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MANUFACTURE OF AMMONIUM NITRATE: THE USE OF A PIPE REACTOR AND OF A TOTAL AIR RECYCLE SYSTEM FOR PRILLING TOWER POLLUTION CONTROL

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SUMMARY

The paper describes the use of a pressure pipe reactor in the manufacture of ammonium nitrate liquor of concentration above 95% by feeding it with 50-53% nitric acid and ammonia.

The second part describes a system to eliminate pollution of prilling towers by total recycling of the air. The system applies to dense and porous ammonium nitrate prills.

1. INTRODUCTION

Most of the ammonium nitrate produced in the World is used as fertilizer, either as NPKs or as a straight fertilizer. A part is also used in the manufacture of some explosives.

In all the cases the manufacture of ammonium nitrate starts from the preparation of an ammonium nitrate solution by neutralization of weak acid (50-60% HNO_3 by weight) and ammonia. The strength of the ammonium nitrate solution depends on the temperature and concentration of the raw materials and of the operating conditions of the neutralizer. Figures 1 and 2 show the concentration that can be achieved in a neutralizer at two different pressures of operation.

In most of the cases the solution strength, as obtained in the neutralizer, is low and requires being concentrated to above 95% prior to its utilization in the subsequent granulation or prilling tower.

The first part of this paper deals with the design of a new reactor which achieves the neutralization of nitric acid and ammonia in a cheap and efficient way.

The second part of the paper describes a system to eliminate the pollution of prilling towers by total recycling of the air from the top to the bottom of the tower. The system is in operation in towers manufacturing both dense and porous ammonium nitrate prills.

2. DESIGN OF THE NEUTRALIZERS

The chemical reaction between nitric acid and ammonia is instantaneous, highly exothermic (H = 34.6 Kcal/mol) and generates heat enough to evaporate all the water contained in the weak nitric acid. In practice, however, the steam evolved in the neutralizer is at low temperature and pressure and therefore the theoretically heat selfsufficiency becomes in practice an export of low temperature steam and simultaneously an import of high temperature steam.

The main differences between processes for the manufacture of ammonium nitrate solutions are due to the design of the neutralizers and to the different ways of using the energy evolved in the neutralization.

2.1. Vacuum or atmospheric pressure neutralizers

The were very used in the past when the cost of energy was cheap. They used to be of big volume due to its low pressure and temperature of operation.

For the above reason the steam evolved could not be used to concentrate the ammonium nitrate solution made in the neutralizer. On top of that the equipment required for the steam pollution abatement was bulky and therefore expensive.

2.2. Medium pressure neutralizers (up to 4 atm abs)

Commonly used nowadays because reaction temperature, although high, is still into safe limits and the steam evolved can be used for the subsequent concentration of the ammonium nitrate liquor.

Some of those neutralizers incorporate a boiler made of high alloys placed in the reacting liquor. The boiler is fed with water and produces clean steam. As a counterpart the solution strength produced in the neutralizer is low.

2.3. High pressure neutralizers (above 4 atm abs)

The processes Fauser and Stengel are typical.

As the reaction temperature is high (200-240ºC) the neutralizers are of small size to keep low the hold up and the residence time.

Those processes produce ammonium nitrate solutions up to 90% strength without the need of an evaporator. It means that the investment requirements are low.

The main drawbacks are safety and low thermal efficiency.

2.4. Pipe reactor neutralizers

It is surprising that equipments as simple as pipe reactors have not become popular in the fertilizer industry up to the seventies. There are few ideas cheaper and simpler than mixing and reacting two fluids in a pipe or mixing device.

From 1966 the number of patents and papers regarding the use of pipe reactors in fertilizers increase. Most of them refer to the manufacture of ammonium phosphates. From 1985 they introduce also the use of pipe reactors for ammonium nitrate manufacture. Quite definitely, the experience obtained in the performance of ammonium phosphates pipe reactors has enabled the safe design of pipes for ammonium nitrate.

3. THE FESA-ESPINDESA AMMONIUM NITRATE PIPE REACTOR

The FESA-ESPINDESA pipe reactor for ammonium phosphates is described in several papers and used in fertilizer plants in several countries. Some of them are among the largest capacity plants in the World. The main feature of this pipe reactor is the achievement of on intimate contact of the reactants at a high velocity, which for example enable the manufacture of DAP slurry in a single piece of equipment of small size.

A modification of that reactor was tested to the manufacture of ammonium nitrate in a plant producing 100 Tpd. The goal to be achieved was to make 95% ammonium nitrate solution from liquid ammonia and 50–55% weak nitric acid. The fig.3 summarizes the process as it is described in the European Patent No. 0 277 901 AI, where reactor, chamber and concentrator are integrated into one single piece of equipment.

The raw materials are preheated in E-01 and E-03 by the steam evolved in the neutralizer. Ammonia is previously evaporated in E-02 by the waste steam evolved from the concentrator.

Hot nitric acid and ammonia are fed to the pipe reactor R-01 which operates at 4–6 atm abs. Reaction takes place and the products discharge in the separator C-01 at 150-170ºC and 3–4 atm g. The steam evolved from the pipe flows up through the shell of concentrator E-04. Part of this steam is condensed and the rest is exhausted from the top of the shell and flows to E-01 and E-03.

The ammonium nitrate solution from the pipe is 75-85% strength and passes by vacuum to the tubes of concentrator E-04 which is kept at 0.3 atm abs. Low temperature steam is produced by flash and used to evaporate the ammonia.

The solution falls inside the tubes and once concentrated to 95% is sent to granulation or prilling.

<u>Performance</u>

<u>Feed</u>

Weak nitric acid temperature before E-01	25ºC
" " " " after E-01	70ºC
" " " concentration	51% by weight
Ammonia to pipe reactor	80ºC

<u>Separator C-01</u>

Pressure	4 atm abs
Solution temperature	170ºC
" concentration	73%

<u>Flash and concentrator area</u>

Pressure	0.3 atm abs
Temperature	132ºC
AN solution concentration	95%

4. AMMONIUM NITRATE PRILLING TOWERS POLLUTION CONTROL

Several ways have been described to abate the pollution caused by ammonium nitrate prilling towers. Scrubbers and filters, have been used to clean all or part of the air from the finely divided ammonium nitrate mist and powder entrained when gets in contact with the ammonium nitrate solution or melt being prilled. At the end, all those systems exhaust more or less polluted air to the atmosphere.

The FESA-ESPINDESA system is now in its 8th year of operation and differentiates from the others in not exhausting anything to the atmosphere but recycling all the air to the bottom of the tower. Figure 4 describes the system.

Polluted and hot air from the prilling tower T-01 is scrubbed with a diluted solution of ammonium nitrate in the scrubber C-03. The scrubbing solution becomes enriched in ammonium nitrate and is continuously purged to the ammonium nitrate liquor system of the plant, being incorporated to the process and resulting in a nitrogen efficiency close to 100%.

The scrubbed but still hot air passes to a second tower C-04 where gets in contact with cold water. The air cools and part of its moisture condenses as water which is used as make up in the scrubber C-03, the rest being exported. The temperature of the recirculating cold water is kept low by means of an external heat exchanger E-04. The scrubbed and cooled air is sent to the bottom of the tower by the blower GB-03.

The pressure of the system is maintained close to the atmospheric to avoid as much as possible air inleakages.

The scrubber C-03 and tower C-04 are designed for low pressure drop to minimize power consumption. The addition of this system to a conventional prilling tower means an extra power consumption of only 16 Kwh/MT of ammonium nitrate this including the air blower and recirculating pumps.

Both grades, dense and porous prilled ammonium nitrate are produced in towers fitted with this system, without affecting the quality of the product. In fact this total recycle air system makes the operation of the prilling tower less dependent of the atmospheric conditions.

No signs of erosion, corrosion, buildup, fouling or plugging problems have appeared in the above mentioned 8 years of operation neither in equipment nor in ducts. The tower head and bottom can be visited while in operation.

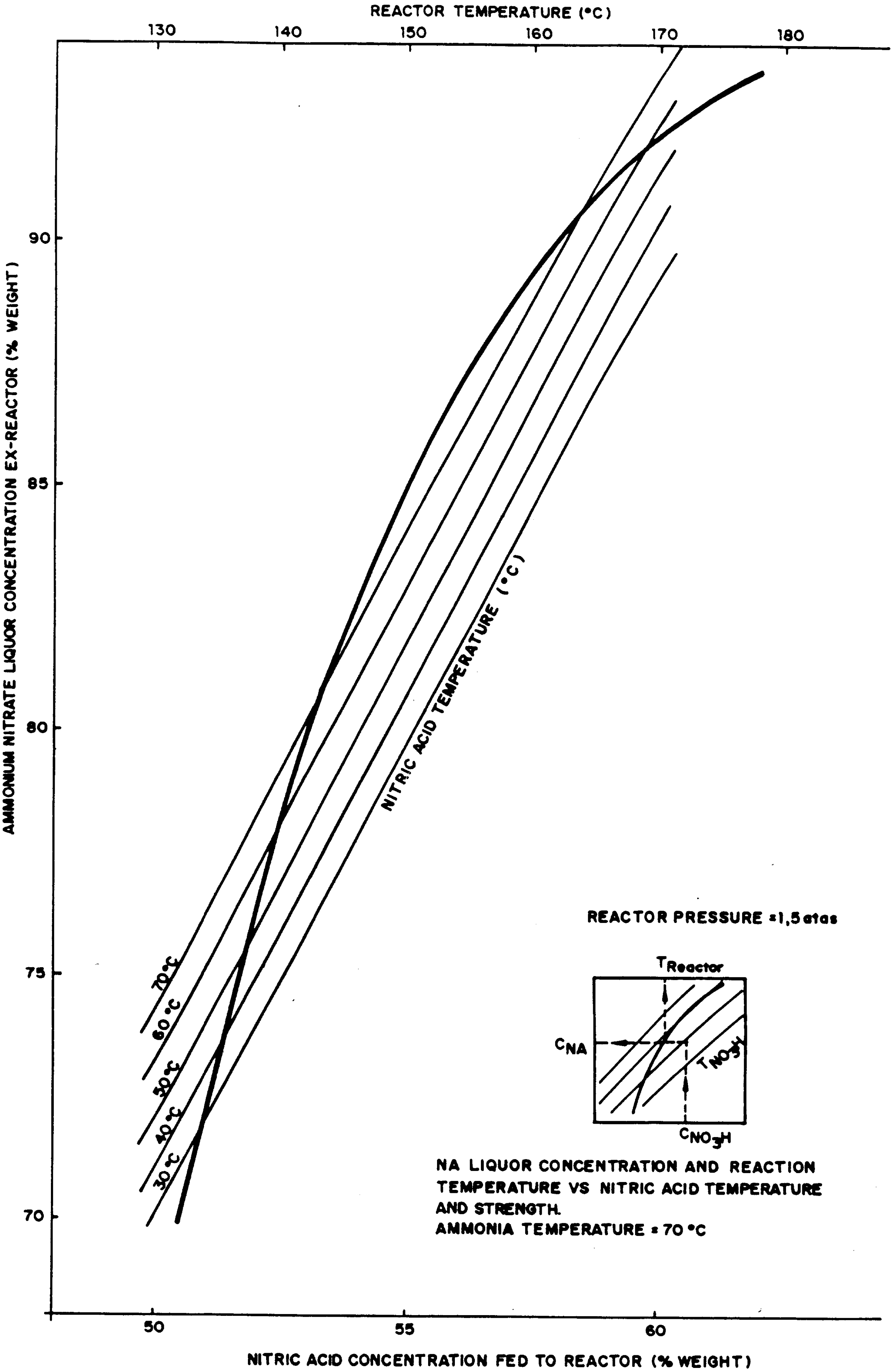
REACTOR TEMPERATURE (°C)
130
140
150
160
170
180
AMMONIUM NITRATE LIQUOR CONCENTRATION EX-REACTOR (% WEIGHT)
90
85
80
75
70
NITRIC ACID TEMPERATURE (°C)
70°C
60°C
50°C
40°C
30°C
REACTOR PRESSURE =1,5 atas
T Reactor
C NA
T NO3H
C NO3H
NA LIQUOR CONCENTRATION AND REACTION TEMPERATURE VS NITRIC ACID TEMPERATURE AND STRENGTH.
AMMONIA TEMPERATURE = 70 °C
50
55
60
NITRIC ACID CONCENTRATION FED TO REACTOR (% WEIGHT)

FIG. 1

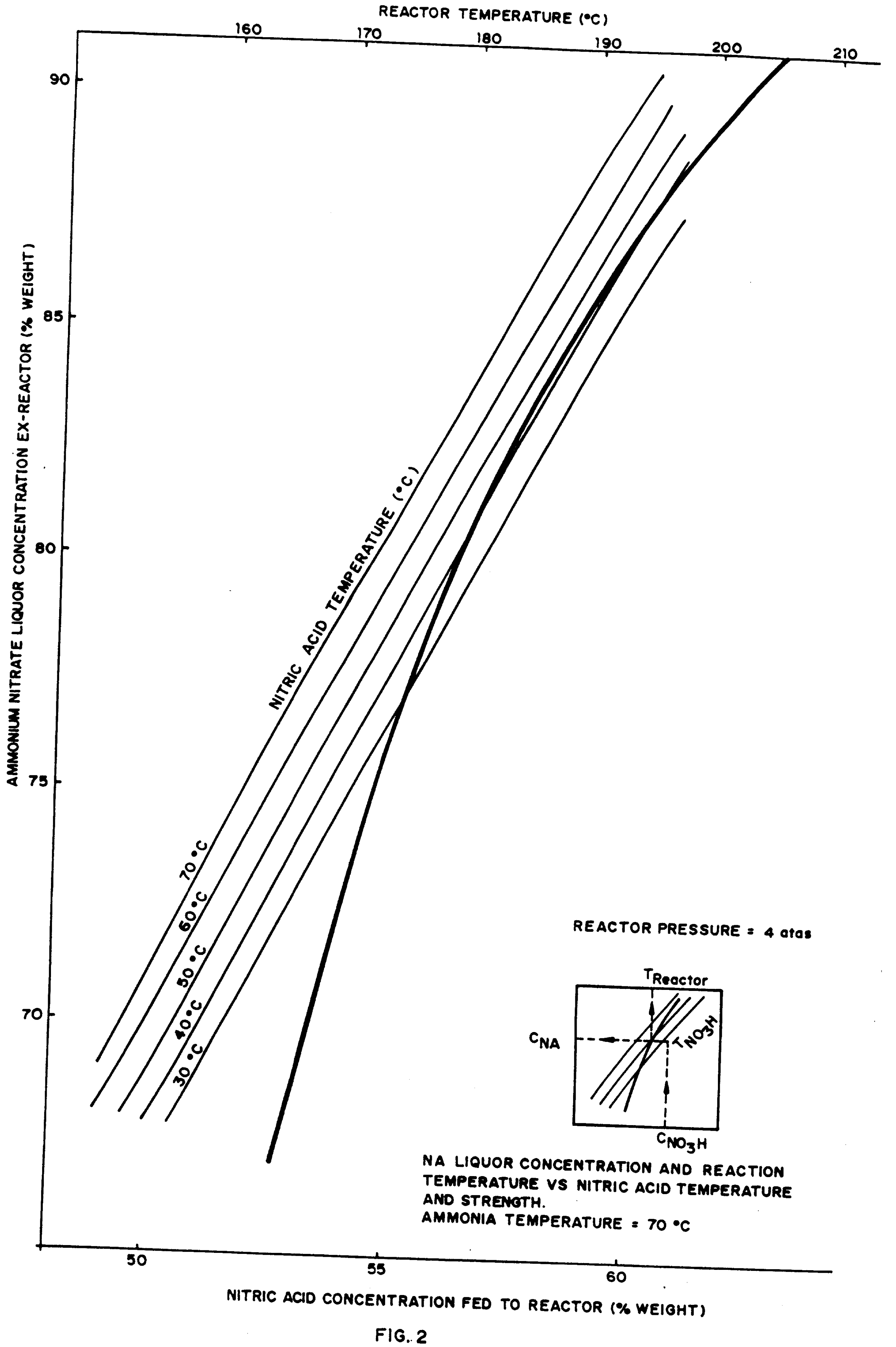
REACTOR TEMPERATURE (°C)
160
170
180
190
200
210
AMMONIUM NITRATE LIQUOR CONCENTRATION EX-REACTOR (% WEIGHT)
90
85
80
75
70
NITRIC ACID TEMPERATURE (°C)
70 °C
60 °C
50 °C
40 °C
30 °C
REACTOR PRESSURE = 4 atas
T Reactor
C NA
T NO3H
C NO3H
NA LIQUOR CONCENTRATION AND REACTION TEMPERATURE VS NITRIC ACID TEMPERATURE AND STRENGTH.
AMMONIA TEMPERATURE = 70 °C
50
55
60
NITRIC ACID CONCENTRATION FED TO REACTOR (% WEIGHT)

FIG. 2

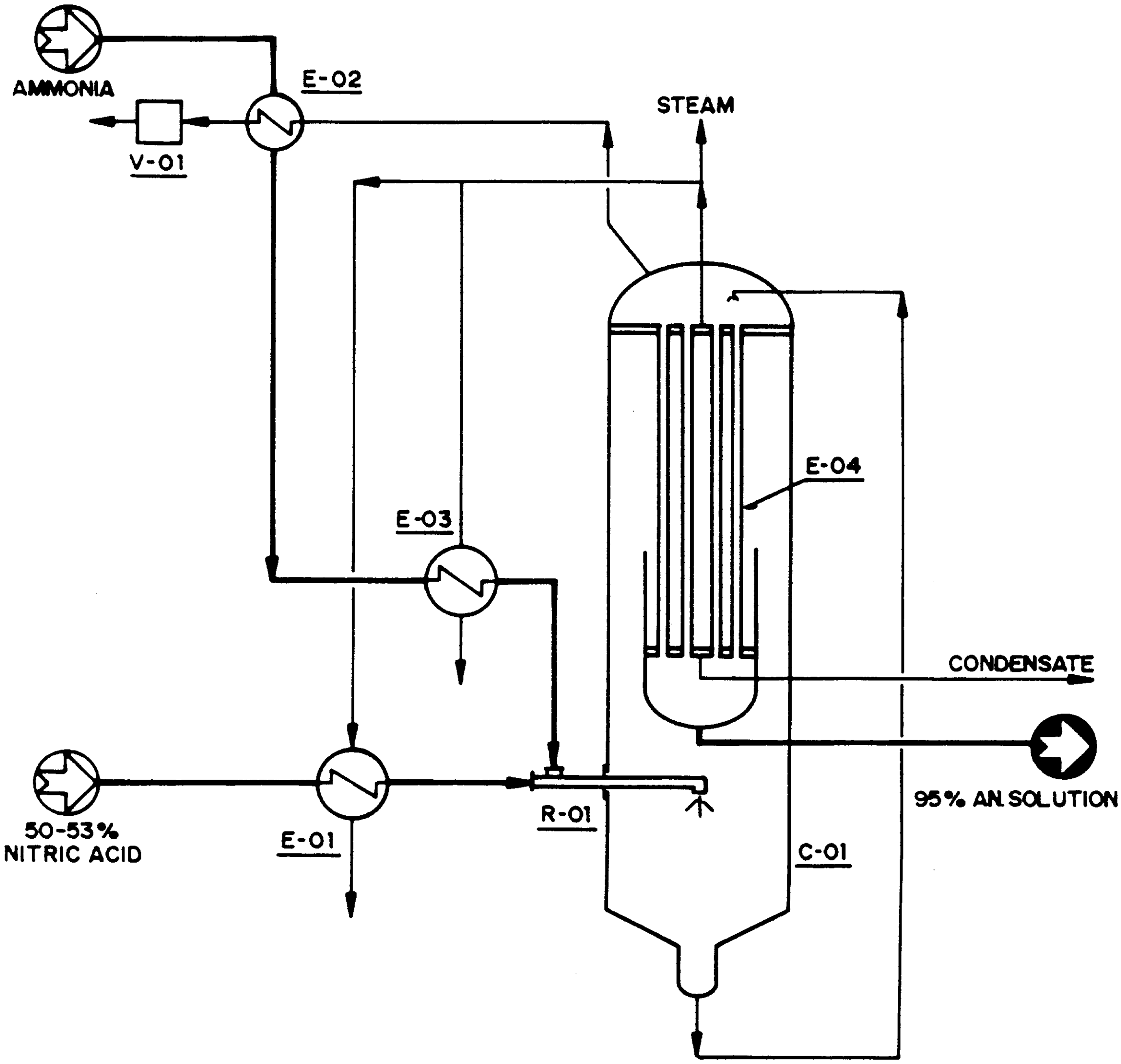

FIG. 3.- MANUFACTURE OF
95 % AMMONIUM NITRATE SOLUTION
BY PIPE REACTOR

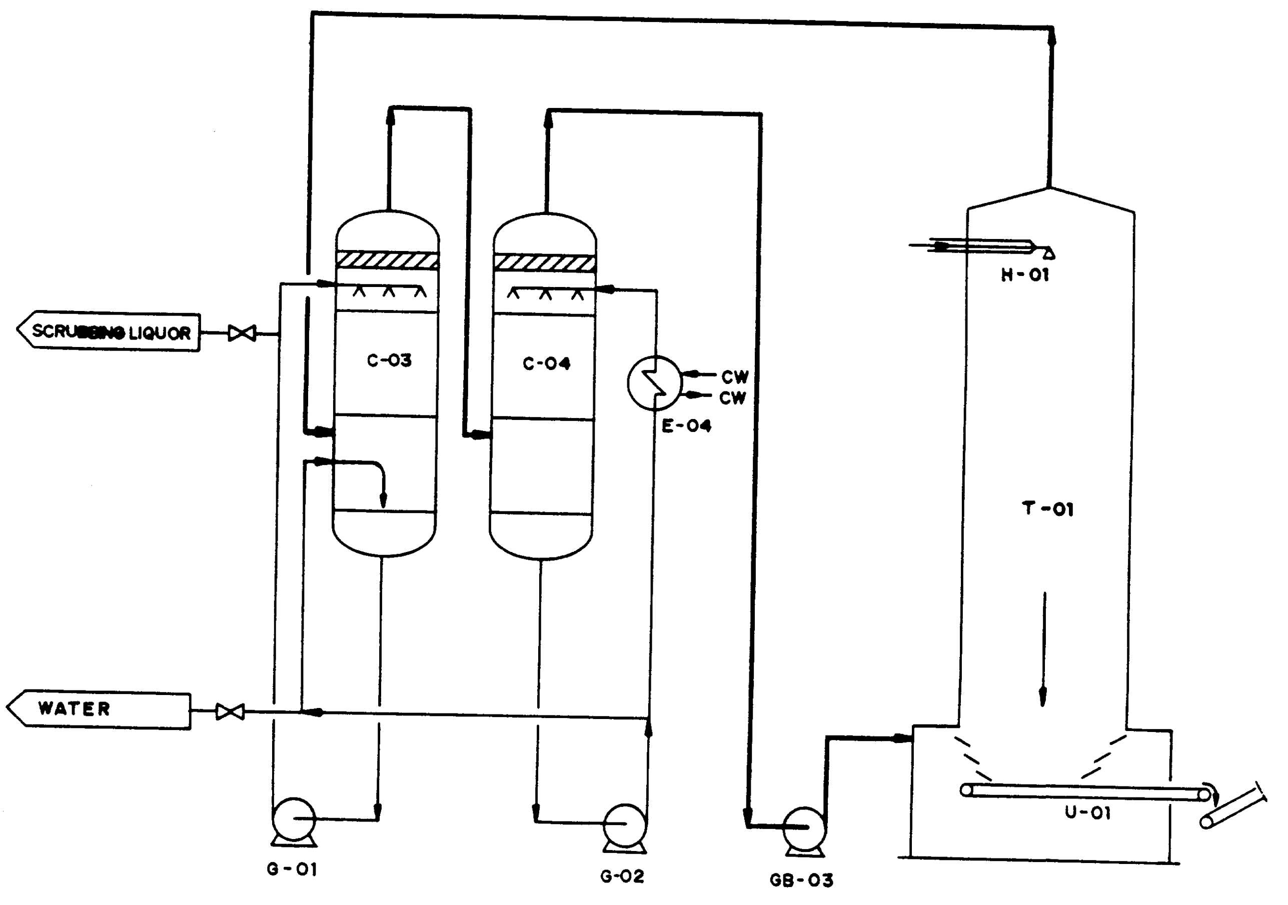

FIG. 4.- TOTAL RECYCLE
AIR SYSTEM FOR PRILLING TOWERS
POLLUTION CONTROL