Developments in Nitric Acid Production Technology

Modern nitric acid plants are designed mostly according to three nitric acid process versions - mono medium pressure, mono high pressure and dual pressure. Medium pressure at about 4-6 bar will be preferred where a high ammonia efficiency is decisive for the plant economics. High pressure of more than 8-12 bar is an advantage with regard to the absorption performance. The dual pressure process offers both of these advantages as this process combines a medium pressure combustion with the use of an absorption at higher pressure.

As elsewhere in the fertilizer industry, the upgrading of technology within nitric acid plants is usually driven by cost pressures and the need to be competitive. Here, Uhde addresses some important points regarding economic selection of machinery for a dual pressure nitric acid plant and improved major process equipment, especially for elevated plant capacities. (An article on the Uhde EnviN0x® process, which significantly reduces N2O and NOX emissions at nitric acid plants, can be found on pages 42-44, March/April 2004 Fertilizer Focus).

Compact Compressor Train for Dual Pressure Plants

Some years ago, the production capacity of nitric acid plants was continuously growing up to a maximum of nearly 2,000 tpd. These large plants were designed entirely as dual pressure plants equipped with single line compressor trains. The compressor set was a single shaft design with air compressor, NOX compressor, tail-gas turbine and steam turbine, or electric motor. However, in recent years turbo machine manufacturers have developed geared compressor trains with more efficient radial compressor wheels as well as radial expansion turbines, even for elevated capacities up to approximately 1,200 tpd of nitric acid. Currently, this capacity seems to be the maximum due to limits on rotor tip speeds.

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Assessing nitric acid plant economics the Uhde way

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mesh with a planet wheel i.e. in each case, two air compressor, two nitrous gas compressor and two expansion turbine stages can be combined so that a steam turbine can be connected direct via the fourth pinion, and the motor drive or the generator via the central shaft. At the inlet of the first stage of the air compressions section, adjustable guide vanes are installed for controlling the air-flow and at the inlet of the first expander stage the plant pressure can be set by adjustable expander guide vanes. The resulting turbo set offers a maximum of flexibility regarding plant capacities, process pressures and start up conditions.

These two-stage compression sections with no intermediate cooling are ideal for the pressure conditions which prevail in the dual pressure nitric acid process and, due to the very compact and thus space-saving design, provide advantages where efficiency is not a particular priority. The single-shaft trains with specific power consumption of approximately 140 kWh per tonne of nitric acid are energetically more favourable compared to approximately 180 kWh per tonne of nitric acid required by multi-shaft trains; however, the latter investment is about 20% lower.

In the following tables, both concepts are compared for a 1,000 tpd nitric acid plant. The reduced power consumption (1,700 kW) of the inline concept is converted via an exchange factor of 3.7 tonnes per MWh to surplus steam (6.29 tph), which can be exported with a steam price of about Euros 10 per tonne. Consequently, regarding the operating expenditures (OPEX) of the inline concept, savings per year amount to Euros 0.528 million. Regarding capital expenditures (CAPEX) of the bull gear concept, the savings in investment are about Euros 1.9 million.

This is a typical polar situation in investment - either choosing the design concept with high CAPEX and low OPEX or choosing the design concept with low CAPEX and high OPEX on the other. To determine the optimum concept, the Net Present Value (NPV) of costs and savings per year has been calculated - a discount rate of 10% and a financial horizon of 10 years have been assumed.

The accompanying diagram shows that the operating savings per year of the inline concept have a much bigger impact on the Net Present Value than the investment savings of the bull gear concept. For a reference plant of 1,000 tpd with a discount rate of 10%, the inline single shaft compressor train is the economically superior concept after approximately 5 years of operation.

New Burner Design

With increasing plant capacity, the effective catalyst gauze diameter has also to be increased stepwise in order to keep optimised specific N-loads. Therefore, Uhde has developed a burner with an effective gauze diameter of 5,710 mm and an inner shell diameter of 6,000 mm for a capacity of more than 1,500 tpd of nitric acid (100%). This ammonia burner up to now is the biggest in the world for nitric acid application. In addition to that, the new Uhde burner design can be extended to a maximum 6,200 mm effective
A very important issue is an adequate sealing system for big burner flanges, especially when considering the fact that nowadays the use of non-asbestos gasket material is mandatory. Uhde has introduced a special air sealing system, connected to the compressed process air-line downstream of the air compressor. The air pressure in the sealing chamber is always about 0.1 bar higher than the system pressure within the reactor. In case of a possible leak at the inner gasket, air escapes from the sealing chamber to the inner vessel, which is harmless to the process. In case of a leakage at the outer gasket, only air and no ammonia/air mixture escapes via the flange connection, which is harmless to personnel and environment.

Uhde has been involved in nitric acid technology for more than 80 years and has developed the process successfully so that more than 200 Uhde nitric acid plants have been built world-wide, tailor-made for client’s applications. Uhde thus ranks among the world’s leading engineering companies engaged in the design and construction of nitric acid plants.