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Highlights in Production Costs of the Dual-Pressure Process for Nitric Acid Manufacture

J. R. FERRER, L. M. MARZO

ESPINDESA
Madrid, Spain

In the contemporary climate of high energy and metals costs, the dual-pressure process for nitric acid manufacture has a clear economic advantage over the mono-pressure process, especially for large plants. This superiority is mainly due to the differential operating costs related to ammonia and platinum catalyst. To make a proper evaluation, though, the unit consumptions should not be measured under ideal operating conditions (for example, in a limited test run in a new plant, with a catalyst gauze in peak condition). A more sound comparison of the unit consumptions should be based on measurements made over a complete year.

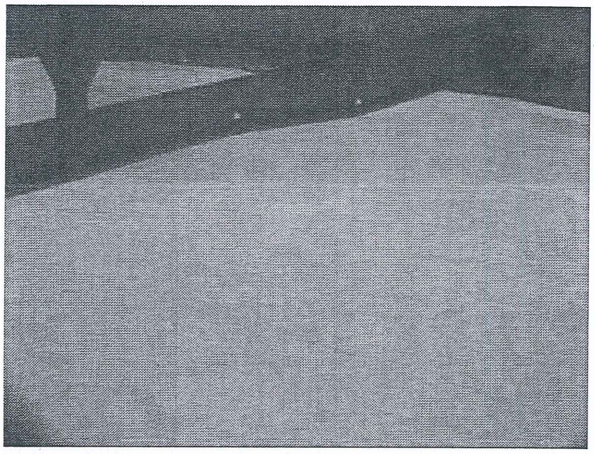
Ammonia efficiency deteriorates over time. The dual-pressure process starts with an initial yield close to 97%, which decreases gradually to around 95% six months later. In contrast, the mono high-pressure process starts with an initial yield of around 94%, but that falls quickly to around 90% in only about three months of operation.

The net consumption of precious metal catalyst per tonne of 100% nitric acid (including recovery in the "getter") is 35 mg in a dual-pressure plant and as high as 90 mg in a mono high-pressure plant.

INTRODUCTION

So as to obtain a high absorption efficiency, most nitric acid processes are designed with the absorption section operating under high pressure. The ammonia combustion section runs either at the same pressure level (the process referred to hereafter as the "mono high-pressure process") or at medium pressure, in which case there is an intermediate nitrous gas compression stage (the "medium-high dual-pressure process"). In the current climate of high energy and metals costs, the economics of the dual-pressure process are superior to those of the mono high-pressure process by a clear margin, at least in large-capacity plants.

The unit consumption figures on which licensors base their guarantees and which are checked in the test run have a limited value when comparing processes, because they correspond to ideal operating conditions: a short test run in a new plant with a catalyst gauze pack at the peak of its efficiency. A much more valid comparison would be based on unit consumptions observed over a complete year, as is shown in this report.



PLATINUM GAUZE IN OPERATION

UNIT CONSUMPTIONS

The relevant unitary consumptions in a nitric acid plant are the following:

- Ammonia
- Catalyst
- Steam
- Electric power

The first two account for about 90% of the operating cost per tonne of nitric acid, so the present comparison focuses on the costs of ammonia and catalyst per tonne of acid.

Ammonia costs

Figure 1 shows actual ammonia conversion yields through a year.

- The continuous line represents the evolution of the overall ammonia yield (catalyst gauzes + absorption + DeNOx unit) along the time for a dual-pressure process. The initial yields are above 96.8% and decrease slowly to 95.0% six months later.

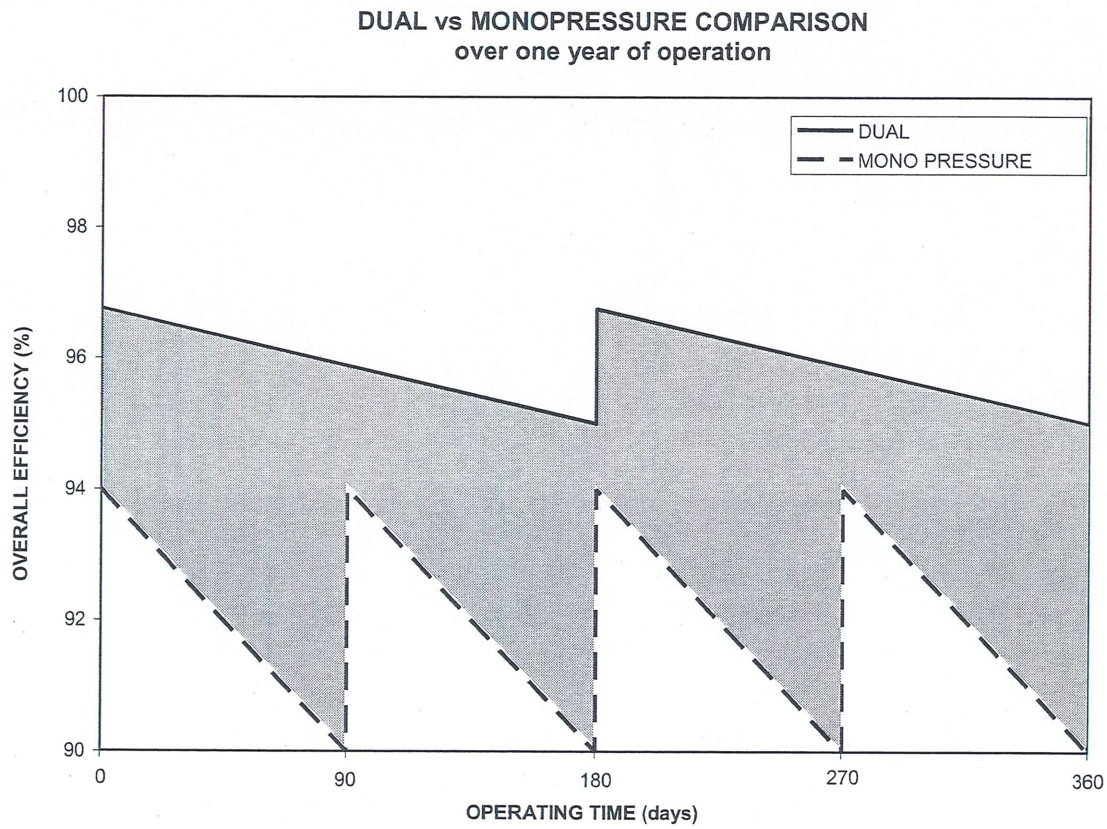


FIG. 1: AMMONIA EFFICIENCY

- The discontinuous line is the equivalent for a mono high-pressure process. The overall initial yields are around 94% and decrease quickly to values close to 90% in about three months of operation, at which point the plant has to be shut down for a gauze change and the cycle begins again.

The difference of yields through a year corresponds to the shaded area:

- The overall annual yield of a dual plant is 95.90%.
- The overall annual yield of a mono pressure plant is 92.00%.

That difference in yield (3.90%) translates into a difference of 11,960 kgs NH_3 per tonne HNO_3, which, at the present cost of 410 €/tonne NH_3, means that the annual ammonia cost of a 1,000-t/d dual-pressure process plant operating for 345 days per year is 0.01196 x 1000 x 345 x 410 = €1,691,792 (US $2,453,026) lower than that of a mono high-pressure process plant.

Precious metal cost (Pt/Rh)

The net catalyst consumption per tonne of nitric acid in ESPINDESA´s plants, including the credit of Pt/Rh recovery from the "getter" made by the gauze manufacturer, is 35 mg/tonne of 100% acid.

The equivalent net consumption in a mono high-pressure plant is about 90 mg.

That difference of 55 mg/tonne means that, at present precious metal prices of €50 (US $72.50) per gram, the annual precious metal cost will be 0.055 x 1000 x 345 x 50 = €948,750 or US $1,375,688 less for the dual-pressure process than for the mono high-pressure process.

Gauze manufacturing and handling costs

Another related cost is the manufacturing of gauzes. The average cost of manufacture per set of gauzes is €100,000 for this plant size. The mono high-pressure process requires two or three more changes of gauzes per year than the dual-pressure process, which attracts an extra cost of 100,000 x 2.5 = €250,000 (US $362,500) per year

Additionally, changing the gauzes means shipments to/from manufacturer shop, insurance of the gauzes during shipment, etc., which, assuming an average cost of €30,000 per consignment, means 30,000 x 2.5 = €75,000 (US$108,750) higher for mono pressure process.

Annual savings

So, without considering differences in inventory cost of the Pt/Rh catalyst, steam credits and electrical energy consumption, all of which are in favour of the dual-pressure process, the annual savings in operating costs achieved by using a 1,000-t/d dual-pressure plant rather than a same-size mono high-pressure plant are shown in Table 1.

Table 1
Annual Savings in Ammonia and Catalyst-Related Costs by Using a Dual-Pressure Instead of a Mono High-Pressure Process

	Euro	US Dollar
Ammonia	1,691,792	2,453,026
Precious metals	948,750	1,375,688
Gauze manufacture	250,000	362,500
Handling and insurance	75,000	108,750
Total	**2,965,542**	**4,299,964**

LOST PRODUCTION

The fact that the conversion efficiency of NH_3 to NO falls off more quickly in mono high-pressure than in dual-pressure processes makes it necessary to change the catalyst gauzes in mono high-pressure process every three months.

This difference means that a 1,000 t/day dual plant produces around 6,000 tons more of nitric acid per year.

FLEXIBILITY TO DEMAND PEAKS

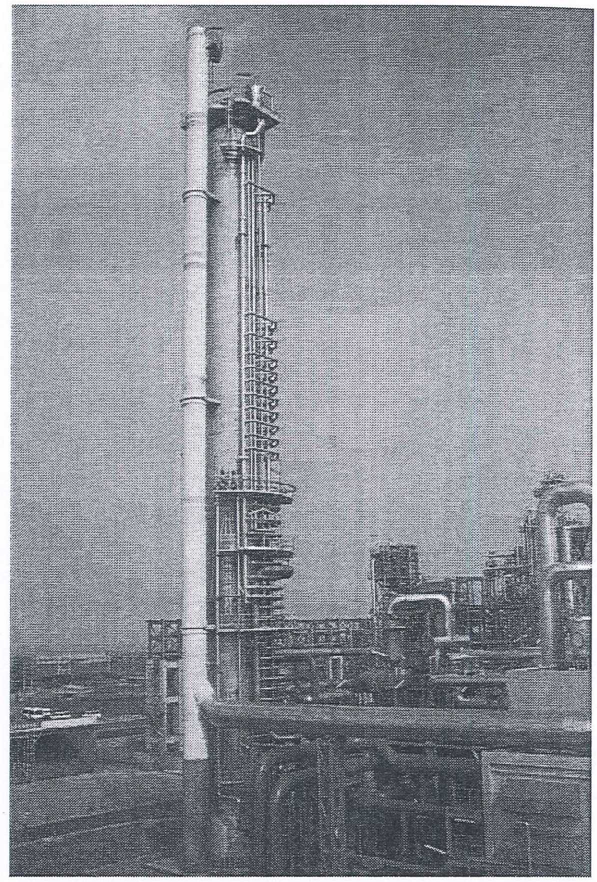
Because of the lower rate of catalyst deterioration, in periods of peak demand it is possible to extend the operating campaigns of ESPINDESA's dual-pressure process to as much as 9 months and to defer the gauze change until a time of lower demand.

ACID QUALITY

The present technologies for manufacturing the plastics intermediates MDI and TDI often require 65-69% nitric acid with a nitrogen oxides content no greater then 70 ppm (measured as NO_2).

It is possible to attain a product concentration of 68% HNO_3 using a dual-pressure process because the ammonia oxidation is carried out at a higher $NH_3/(NH_3 + air)$ ratio than in a mono high-pressure process. That produces higher NO_2 concentrations at the absorber inlet.

The dual-pressure process attains the nitrogen oxides content of below 70 ppm easily because the bleaching column removes nitrogen oxides under lower pressure and returns them to the nitrous gas compressor. This desorption is not produced in mono high-pressure processes.



DUAL-PRESSURE NITRIC ACID PLANT

SUMMARY

A dual-pressure process permits:

- exploiting the cooling effect of evaporating ammonia at low pressure to operate the absorption at low temperature, minimising residual NOx in the tail gas;
- oxidizing the ammonia in optimum yield conditions with minimum losses of catalyst;
- higher concentration in final product (68%);
- lower NO_2 content in final product.

Against this must be set the slightly higher investment cost resulting from need for a nitrous gas compressor and low-pressure heat exchangers.