

# Improving NA concentration through modelling: Sensitivity analysis on pressure and water balances

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## INTRODUCTION

Simulation programs apart of the support during design stages are a tool for a better and quicker estimation of impacts of new operating conditions in order to can predict nitric acid plants behaviour. This subject is especially interested in Nitric Acid Units when they are using Nitric Acid concentration close to the azeotropic grade.

## 1. BACKGROUND

During the 80's was commonly used, in design stages, in-house programs for specific equipments as absorbers, cooler-condensers, Boilers, Heat exchangers, Piping Oxidations, etc...; as well as overall heat and material balances based in data previously calculated or estimated.

Predicting behaviour of the unit in different conditions by using this calculation method is quite complex and it was not usually made.

Nowadays there are simulation programs as ProSimPlus HNO<sub>3</sub> specifically developed for nitric acid units, and they can make predictions or approach to plant performance out of the normal operating conditions.

## 2. THE STUDY CASE

In this report we are talking about specific case as follows:

One nitric acid unit was designed to obtain 68% nitric acid as raw material for nitration units (Dinitrotoluene, Nitrobenzene). At once it was important to know a different capacity and weather conditions the achievable nitric acid concentration. The capacity is directly related with the influence of the pressure (compressor performance curve P-Flow) as well as the influence of the weather conditions with the water added to the system. This study compares the data obtained by simulation with data obtained in operation

## 3. THE PROCESS

The process to obtain azeotropic nitric acid (68%) is an ESPINDESA dual process as simplified in block diagram in figure 1. The diagram was simplified not to include the ammonia vaporization and DeNO<sub>x</sub> unit.

## 4. PREVIOUS DATA

The plant was already built and designed, and different data are already known. These data can be split in design data and data from manufacturers

Design data to be incorporated to the model

- Surface from heat exchangers including cooler condensers,
- Design data from absorption and bleacher towers,
- Oxidation volume in pipes,
- Efficiency in gas-liquid separators

Manufacturers data to be incorporated to the model

- Compressor efficiency and performance curves

## 5. VARIABLES

5.1 *The water is coming from three sources as follows:*

By reaction of ammonia with oxygen  
By water in ambient air  
By water adding to the absorption tower

For the first stage of this study the water was fixed as follows

The water in the air is fixed to saturation at 12 °C, in the operating unit is used at refrigeration unit in order to saturate the air.

Secondary air 18% of total

Ammonia/ (ammonia + air) ratio are fixed when gauges temperature as fixed by cascade control at 870 C

Water to the absorber is initially fixed to a level higher to the minimum required by plate performance.

5.2 *Compressor data:*

In the figure 2 is shown the compressor curve (discharge pressure of the High Pressure nitrous gas compressor in front of suction volume of the Low Pressure air compressor).

In the same curve is shown the surge curve which includes simultaneously the surge and antisurge limits for LP air compressor as well as surge and antisurge limits of the HP Nitrous compressor, as well as the maximum pressure to be achieved due to mechanical design of the unit.

The real problem is to know at different data of the compressor close to the antisurge limit the obtained concentration maintaining the NOx emission in the absorber.

## 6. MODEL

The previous mentioned data are incorporated to the model as shown in figure 3. which includes separately process gas side to tail gas side, linked through heat transfer in heat exchangers.

## 7. OPERATING DATA

Several operating points were obtained in the unit by adjusting compressor speed, Inlet Guide Vanes (IGV) at air compressor inlet and Inlet Guide Vanes (IGV) at expander Inlet.

Air compressor Flow	Nitrous Compr Disch	NA Prod	NOx
107000 Am3/h	6.3 bar g	59-60%	--
112000 Am3/h	7.6 bar g	62-63%	630 ppm
120700 Am3/h	10.5 bar g	68-69%	225 ppm

## 8. SIMULATION DATA

With design data and operating data the following results was found from simulation.

Air compressor Flow	Nitrous Compr Disch	Calculated NA Prod	NOx
107000 Am3/h	6.3 bar g	59,8 %	995 ppm
112000 Am3/h	7.6 bar g	62,3	605 ppm
120.700 Am3/h	10.5 bar g	68,7	212 ppm

It was confirmed the simulation data gives good prediction of acid strength and NOx emission.

In order to assure the performance of the calculation, other data were compared

Calculated                      By laboratory

Weak acid strength	28,7 %	28%
HNO <sub>2</sub> in acid product	38 ppm	< 40 ppm
Nitric acid product temp	49,4 °C	48,5 °C

## 9. SUMMARY

With the obtained data, and in order to fulfil the requirements from end users to minimum concentration 65%, it was fixed the minimum capacity of the unit at 116000 Am<sup>3</sup>/h (Nominal capacity 154000 Am<sup>3</sup>/h, design capacity of compressor train 170000 Am<sup>3</sup>/h).

The simulation values obtained with ProSimPlus HNO<sub>3</sub> software (<http://www.prosim.net>) fit to operating values and can be used in future to anticipate changing operating values