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Current Developments in Antipollution Control in the Fertilizer Industry Illustrated by a Case Study for an Urea Granulation Plant

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ABSTRACT

The fertilizer industry is currently building new plants which comply with the stricter antipollution laws in force today.

Existing plants operating older scrubbing equipment are being required to improve their environmental standards which in turn induces a need for more efficient systems while reducing maintenance whenever possible.

We will analyse the increase in environmental performance of a specific fertilizer plant for producing urea and more specifically one using the fluidized bed granulation technology.

SOCREMATIC, part of the PROCEDAIR/FIVES-LILLE GROUP started to install «TURBULAIRE » scrubbers » at the end of the seventies in a urea fluidized bed granulation plant in Holland.
Since then several systems using this unique Venturi type ring system have been installed worldwide in urea plants using the HFT fluidized bed granulation process.

An in-depth analysis of major technical factors observed during an extensive survey of installed pollution control systems led us to propose several developments in order to achieve higher efficiency, better reliability and lower maintenance. They were implemented in different newly built plants over the last five years and some have been in full operational service for a while.

Current feedback proves the validity of these developments and strengthens the will to even further increase their environmental performance.

As well as reducing the urea dust emission from the granulator and coolers to a concentration of less than 30 mg/Nm^3, SOCREMATIC has recently studied and proposed an antipollution system to lower the residual gaseous ammonia content to values lower than 20 ppm in the exhaust stack.

The ammonia abatement system will use a urea solution acidified by an inorganic acid and will be located in the existing scrubber vessel. The resulting salts however, will not contaminate the final product as they will be evacuated to a separate recycling tank. The first of these will be installed in a new fertilizer plant in Asia and will start operating in 2001.

1.- INTRODUCTION

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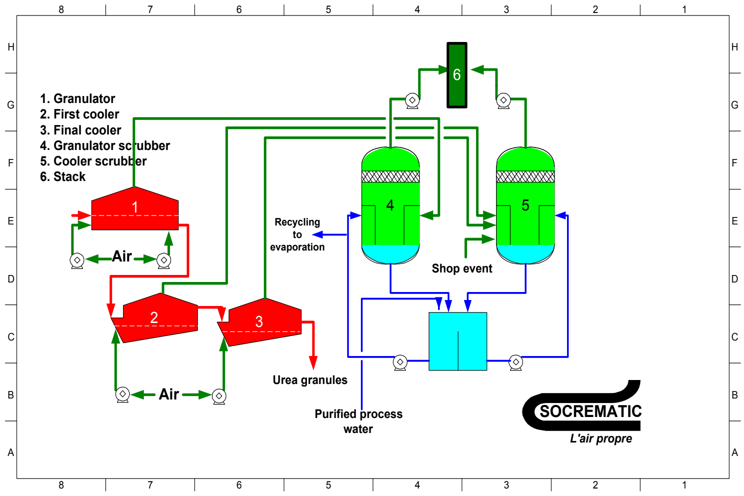
SOCREMATIC/PROCEDAIR designing and has been building specially developed scrubber systems for the fertilizer industry for over 20 years using trade names such as “AIR-MIX”, Turbulaire scrubber.

In the eighties, the urea fertilizer market shifted away from traditional prilling plants using huge air flow but moderate urea dust content towards granulator plants using very moderate air flow with a higher but coarser urea dust content.

Several granulation techniques were proposed such as drum granulation, pan granulation and fluidized beds. The fluidized bed technology however, became very popular and consequently an efficient scrubbing system was required to handle the urea loaded off-gas from the granulator, the first and second cooler and even from the factory itself in order to meet the customer’s wish to comply with the prevailing local emission standards.



TYPICAL SYSTEM LAYOUT IN A UREA GRANULATION PLANT

The «Turbulaire » scrubber installed from the seventies onwards, suited the need for a relatively low cost, sturdy and almost zero maintenance scrubber respecting the required air emission standards.

As recently improved installations have already reached a 30 mg/Nm^3 urea dust emission value well below 0.2 kg per ton of product, the emphasis is now being placed on reducing the gaseous ammonia emission. The introduction of an organic formaldehyde based granulation additive in the urea solution prior to the granulation reduces effectively these emissions by 50%, moreover some governments/companies now wish to aim for a further decrease to 20 ppm.

The first scrubber system complying with this limit has been developed by SOCREMATIC/PROCEDAIR/GFL and will be operational in 2001. It will incorporate a separate chemical scrubbing stage using an inorganic acid namely sulfuric acid as reactant; this absorption stage is installed in the same vessel as the dust scrubbing stage. Proven technology is used to separate the absorption step from the dedusting step since in this way no resulting salts can end up in the recycled urea solution from the dedusting stage. Thus, an up-to-date system responding to the latest air environmental standards has been designed.
This paper will essentially deal with the description of this scrubber system.

2.- SCRUBBER DESIGN
2.1 Description

The «Turbulaire » scrubber consists of a vertical cylindrical shell with conical top and conical hopper at the lower end. It is divided into two chambers : the agglomerator chamber and the eliminator chamber.
The agglomerator chamber is in the lower portion of the scrubber and includes the hopper containing the scrubbing liquid bath, the gas inlet passage with conical throttle and the liquid level regulating assembly.

The eliminator chamber is above the agglomerator chamber and consists of a set of swirl vanes and a sump preceeding the gas outlet.

The gas inlet is located radially on the side of the shell and the gas outlet at the top center. The agglomerator cylinder is surrounded by the gas inlet passage. The shell and the peripheral nozzle of the agglomerator chamber form an annular throttling gap at the bottom of the gas inlet passage. The normal operating level of the scrubbing liquid bath is just below the throttling gap.

Spray nozzles located on top of the peripheral chamber are installed at regular intervals so as to humidify the entire annular volume. Through an external common inlet, the scrubbing liquid is distributed to the nozzles by means of an internal manifold, integrated into the shell. In order to facilitate the control maintenance of the nozzles, they are mutually linked by external flexible connecting hoses.

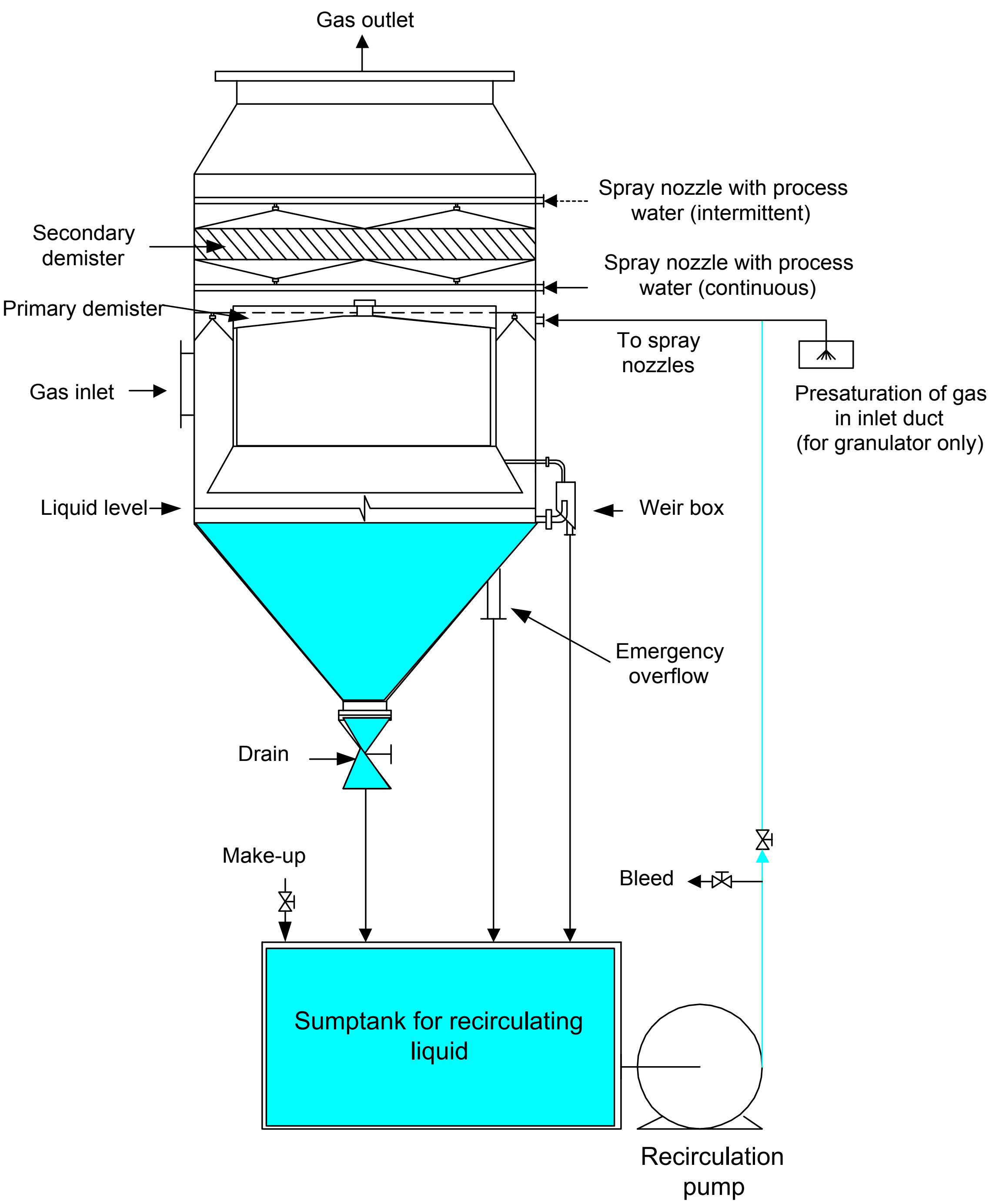
Swirl vanes are mounted at the top of the agglomerator chamber. A horizontal plate joining the agglomerator with the shell forms the eliminator sump. Large pipes drain the liquid from the sump into the scrubbing liquid bath in the hopper.

The current standard scrubber system has a secondary mist eliminator of the metal mesh type installed above the swirl vanes section. Continuous flushing of the mesh pad is recommended and carried out through spray nozzles mounted on an efficient distributor network so as to cover the entire surface of this secondary mist eliminator.

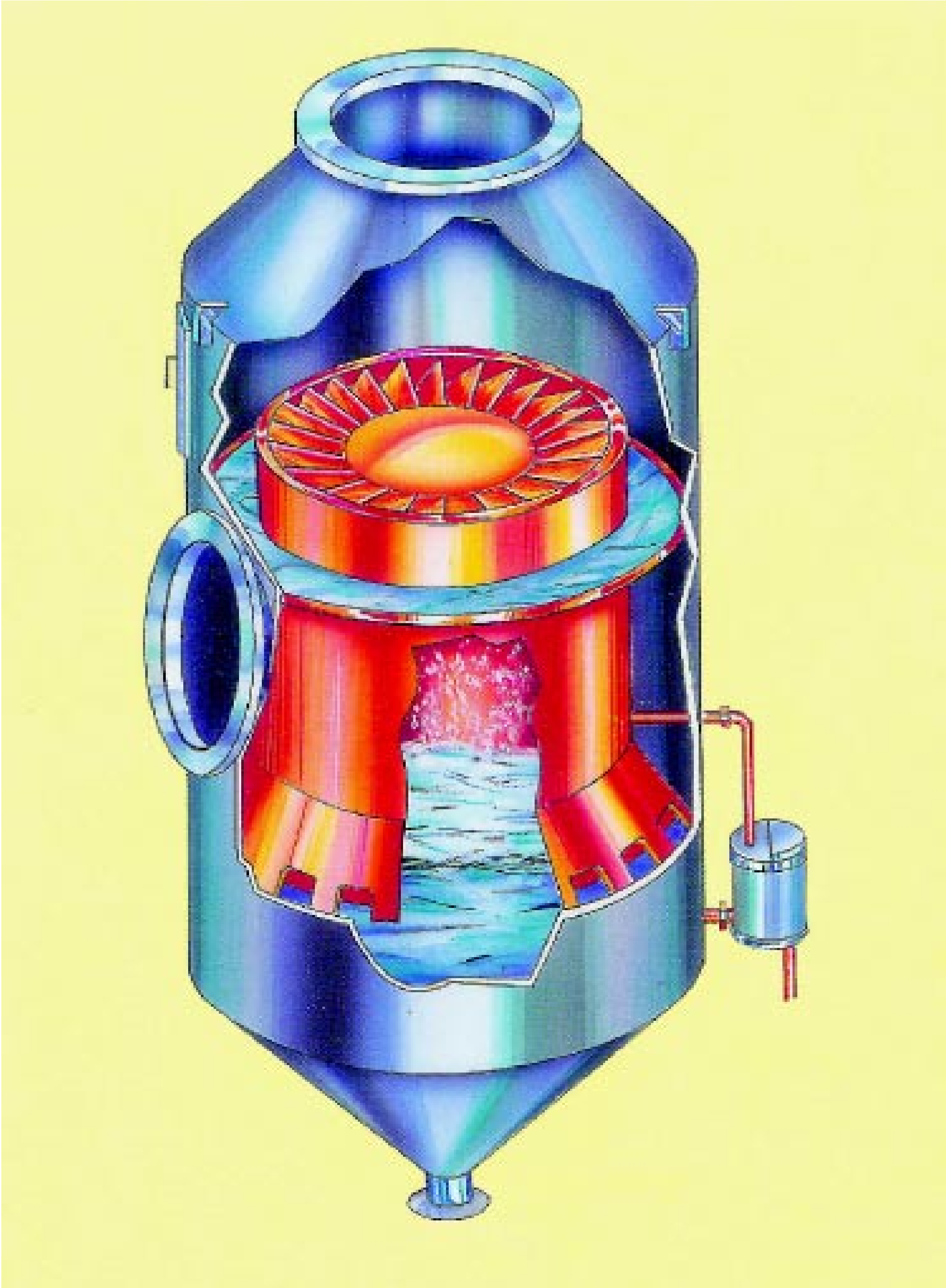
A liquid level regulating device of a weir box type is mounted on the lower exterior region of the shell so as to maintain the water level in the sump at a predetermined level.

Several manholes are provided for inspection. The scrubber is mainly manufactured in
AISI 304L or 316L stainless steel.

The following illustrations represent a schematic cut-away view of a «TURBULAIRE » type scrubber with a secondary mist eliminator.



<u>TURBULAIRE SCRUBBER IN UREA GRANULATION PLANT</u>



2.2 Operation

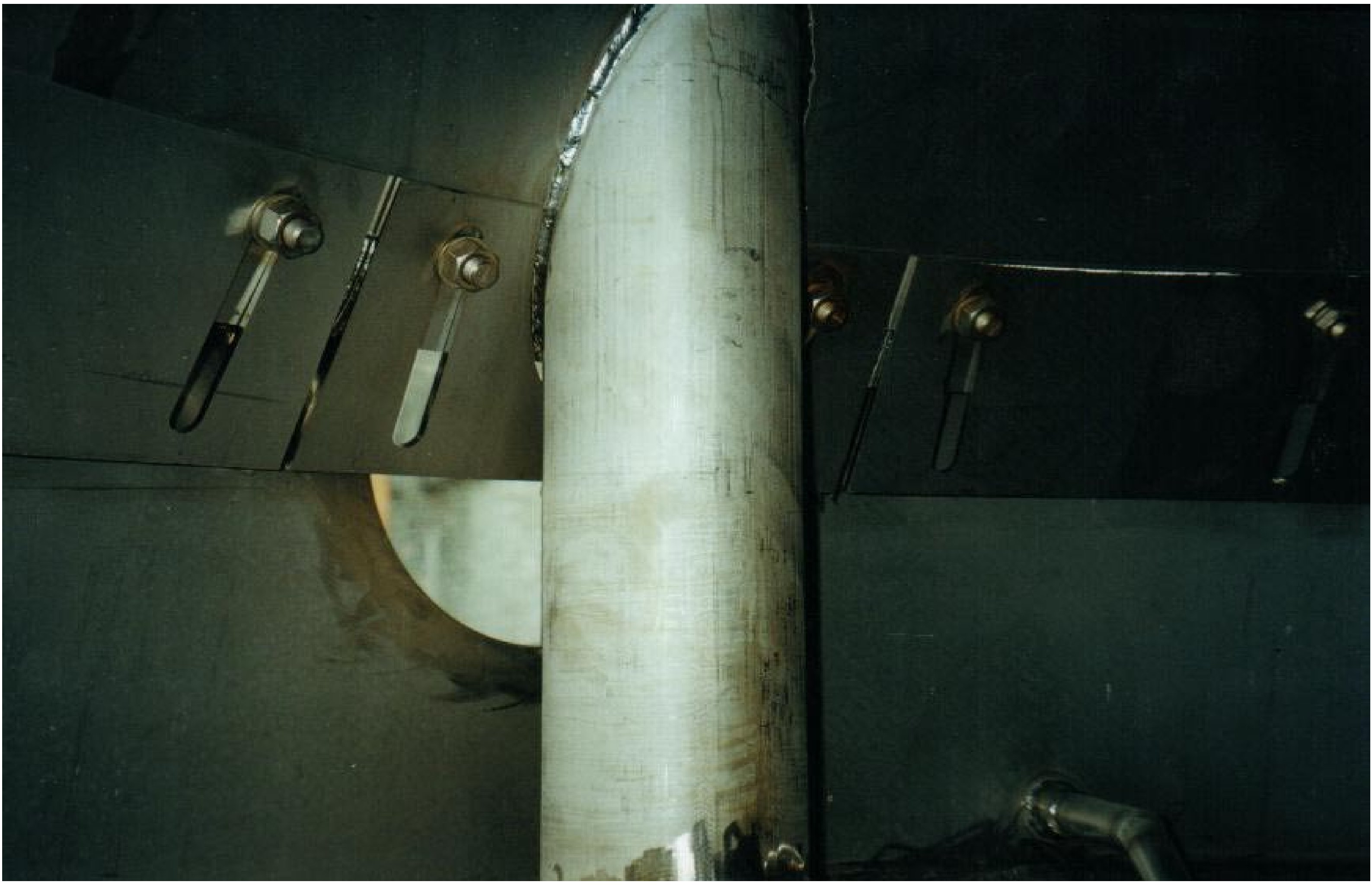
As the flue gas enters the scrubber through the inlet, its speed is increased to the desired operating velocity as it passes through the predefined throttling gap. The dust-laden gas is then discharged at high velocity and penetrates the liquid bath wherein the dust combines with the liquid to form a slurry which is discharged through the hopper outlet valve or continuously through the weir box. The turbulence resulting from the entrance of the high velocity gas into the scrubbing bath is sufficient to produce a dense spray. This spray is removed from the gas by the swirl vanes and the secondary mist eliminator.

The spraying in the peripheral chamber immediately at the gas entrance ensures the pre-saturation of the gas before its impaction with the liquid bath. Particles of moisture are formed around the dust particles, thus building up its particle size and allowing them to be separated more easily from the gas stream.

The efficiency of the scrubber can be raised by means of increasing the pressure drop through the unit by restricting the annular throttling gap.

Following the nominal inlet gas (volume, temperature, moisture content and density), the value of the gap is predefined. For different conditions , other values might be required. This is perfectly possible by adjusting the gap opening.

Indeed, the skirt gap opening can be adjusted by repositionning the slide plates on the annular skirt. The gap opening being controlled with a set of gauges made to correspond to peripheral gap values.



ADJUSTABLE SLIDE PLATES ON THE ANNULAR SKIRT PRIOR TO OPERATING (INSIDE VIEW)

ADJUSTABLE SLIDE PLATES ON THE ANNULAR SKIRT PRIOR TO OPERATING (OUTSIDE VIEW)

3. SPECIFIC FEATURES

3.1 Secondary mist eliminator

Owing to the high solubility of urea, it is of course understandable that dust caught mechanically by impingement and turbulence in the bath will also carry mist escaping from the swirl vane section along with it. Therefore a secondary mist eliminator, a metal knitted meshpad, has been installed at the top of the scrubber. This pad was especially developed by a well-known manufacturer with a superior liquid draining capacity due to an improved internal geometry.

SECONDARY MIST ELIMINATOR WITH ADJACENT SPRAYRAMP

3.2 Spray system

It was noted that the secondary demister was difficult to clean with a simple spray system. As only a limited amount of make-up water can be used to purge a 40 % urea solution, an elaborate sytem using a sequential spraying was installed to provide enough water per surface area.

SWIRL VANE SECTION WITH SPRAY SYSTEM

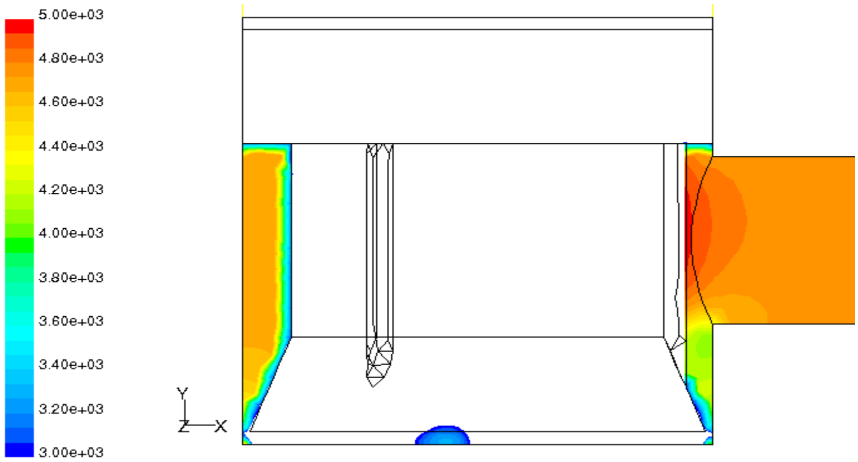
3.3 Pressure drop and control

A special study was carried out in order to trace any «high turbulence area » causing an abnormal increase in energy measured by a pressure drop. You will find below the static pressure simulation chart of the entrance followed by the annular throttling gap, in general and in detail. These simulations resulted in a better positionning of the down-comer tubes from the first demister section and the distribution of the gas over the entry section.

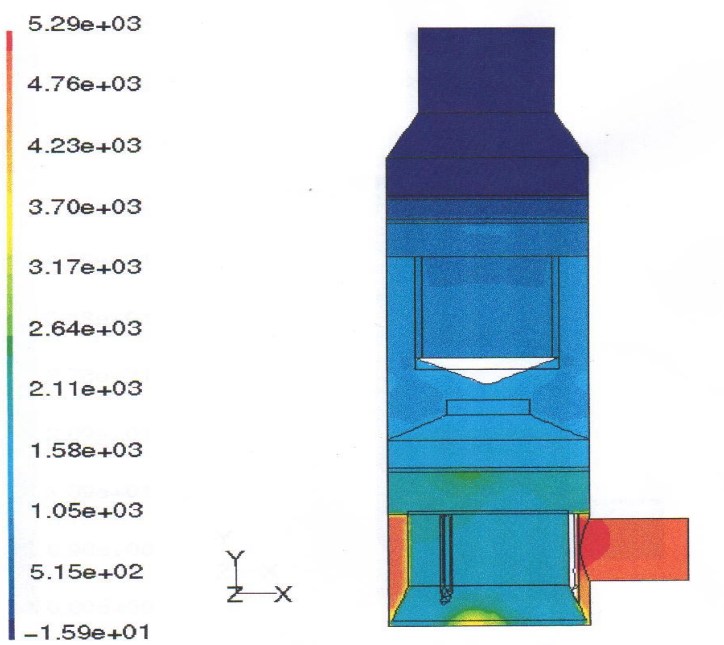
Unfortunately energy is needed to capture the dust particles in the gas. Based on the measurements of several installed systems, following pressure drop values are required to obtain a maximum 30 mg/Nm^3 urea dust emission :

- 400 mmW.C for the granulator scrubber,
- 200 mmW.C. for the cooler scrubber.

The next diagrams illustrate the pressure loss from the gas entrance to the swirl vane section as well as over the total scrubber.



PRESSURE LOSS THROUGH THE SCRUBBER



pressure profile in the plane of symmetry (Pa)

3.4 Multiple gas streams in «cooler » scrubber

This scrubber generally receives several air streams, from one or two coolers in series, from shop ventilation, etc...

Because of different relative humidities and temperatures of those air streams, mixing outside the scrubber could lead to dust build-up in collecting flues upstream. Therefore we have provided multiple inlets to this particular scrubber system.

4.- NEW DEVELOPMENT : 90 % AMMONIA ABATEMENT

Certain companies operating urea granulation plants do already add organic formaldéhyde to the urea melt prior to granulation to reduce the gaseous ammonia emission by more that 50%. Some want to go even further and at urea dust and gaseous ammonia abatement system is currently being built in Asia this has been designed to provide an even greater efficiency.

Careful analysis of all the parameters has encouraged us to propose the urea dust abatement system and the gaseous ammonia absorption system in one large vessel rather than in two separate vessels. Indeed the latter layout would incorporate a longer ductwork and would thus create a much higher energy demand on the blowers and would need a larger implantation area whereas the urea dust abatement system would adopt the classical “Turbulaire” layout.

The absorption section consists of two stages in which an absorption medium is used. Each stage being continuously irrigated with an acidified ammonia sulfate/sulfite solution.

This solution will be kept at predetermined pH value using sulphuric acid. The purge on the recirculation loop will be regulated with a pre-set density. The absorption section will be followed by a final high efficiency demister section, so as to eliminate the nuisance of mist carry-over. The absorption medium has already been installed and has proven to be successful in several plants throughout the world.

CONCLUSION

The new urea granulation plant which will operate the system described in this paper is scheduled to begin operating in May/June 2001.

This plant will be a trend setter using state of the art technology.

SOCREMATIC and its client will monitor the daily operation of the plant closely and hopes to be able to inform you of the figures obtained in a future technical paper.

SOCREMATIC is proud to be able to offer solutions which meet the current anti-pollution laws. It will continue to research and develop in order to serve its customers and the environment.