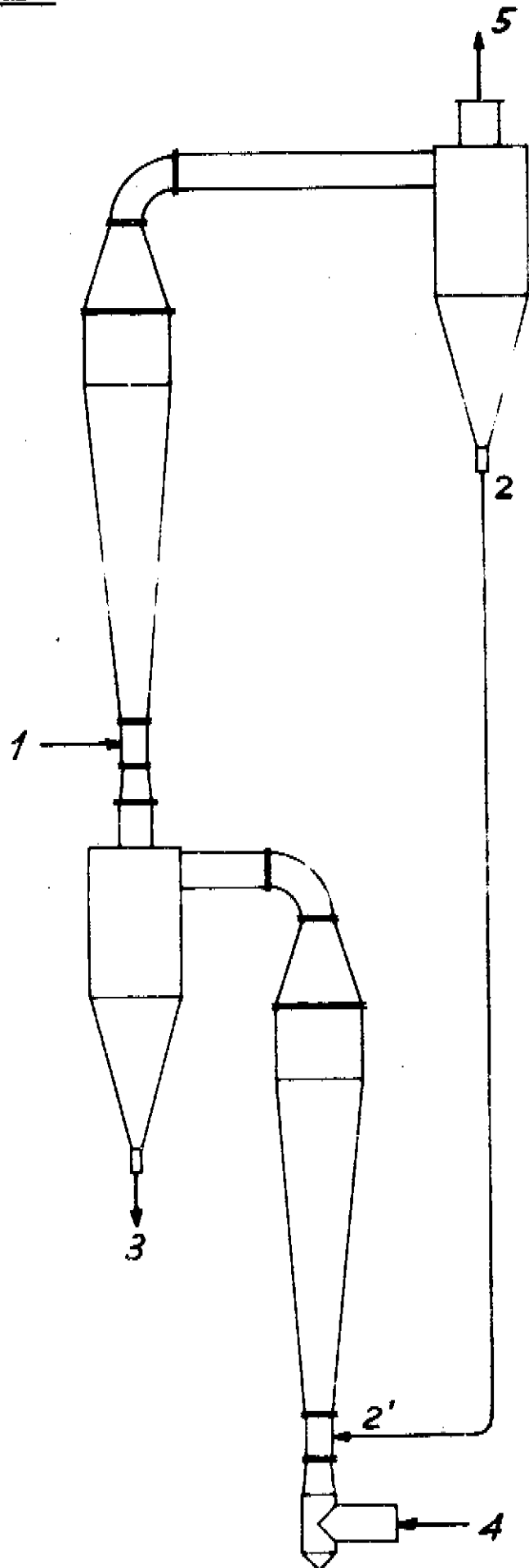


- (1) Lower section
- (2) Hot gases inlet
- (3) Constriction
- (4) Dilute acid inlet
- (5) Fluidisation level
- (6) Section of constant cross-section
- (7) Acceleration of the gas liquid mixture
- (8) Cyclone
- (9) Concentrated acid discharge
- (10) Outlet for the cooled gases and water vapour

- Partie inférieure
- Entrée des gaz chaude
- Etranglement
- Entrée de l'acide dilué
- Zone de fluidisation
- Partie à section constante
- Collecteur de sortie du mélange de gaz liquides
- Cyclone
- Décharge d'acide concentré
- Sortie de gaz froids et de vapeur d'eau

FIGURE 2

- (1) Dilute H_3PO_4 inlet
- (2) Discharge of concentrated H_3PO_4
- (2') Concentrated H_3PO_4 inlet to the 2nd concentrator
- (3) Superphosphoric acid discharge
- (4) Hot gases inlet
- (5) Cool gases outlet



- (1) Entrée de H_3PO_4 dilué
- (2) Décharge de H_3PO_4 concentré
- (2') Entrée de H_3PO_4 concentré dans le 2ème concentrateur
- (3) Décharge d'acide superphosphorique
- (4) Entrée de gaz chauds
- (5) Sortie de gaz froids

DISCUSSION

MR. ARZANI: Our previous experience with the traditional fluidised bed led us some years ago to undertake studies of the application of the fluo-liquid system. This technique was not very well known at that time outside specialised circles. After acquiring a sufficient experience of the physical parameters governing the formation of the fluo-liquid suspension, we started practical trials to concentrate solutions and aqueous suspensions. Phosphoric acid was one of the first materials with which we worked. Results were immediately promising, and with the construction of a pilot plant of suitable dimensions to evaporate about 500 kg/hour of water, we realised the great possibilities offered by this new concentration system, the most immediately noteworthy feature of which is the extreme simplicity of the plant. The fineness and dispersion of the liquid droplets, as well as the great turbulence of the fluidised bed, afford a high thermal exchange coefficient between the gases and the liquid, thus enabling excellent thermal yields to be obtained by reducing to small fractions of seconds the necessary time for heating and concentration of the acid. The high gas/liquid ratio, considerably reducing the partial pressure of the water, acts in a similar way to a vacuum. The boiling temperature of the acid is therefore not very high and local overheating, which can cause mist formation, is avoided. The low temperature permits the use of inexpensive materials of construction. Plastic materials can be used on a large scale. The transfer of water from the acid to the gas takes place until the partial pressure of the water in the gas is equal to the tension of the water vapour in the phosphoric acid/water system. During the trials it was observed that equilibrium is obtained in a very short time. The final concentration of the acid can thus be varied simply by altering the exit temperature of the gas from the evaporator. The energy mixture and the high kinetic system prevent the formation of solid deposits on the walls of the apparatus and also afford good defluorination of the acid.

The fairly large size of the acid droplets facilitates the separation of the two liquid and gaseous phases at the evaporator exit. But without using special collecting apparatus the P_2O_5 yield is very high.

Preliminary studies enabled us to define the most suitable form of the evaporator, where it is indispensable to maintain a stable fluidised layer of liquid droplets. This unit is comprised essentially of a vertical conduit very similar to a Venturi tube. There is a first part of constant section ending in a constriction, after which the conduit takes a divergent conical shape. The section may be circular or elliptical. The angle of aperture of the divergent part is generally selected so as not to create excessive turbulence or contact of the gaseous effluent with the walls. This phenomenon would increase the load losses, or, worse still, could engender corrosion or deposits on the walls themselves.

As in many traditional fluidised beds, the necessary heat for evaporation of the water is introduced into the unit as heat from the fluidification gas itself. The hot effluent which can also take the form of recovered gases with appropriate chemical and physical characteristics is directed upwards from below. As it passes through the constriction, at which point the acid to be concentrated is also introduced, it is moving at a considerable speed sufficient to disperse the acid into droplets and to draw it upwards. The speed gradually slows down in the enlarged section and reaches a value corresponding to the conditions of formation of the fluidised bed. The drops of concentrated acid - now smaller because of the evaporation of the water - are drawn upwards by the current of gas which is now cooled down.

We have observed that it is sufficient to use a normal cyclone to separate the acid from the gas. Before letting the gas into the atmosphere it can be washed with water in open cycle or with appropriate solutions to recover the fluorine content.

The retention time of the acid in the concentrator can be estimated at a few tenths of seconds, and the acid content at a few litres. The system offers extreme flexibility. Starting up and shutting down are almost instantaneous and, if necessary, the acid concentration can be varied from moment to moment. Moreover, the evaporation system offers a large production capacity from a small-sized unit. Because of the extreme simplicity of the plant, its capacity and the relatively small use of costly materials of construction, the necessary investment for a concentration unit of this type is very low.

The high yield, both from the thermal and from the material point of view, the decreased scaling, reduced labour costs for the maintenance of an essentially static apparatus and the possibility of complete automation give reduced operating costs. In addition, the use of both liquid and gaseous fuels, the small water consumption and, particularly the low content of effluent impurities mean that construction can be carried out in any location without additional service investment.

The first industrial installation based on this principle started operation in the summer of 1967 and was constructed at a location where all the above-mentioned disadvantages were to be found - lack of steam, limited water availability and a strict control of atmospheric and water pollution owing to the proximity of inhabited areas. So far, the plant has operated at its maximum capacity of 70 tpd P_2O_5 , concentrating 29-30% phosphoric acid to 46-47%. The data indicated on pages 5-6 of the paper are average values for three months continuous operation. As fuel, we used either coke oven gas, hydrogen or bunker oil. The average production achieved during this period was 65 tpd P_2O_5 in the conditions indicated.

The plant is completely automated and requires supervision at regular intervals by only one worker. Performance is regulated by varying the gas temperature at the entry of the concentrator but not its throughput. It will be recalled that in the fluidised bed one has optimum conditions of turbulence and fluidification at specific rates of flow of the gaseous effluent. The acid feed to be concentrated is controlled by the gas exit temperature of the evaporator. By modifying the latter it is possible to vary at will the final acid concentration.

It is unnecessary to mention the other control and measuring systems installed, for they are those of a normal industrial installation. Maintenance operations so far have been as frequent as is normally required by a unit treating phosphoric acid. Scaling is negligible. As a precaution, about once a month we remove the small encrustations which form where the gas feed is slowest. After separation from the concentrated phosphoric acid, the gases emerging from the concentrator pass through a series of washing units of very simple design to reduce their fluorine content, the emission of which into the atmosphere is limited by local regulations. About 80-90% is recovered as fluosilicic acid in 25%

solution. Almost all of the residual quantity is fixed in the final washing unit where water circulates in open cycle. The maximum fluorine content of effluent gases emitted to the atmosphere is about 0.03 g/m^3 , corresponding in this case to about 0.6 kg/hour . The total quantity of recovered fluosilicic acid is proportionate to the fluorine content of the dilute acid which again depends on the phosphate used. In general, in terms of market prices, the amount is sufficient to cover the various costs of concentrating the phosphoric acid.

In conclusion, we consider the operation of this new fluid phase phosphoric acid concentration plant to be perfectly satisfactory, and we believe that, when we have to construct other units, we shall use this process. We do not exclude the possibility of also using it in the future for other products.

MR. RAEMAËKERS (Sté Us. Ch. Uguine Kulhmann, Belgium): The method described in this paper can be considered as a quite new concentration technique which, in its simplicity, is most attractive. This simplicity appears both in the conception of the plant and its operation:

- in its conception, because the thermal exchange is achieved in the most direct and efficient form in an apparatus of minimum volume.
- in its operation, because the reduction of retention time to the minimum possible suppresses all inertia in the system and permits continuous and immediate regulation.

This new technique seems also to be very well suited to the particular problems of phosphoric acid concentration. All producers are still awaiting the appearance of a unit where cleaning is made less frequent or easier. The unit in question seems to correspond perfectly with their desire.

Finally, for all interested in fluorine recovery, the increased proportion recovered from the concentration operation will be of extreme interest.

Having mentioned the main advantages of the process, the description of this technique certainly calls for a number of comments and questions which will permit clarification.

At least three points seem to me to be of general interest and consequently I should like to raise them to open the discussion.

In this method of concentration where hot gases are placed in contact with minute droplets of acid, precipitation must occur at the scale of these fine droplets as a result of the formation of insoluble compounds in a more concentrated medium. One can imagine that these precipitates, formed extremely rapidly, are also of very small size, i.e. there is an extremely fine precipitate which has had no opportunity of increasing in size.

As we know, the elimination - either by decantation or centrifugation - of insoluble materials formed in concentrated acid is not an easy operation. In concentrated acid from a classical concentration unit, these insoluble

materials have had a chance to grow during concentration, and thus elimination is facilitated.

Could Mr. Arzani tell us how, in his process, the problem of eliminating insoluble materials from the concentrated acid is dealt with, compared with a classical concentration process?

I have a second, related point. To produce superphosphoric acid with two concentrators in series, this new process concentrates the acid in the second concentrator from 30% to 50%, after which this concentrated acid is sent directly to the first concentrator where it is transformed to superphosphoric acid. In this second stage, the proposed method avoids the particular formation of insoluble polyphosphates - which is not the case for the first stage where insoluble compounds of another form are produced.

Consequently, I should like to know if, between the two concentration stages, the concentrated 50% acid is treated to eliminate insoluble materials.

Finally, the recovery of fluorine in the form of 25% fluosilicic acid makes the process still more interesting. As there is no P_2O_5 mist, this fluosilicic acid must contain very little P_2O_5 . Thus I should like to know the P_2O_5/F ratio in this fluosilicic acid.

MR. ARZANI: As to whether the fineness of precipitated solids could slow down the solid-liquid separation, I can say that our acid from this unit has an average content of 0.6% solid material after about 24 hours in a static separator. This is about the same as in our other plant with traditional concentrators.

With regard to the question on superphosphoric acid, we have so far made trials only in a pilot plant, and the problem of separation of solids from the acid has not arisen up to now. But if we construct an industrial plant, I think we shall consider the possibility either of eliminating solid materials by decantation or eliminating the fluorine contained in the acid by treatment with sodium.

With regard to the P_2O_5 content of the fluosilicic acid, this depends on the fluorine content in the acid. If the dilute acid has a little fluorine content before obtaining a 25% concentration, the solution must receive considerable circulation in the scrubbers, and in this case the amount of P_2O_5 can reach 0.5%. But with an acid with a normal fluorine content, such as that produced from Florida phosphate, the P_2O_5 content in the 25% fluosilicic acid is certainly less than 0.2%. But we are now adding a second cyclone to reduce this P_2O_5 content to less than 0.05%.

MR. P. MORAILLON (Péchiney-St. Gobain, France): Why does this process avoid the formation of a mist of P_2O_5 ?

Why is there so high a load loss in the fluorine recovery apparatus? According to the details given, there is a load loss of 1200 mm. of water.

MR. ARZANI: We believe that mist formation does not occur because the hot gas is cooled almost instantaneously with the phosphoric acid. We have tried increasing the gas temperature at the entry of the concentrator. Above 700° C we could observe the beginnings of mist formation, but at lower temperatures this does not occur. I think this is due to the phenomenon of quenching of the gas temperature.

With regard to the efficiency of the cyclone, this was constructed to work efficiently with droplets of up to ten microns. But in the first industrial unit we included the possibility of erecting another high efficiency cyclone. As far as the P₂O₅ yield is concerned, we found that this second cyclone is unnecessary, although it is necessary to reduce the P₂O₅ content in the recovered fluosilicic acid.

With regard to the very high load loss in the gas scrubbing, this occurs because we have used scrubbers with a high gas speed on entry. This is about 80m/second in order to avoid atmospheric pollution from the fluorine. The load loss in the scrubbing system can be reduced, but in this case it is quite probable that the fluorine content in the gas emitted to the atmosphere is increased.

MR. MORAILLON: Could you tell us how much fluorine remains in the gases sent to the chimney?

MR. ARZANI: Yes, about 0.3 g/m³.

MR. WEBER (Dorr-Oliver Co. Ltd., U.K.): I would like to refer to table I on page 8. I think there is a mistake in the calculation of the steam consumption for the conventional forced circulation evaporator. The correct figure should be about 1730 kg rather than 2400 indicated. You have 3333 kg of 30% acid, which results in 2000 kg of 50% acid, i.e. you have to evaporate 1733 kg of water. It is normal in a vacuum evaporator to use about 1.3 kg of water per kg of water evaporated. This gives you some 1733 kg which is only about two thirds of the figure that is indicated.

The other point on the tabulation that I would like to make is that it is very easy to recover fluorine as hydrofluosilicic acid in the vacuum evaporator by the Swenson system. It depends on the phosphate rock. In the case of Morocco rock, for instance, the recovery of fluorine could be of the order of 70% of the fluorine in the 30% acid.

Also, the stated electricity consumption for the Swenson unit is high, unless it also includes the fluorine recovery. Moreover, with the capacity indicated, it is very easy to do it in one stage; it would not require a two stage evaporator. This would reduce the relative investment cost.

MR. ARZANI: All the operating details in the paper relate either to our company's two installations or to offers received from constructors. It is possible that, as far as steam consumption is concerned, account has also been taken of the steam necessary for all the heating of the acid, i.e. there is not only the steam necessary for the evaporator but for the whole steam requirements of the plant.

With regard to fluorine recovery, I know it is possible to do this in other installations, but in ours it is not recovered. It is possible, but not simple.

Energy consumption depends on the whole plant and also on the cost of the plant. There may be more expensive plants which have a lower specific consumption of steam, energy, etc. whilst less costly plants have higher operating costs. There are so many phosphoric acid concentration units that it is difficult to quote precisely what are the specific consumptions of steam, energy, etc. It is very difficult for me to make a perfect evaluation of everything. I have taken an average of several plants.

MR. FRÜCHEN (Pierrefitte, France): Can Mr. Arzani specify what materials are used in the active part of his apparatus, i.e. the Venturi in the case of both ordinary and superphosphoric acid?

MR. ARZANI: In the case of ordinary acid the Venturi is partly made of Asteloy C and partly of Monel in its metal parts and from Teflon or Polypropylene in its plastic parts. As I have already said, we have as yet no industrial plant for the production of superphosphoric acid, and we are now carrying out several trials to determine the most suitable metal materials. I think it is also possible to use the same materials for superphosphoric acid, although with more corrosion. But corrosion is very slight with our present plant and I think it will be possible to construct a superphosphoric acid unit with the same materials, but recognising that the evaporator will have to be replaced, say, every two or three years. The cost of the Venturi tubes is not very great. Rather than use very costly materials, it is preferable to use a less costly material and carry out replacements at regular intervals.