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AN ALMOST ZERO DISCHARGE CONCEPT FOR THE CAN/NPK PLANT OF UKF IJMUIDEN TA/86/17
HAS BEEN DEVELOPED TO MEET THE STRINGENT RULES FOR WATER POLLUTION
CONTROL IN THE NETHERLANDS

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SUMMARY

A review is given of the regulations for water pollution control in the Netherlands. A description of the CAN/NPK plant which consists of 4 units for the production of 750,000 tonnes per year is outlined. The main sources for pollution of this plant, the actions taken so far and the experiments done to bring these effluent losses down for 40% are discussed.

The program developed for a further reduction consists mainly of a circulation washing system for the production units and a dissolving tank for the spills in the plant. The washing liquid is circulated and supplied to the process. When this program is completed the water pollution is brought down for another 50% to about 10% of the original level.

REVIEW OF THE REGULATIONS FOR POLLUTION CONTROL IN THE NETHERLANDS

Legislation

The water pollution control act came into force in 1970. According to this new law all pollutors had to make a request to Central Authority for a license to legalize these activities. In the request a detailed description of the process used, the installations, the nature and the amount of the losses had to be described. In the license the request for the pollution is granted and normally a reduction program to a very low level is prescribed by the Authority or the company itself has to develop a reduction program which has to be approved.

Tax system

With the pollution control act the tax system was introduced. This system is based on the principle that the company (the pollutor) has to pay for the average load of oxygen demanding components expressed in so called inhabitant equivalents (i.e.) which are drained off per day.
For other components the total amount per second which is discharged determines the heights of the taxes to be paid.

In general for our situation the total number of inhabitant equivalents (i.e.'s) are determining this tax. This value is given by the next formula:

$$\text{number i.e.'s} = \frac{Q}{180*} (CZV + 4.57\ N)$$

* Note In 1986 the standard oxygen use of 180 gram for one i.e. is changed to 136 gram. This will mean that the total number of i.e.'s to be paid will increase with 32%. In this paper however, the old standard is used.

Q = number of m^3 effluent per day
CZV = chemical oxygen demand in mg/l
N = sum of ammonium nitrogen and organic bound nitrogen determined according to Kjeldahl in mg/l.

The amount of tax to be paid for one i.e. was in 1971 f 2.00 ($ 0.80). This cost has been gradually increased and is now (1986) f 29.50 ($ 11.80) The number of i.e.'s lost to the surface water was in 1971 for the CAN/NPK plant 70,000 which meant f 140,000 ($ 56,000). In 1985 this value was brought down to 44,000. For 1986 this value has to be multiplied by 180/136 (because of the change in i.e. standard value) and is raised to more than 58,000 i.e. This will mean an amount of tax to be paid of f 1,720,000 ($ 688,000) in 1986.

In spite of a decrease in the pollution rate of more than 40% the amount of tax to be paid is more than twelve times the initial value.

UKF (MEKOG) IJMUIDEN

At IJmuiden Mekog is a production location of UKF, the fertiliser division of DSM. The facilities are situated adjacent to the site of the Hoogoven Steelworks.
The UKF site includes an ammonia plant with a capacity of 300,000 t N per year in ammonia, nitric acid plants with a total capacity of 100,000 t N per year in HNO_3 and a CAN/NPK plant with a capacity of 750,000 tonnes per year.

DESCRIPTION OF THE CAN/NPK PLANT

Ammonium nitrate section

In the ammonium nitrate section of the plant ammonia gas and 54% nitric acid react in 3 neutralizers under a pressure of 3.3 bar, producing 80-82% ammonium nitrate solution. After expansion, the acidic solution is neutralized with ammonia to prevent decomposition and fed to a storage tank.
In the concentration section the ammonium nitrate solution is pumped from a circulation tank through heat exchangers/evaporators and concentrated to a 96% solution.
The 96% ammonium nitrate solution flows from the separators under gravity through a circulation system to the four production units.

For heating up the nitric acid before the reaction and in the ammonia evaporator contaminated steam from the neutralisation is used. The rest of the contaminated steam passes a steam boiler to produce low pressure steam of 2.5 bar or is fed to the condensors.

Granulation

The CAN/NPK plant consists of 4 production units. In unit 1, 2 and 3 CAN (22 - 27,5% N) is produced with dolomite.
In unit 4 CAN and different types of NPK are produced with dolomite, mono ammonium phosphate, potassium chloride, etc.

In every unit ground dolomite and the other raw materials are mixed in a paddle mixer with ammonium nitrate solution and fed to a blunger. The granulate falls in the rotary granulator/dryer where a further crystallization takes place. The product from the rotary cranulation/dryer is sieved off by a set of screens, the fines and crushed coarse product, are recycled to the blunger.

The good product stream is fed to a rotary cooler (in the NPK unit 4 first to a rotary dryer) then after a set of correction screens fed to the coating drum and transported to the storage facilities.

THE POLLUTION PROBLEM

Process

From the ammonium nitrate production section come two main contaminated streams:
- the condensate from the neutralisation
- the condensate from the concentration.

Although in the neutralizers and after the concentrators separators are installed in the vapour phase, ammonia gas and fine droplets of AN solutions are entrained to the condensors where total condensation takes place.

In the plant process air is sucked from the blunger and through the granulator dryer for the removal of heat and water vapour. The process air is contaminated and passes a cyclone where 95% of the product particles are removed. The rest of the particles together with some ammonia is washed out in an open scrubber system and discharged to the harbour. The amount of process air per production unit is about 37,500 m^3/hr. In the installation a dedusting air system is installed. About 34,500 m^3/h is sucked off to keep an underpressure in the process equipment to prevent uncontrolled dust emissions inside the building of the plant. After passing a cyclone to remove most of the dust particles, the dedusting air is also washed in an open scrubber and the wash water is discharged to the harbour.

Spills

In the granulation section of the 4 production units deposits of solid material grow on the wall and the screw of the blunger. Periodically these deposits have to be flushed away with condensate. These spills are discharged to a waste water unit tank with an overflow to the harbour.

The amount of pollution

Before starting with an action program to reduce the amount of pollution from the CAN/NPK plant the losses to surface water were about:
- 3,300 tonnes of ammonium nitrate per year
- 500 tonnes of ammonia per year
- 1,000 tonnes of other raw materials per year, such as marl, dolomite, ammonium, phosphate, potassium chloride, etc. etc.

The total number of inhabitant equivalents was about 70,000.

REVIEW OF ACTIONS AND EXPERIMENTS

General actions

By changing the raw materials package by adding ammonium sulphate with the marl and later changing from marl to dolomite the reaction of ammonium nitrate with calcium carbonate whereby ammonia is produced could be suppressed. The ammonia concentration in the process air decreased from more than 2000 ppm to about 300 ppm.

By installing more measuring instruments in the installation more insight was given to the operators in the losses with the effluent from the plant.

A better instruction and information program for the operators improved good house keeping.

Better use of contaminated condensate from the neutralisers

The contaminated condensate from the neutralisation is used as process water in the absorption of the nitric acid facilities.
The concentration of ammonium nitrate in the condensate may however not exceed the value of 10 gram NO_3^-/l. When this value is exceeded the condensate is discharged to the surface water.
With the installation of an automatic dilution system with demineralized water the nitric acid facilities are taking in the maximum amount of condensate.

Improvements in the quality of the condensate from the concentration

By installing measuring instruments for temperature and acidity in the concentration section, the free ammonia content of the ammonium nitrate solution before the concentration could be reduced from 0.03% NH_3 to 0.015% NH_3.
This meant that the ammonia losses in the condensate were reduced by about 50%.

An other improvement was the installation of lamellar separators in the steam/vapour gas stream with a condensate injection after the separators of the concentration.

With these actions the pollution rate was reduced with 40%. From 70,000 inhabitant equivalents to 44,000 i.e.'s.

Experiments for a further reduction in the concentration

Experiments were carried out with the injection of diluted nitric acid instead of condensate before the lamellar separators. The nitric acid injection gave only a slight improvement of 15,200 i.e. to 11,000 i.e. which was considered not to be adequate.

Experiments with dry filtration instead of the open scrubber system

A large contribution to the height of the pollution from the plant is given by the open scrubber system. The process air and dedusting air are washed here.

A extensive industrial scale experiment, after some small scale experiments, was carried out by installing a filter unit for the process air from production unit 4.

Due to the overloading of the plant building the filter installation had to be built outside the CAN/NPK building.

The filter unit was of a bag type filter with pulsejet cleaning for an air stream of 38,000 m^3/hr with a dust load of 8 - 32 g/m^3, 360 m^2 filter area was installed. The dust was pneumaticaly blown back into the granulation drum of the section.

Because of the nature of the collected dust, hygroscopic and sticky, the recycle of the dust to the process remained troublesome.

After some years of experimenting the filter unit was closed down permanently.
The investment loss however was substantial f 1,300,000 ($ 520,000).

The only way to solve the problem seemed to improve the scrubber system and to combine this with a dissolving installation for the spills from the plant.

At first some experiments had to be done to prove that recycling of the slurry to the process was possible.

Experiments with a washing unit

An experimental pilot plant was installed (see figure 1). The installation contained a buffertank for the flush liquid to wash the deposits away in the installation, a circulation pump, a constant level tank and a dosing pump.

The experiments were carried out with and without nitric acid to dissolve the dolomite. To prevent erosion the acidity of the solution has to be kept low (pH 2-4).

Experiments showed that by a normal production rate of 25 tonnes CAN/hr, 120 l slurry with 40 - 50% ammonium nitrate could be dosed without negative influence on the granulation and the quality of the final product. When the concentration of the ammonium nitrate solution is lowered under 96% caking problems arise because of a different crystallization behavior of the ammonium nitrate.

FINAL CONCEPT FOR THE FURTHER REDUCTION OF THE POLLUTION

New scrubber system with spillage recovery

The first step in this new concept is to install in one production unit (3) a closed circuit scrubbing system (see figure 2).

The existing scrubber will be replaced by two Venturi scrubbers with Fluomix scrubbers in series. Over the scrubber systems recycle contaminated condensate. The solution has to be kept acidic for the absorption of free ammonia gas in the process air and to dissolve the dolomite particles to prevent erosion and settling.

The ammonium nitrate solution contaminated with dissolved $Ca(NO_3)_2$ and $Mg(NO_3)_2$ is recycled and fed to the flush liquid tank. In this tank the spills from the mixer and the blunger are collected.

From this flush tank a 40% ammonium nitrate containing solution is pumped by way of the constant level tank to the mixer and so recycled in the process stream.

The system is kept in equilibrium by a controlled dosing pump.

Choice of the scrubber system

For the choice of the scrubber system it was important that the ammonia and the dust in the process air and dedusting air had to be removed as far as possible.

According to the license for the air pollution control the dust emission has to be maintained below a level of 70 mg/m^3. No restrictions are set regarding the ammonia in the process air. But because of possible nuisance to surrounding offices the ammonia concentration has to be kept low.

Because of the mentioned limitations the choice has been fallen on a Venturi scrubber in a two stage configuration with a Fluomix scrubber. These scrubbers are suited for recirculation of the washing liquid and they use a relative small amount of liquid which even may be contaminated with particles. The absorption efficiency for ammonia is high and within the UKF there is some good experience with these types of scrubbers.

The limitation of the scrubber system is the sharply defined air velocity in the Venturi. This means that there is not much variation in the amount of air possible. For the process air and the dedusting air two identical scrubber systems will be installed.

New mist eliminator for the concentration stage

The experiments done in the concentration stage for eliminating the liquid aerosol droplets contaminated with ammonium nitrate and ammonia gas, after the separators, were up till now not successfull.

The only concept left to reduce these losses successfully seemed to install a Brink mist eliminator (see figure 3). In this eliminator the gas/vapour stream passes a fine woven metal wire mish demister which is continuously irrigated with an acidic ammonium nitrate solution. When the contaminated vapour stream passes the demister the temperature falls to the saturation temperature and a considerable amount of the ammonia in the gas stream is absorbed.
In the upper part of the eliminator the cooled vapour passes a vertical packed fiberbed retained between two screens. This fiberbed is also irrigated with an acidic ammonium nitrate solution. In this fiberbed most of the ammonium nitrate particles are collected with the rest of the ammonia gas. The up to about 40% concentrated ammonium nitrate solution is recycled to the process. The efficiency of the Brink mist eliminator is estimated for our case at 84%.

CONCLUSION AND ESTIMATED COSTS AND PROFITS OF THE PROGRAM

When the new developed reduction program with the circulation washing system and with the new mist eliminator in the concentration unit is carried out the losses to the surface water are brought down for another 50%.

The Investment costs and savings are given in the following tables.

Investment costs and savings of the scrubber system

Unit	Investment	Savings		
		I.E.	Ammonium nitrate	Dolomite, MAF, KCl
3	f 2,000,000.00 $ 800,000.00	7,840	800 t/y	150 t/y
4	f 2,000,000.00 $ 800,000.00	6,410	520 t/y	260 t/y
1+2	f 3,300,000.00 $ 1,320,000.00	15,740	1,670 t/y	280 t/y

Investments costs and savings of the mist eliminator

Investment: f 1,050,000.00 = $ 420,000.00
Savings : i.e.'s 7,460
: ammonium nitrate 830 t/year.

The realized reduction uptill now is 40% of the initial value. With the execution of the new program a further reduction is obtained of another 50%. The total reduction is therefore 90%. The inhabitant equivalent is brought back from 70,000 i.e. to 6,550 i.e.

fig.1 Experimental Washing Unit

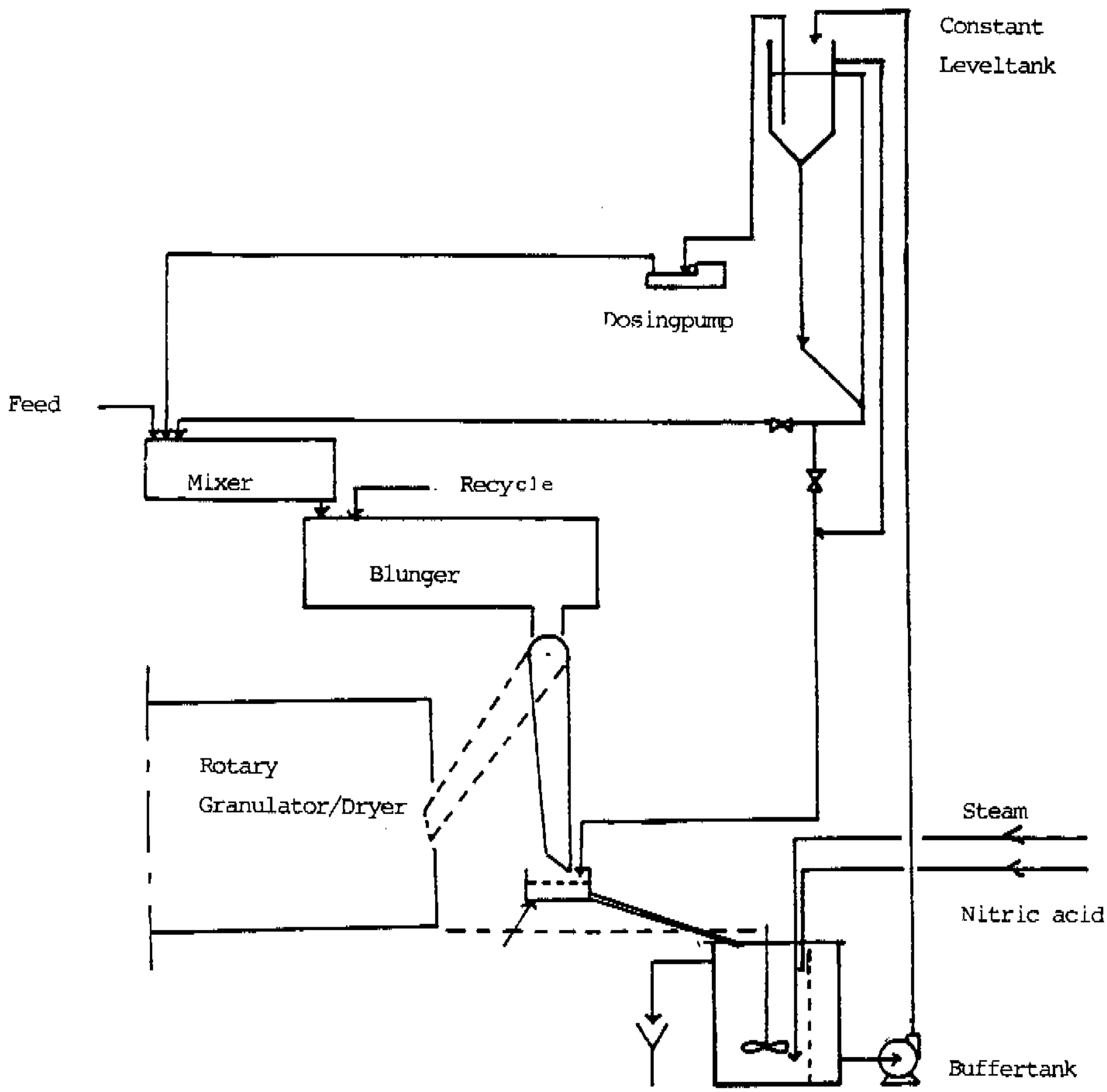


Fig.2 New Scrubber System

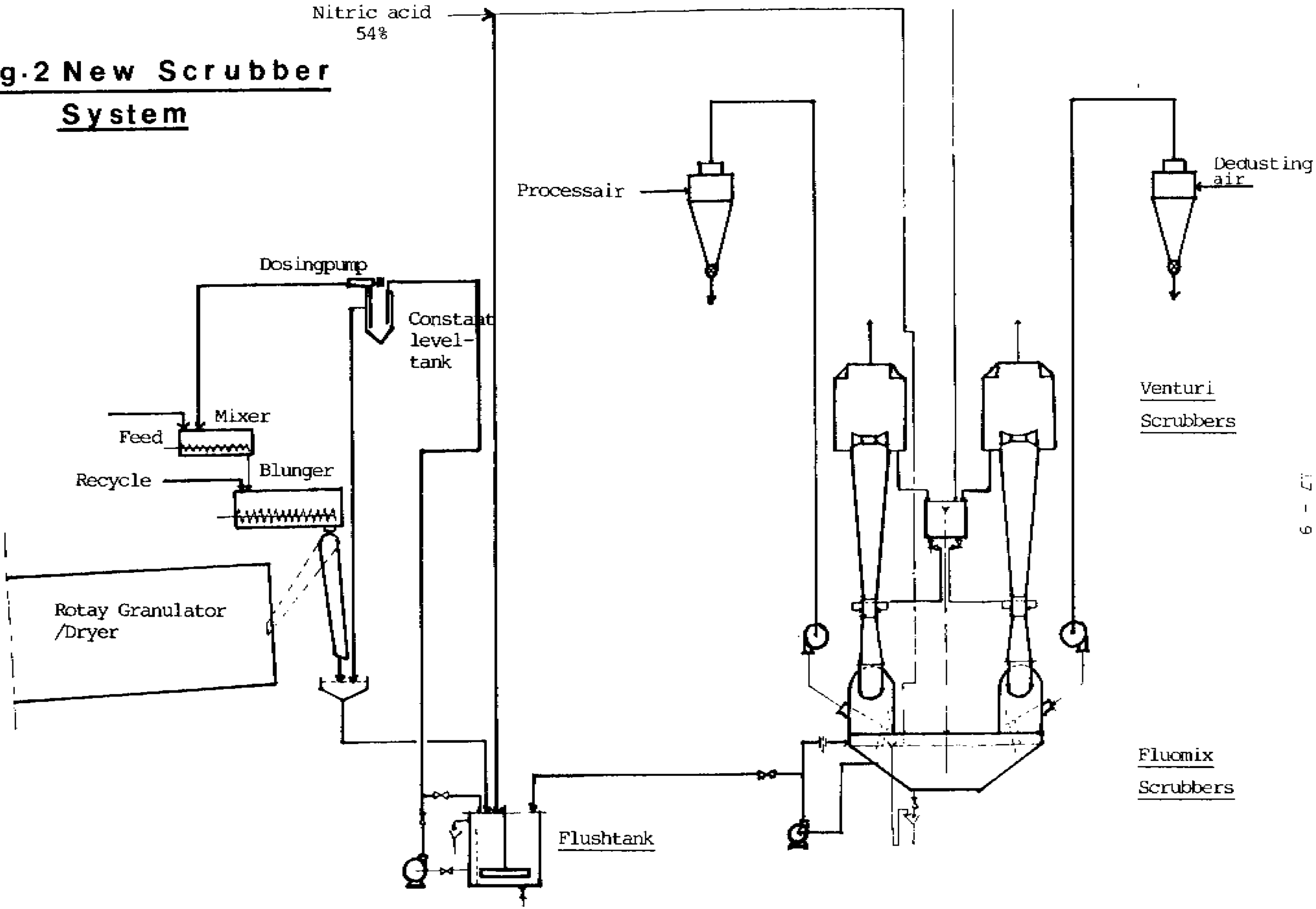
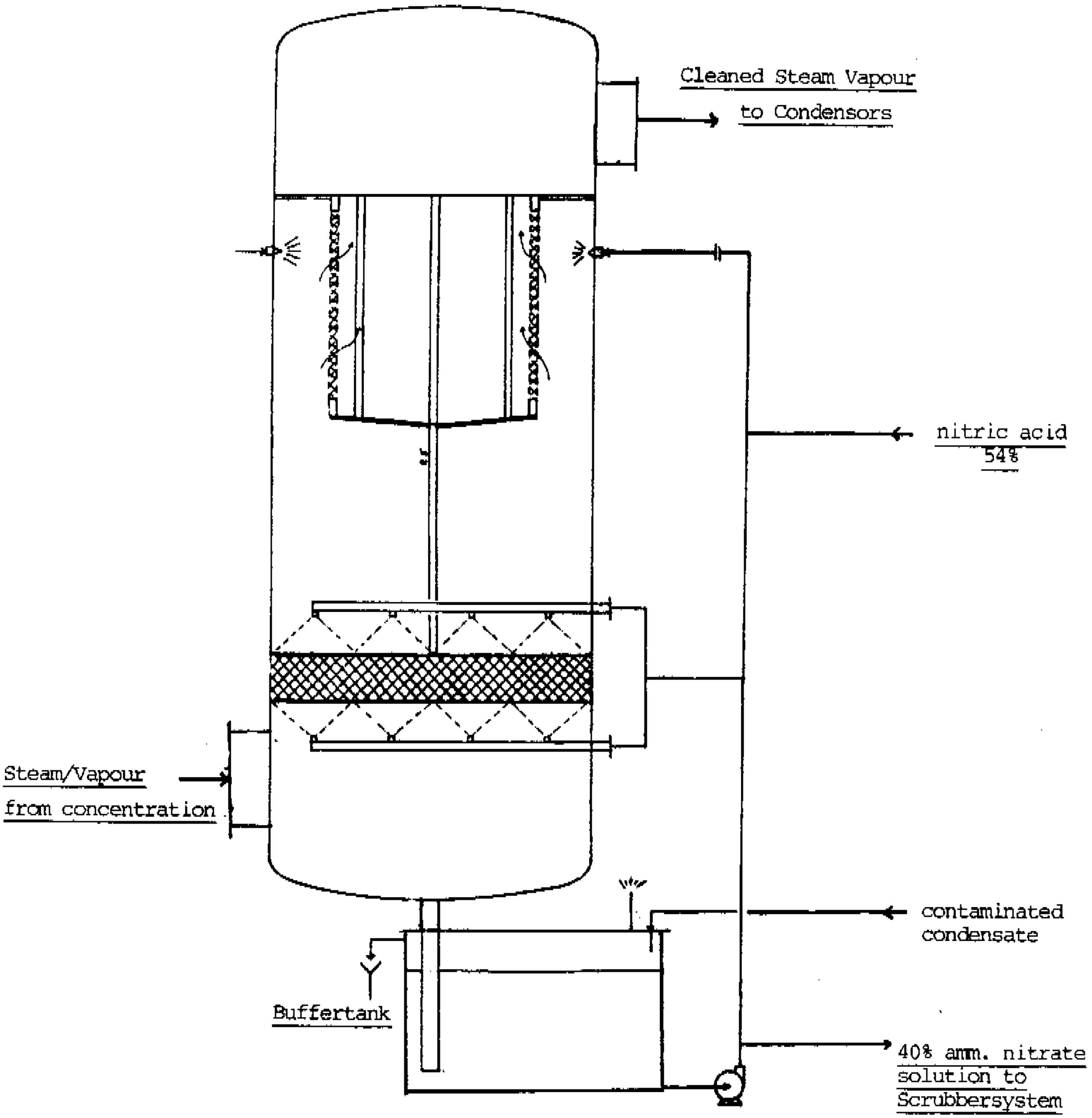


Fig.3 New Mist Eliminator



TA/86/17 An almost zero discharge concept for the CAN/NPK plant of UKF Ijmuiden has been developed to meet the stringent rules for water pollution control in the Netherlands, by W.T. Grothuis, UKF, Netherlands

DISCUSSION : (Rapporteurs Messrs A. Bourgot & M. Sart, Prayon-Rupel, Belgium)

Q - Mr. K.S. BELL, ICI Fertilizers, United Kingdom

1. In your recovery of neutralized condensate as process water make up to the nitric acid plant you do not premix the condensate with nitric acid which many people believe is necessary to avoid the loss of ammonia leading to formation of ammonium nitrate and nitrite downstream. Do you believe that this is not necessary?

2. Have you measured what percentage of the N in the condensate is recovered by this method and how much is destroyed to N2?

A - Yes, we have to add acid to the scrubber because we think the ammonia produced in the process must be acidified, as it is not allowed to lose so much ammonia in the water or in the air. We have had no safety problems so far.

Q - Mr. V. BIZZOTTO, NSM (Norsk Hydro), Belgium

1. Do you believe the Authorities will be enough satisfied with the results you will obtain after implementation of the foreseen improvements?

2. Do you know that after having obtained even better results, other companies are still under pressure of further reducing water and air pollution?

A - 1. By experience we both of us know that Authorities are never satisfied and that the only good value would be zero. To obtain our licence we must reach as low as possible a pollution level of surface waters. The Authorities must approve of our projects and the following stage is only possible after that authorization. We think that the Authorities could be satisfied for the next five years but not much longer.

2. Concerning air pollution, our regulations for cyclones state 70 mg/Nm3, for filtration systems this value becomes 50 mg/Nm3. The neighbouring steelworks reach 25 mg/Nm3 after filtration. We will probably have to add filters to reach that level. We will react accordingly.

Q - Could NSM use the paper presented to-day in future contacts with the Authorities?

A - Our paper is not yet known by the local Authorities; we will give it to them and hope to have it approved.

Q - Mr. V. BIZZOTTO

The purpose of my second question was: our factory produces about 1.25 million t ammonia/yr, 0.8 million t urea, nitric acid and 1.45 t derivatives/yr. This production is about three times yours. In the last four years water pollution is such that we reach about 8000 equivalent inhabitants. We would thus have only one third of your problems and yet the Authorities are not satisfied.

Air pollution is mainly due to ammonium nitrate; in our latest amm.nitrate unit we have less than 15 kg/hr dust (ammonia-dolomite), thus less than 50 mg/m3 evolved air. However, regional Authorities require that we reduce that value still further. We should then associate our efforts to try and convince Authorities of our goodwill and of the limitations of the fertilizer industry in that field.