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Modernization and Intensification of Nitric Acid Plants

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1. Introduction

Nitric acid plants both in AZOTY Tarnów and ANWIL SA in Włocławek are dual pressure plants which means that ammonia oxidation and heat recovery take place under a low pressure whereas absorption under a high pressure. Nevertheless, there are important differences between them in regard to pressure and construction solutions applied and the level of their exploitation. A number of design solutions were implemented which aimed at removal of equipment damage, as well as exchange of machines and equipment and provision of plant continuous operation before 2000. Most of these works were performed by companies themselves, however Fertilizers Research Institute (Instytut Nawozów Sztucznych) participated in realization of some of them. After 2000 the increase of nitric acid plant capacity in the above mentioned Works became necessary. The scope of tasks to be undertaken, the realization of which was necessary to increase plant capacity in the above mentioned Works was to be defined in the first stage. This project was realized in cooperation with Fertilizers Research Institute. Some of the accomplished tasks which allowed for the achievement of stated objectives are presented below.

2. Nitric acid plant 0.5/1.5 MPa, 700 T HNO_3/d in AZOTY Tarnów

2.1 Plant description

Process design of nitric acid plant of a nominal production capacity – 700 t HNO_3/d for Zakłady Azotowe SA in Tarnów-Mościce was prepared by Fertilizers Research Institute and Prosynchem in Gliwice in 1985[1)]. The pressure applied that is 0.5 MPa in ammonia oxidation unit and 1.5 MPa in absorption unit provided energy self-sufficiency of this plant and, NO_x content in outlet gases below 200 ppm and allowed for the nitric acid production with the concentration of 65% by weight.

The plant called Dual Pressure Nitric Acid Plant, presented on Fig. 1 was started in 1992. During Start-up a number of changes were introduced[3,4)] which improved its operation

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efficiency and made it safer both for staff and environment. No significant technological errors were found with guarantee parameters and production capacity confirmed during Start-up.

Fig. 1. Nitric acid plant in AZOTY Tarnów

2.2 Plant modernization stages

The first modernization stage included actions aimed at improvement of plant stability and reliability with a nominal load as well as optimization of heat use. The below mentioned actions were undertaken to achieve these goals:

- Additional low pressure heater (E14) of tail gases was built-up,
- The construction of tube pack in high pressure tail gases heater (E9)[5)] was changed,
- Construction changes were introduced to air heater E1,
- Maintenance and changes in turbine set,

During the second stage of modernization, works aiming at gradual intensification of the plant (increase of plant capacity) by removal of bottlenecks and further improvement of stability and reliability were performed. More actions than in the first stage were undertaken to achieve this objective including:

- Improvement of heat exchange in a low pressure condenser E8 and high pressure condenser E10, by the change of buffles and the change of tube pack[6],
- Improvement of mist elimination efficiency and vortex breaker in separator V8[7],
- Engineering analysis of Dual Pressure Nitric Acid Plant at load of 900 t HNO_3/d[8], the result of which was determination of plant operation parameters and specification of any changes to be introduced into units, that may limit plant operation at such load,
- Control system modernization and intelligent controllers built-up which provide stable operation at high load,
- Economizer E7 modernization – increased efficiency of heat exchange,
- Start-up of double stage Tapproge system for a continuous tube cleaning of the steam turbine condenser,
- Engineering analysis of Dual Pressure Nitric Acid Plant at the load of 950 t HNO_3/d[9], containing operation conditions at this load,

2.3 Results of plant modernization

Due to works performed in the first stage the possibility of nitric acid production on design level with a simultaneous energy consumption improvement was obtained and the number of plant stays was limited.

During the second stage mass and heat balances for the load of 900 and 950 t HNO_3/d were prepared within engineering analysis and operation parameters of particular plant units at the above mentioned loads were specified. This analysis was possible with modernization works performed by AZOTY Tarnów. Some of them include:

- Filtration area enlargement and the use of a different filtration material,
- Gradual filtration area enlargement of NH_3- air filter and flow resistance lowering,
- Limitation of air II content for whitening of nitric acid solution to minimum value which guarantees “proper ” whitening (the removal of dissolved nitrous oxides), which enabled us to direct additional air to ammonia oxidation unit,
- Modernization of pump systems which feed boiler system and construction changes of demister in boiler drum, due to which water separation from wet steam was improved and quality of the overheated steam directed to steam turbine powering turbine set was also improved,
- Separator modernization of nitric acid mist from tail gases after absorption column which improved its operation and limited corrosion of tail gases heater E14.

Research on optimization – the adjustment of catalytic packages for increasing technical nitric acid production in the following platinum campaign was conducted during works over plant intensification.

As the result of modernization discussed above daily production capacity of the plant and the level of its exploitation were increased, as presented on Fig. 2 and 3. Moreover, modernization and strengthening of catalytic baskets were performed, which allowed for built-up of the catalyst for a high temperature N_2O decomposition within JI project.

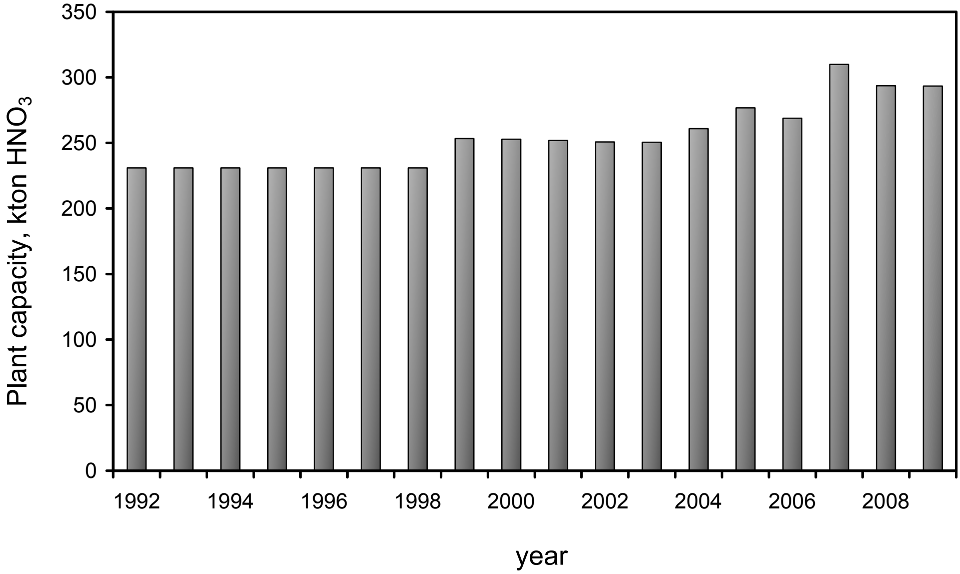

Fig. 2. A change of annual capacity as a result of modernization

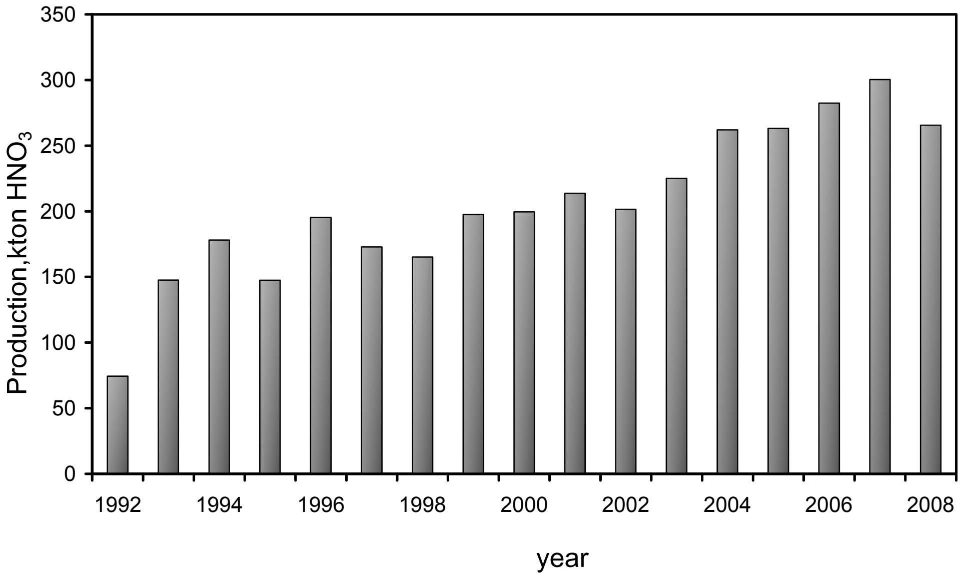

Fig. 3. Annual production of nitric acid in AZOTY Tarnów

3. Nitric acid plant 0.35/0.9 Mpa, 900 t HNO_3/d, ANWIL SA in Włocławek

3.1 Plant description

Nitric acid plant in ANWIL SA was built according to the project of French company Societe Chimique de la Grande Paroisse in 1968. It consists of two trains of a nominal value of 900 t HNO_3/d each. In the 70's it was the first dual pressure plant in Poland. The solutions applied provided energy self-sufficiency of the plant but with the NOx content in tail gases of 400 ppm and NHO_3 concentration in solution of 56.5% by weight.

The plant presented on Fig. 4 was started in 1971-1972. During start-up in the 70's nominal production capacity was obtained and the most important exploitation problems were eliminated.

Fig. 4. Nitric acid plant in ANWIL SA

3.2 Plant modernization stages

No significant modernization works were performed in 1980-2000 due to a poor economic trend. The main objective was to provide continuous operation of the plant which contributed to decrease of the number of plant stays from 25 in 1980 to 7 in 2000.

Actions aiming at modernization and intensification of the plant have been undertaken since 2000. Some worn out equipment was replaced and due to actions undertaken exchange of one of the most important apparatus that is a high pressure tail gases heater E2211 became unnecessary. The results of analysis[11,12)] of operation conditions of this apparatus indicated the necessity of application of condensate drops separation from tail gases after absorption column. Furthermore, periodical controls of wall thickens of this apparatus were performed, as well as maintenance of thinned or damaged tubes by placing rolled steel tubes 2RE10 inside and washing process optimization of nitrous gases compressor and continual controls of dehydrating nozzles permeability.

The preparation of mass and heat balance by Fertilizers Research Institute for the load of 1100 t HNO_3/d (122%) and specification of the changes to be introduced into loop, limiting production capacity, were the next stages of modernization process. A number of actions were undertaken by ANWIL SA based on the results of above mentioned works and their own observations, the realization of which was the condition for the increase of the production capacity. They included mainly:

- the application of selective NO_x reduction,
- the increase of turbine sets energy efficiency,
- the increase of NH_3-air relation,
- the modernization of condenser E2209[14)],
- the modernization of boiler system and whitening column D 2205[15)],
- the modernization of ammonia oxidation reactors by special catalytic baskets, modernization of feeding system and hydrogen and NH_3-air distribution[16)].

3.3 Results of plant modernization

The solutions applied concerning failure frequency of nitrous gases heater E2211 resulted in operation time prolonging of this apparatus. The amount of condensate introduced earlier with tail gases to the separator was significantly reduced due to separator built-up Fig. 5. The modernization of the other technologically important apparatus –condenser E2209 consisted of a different distribution of cooling water, its degassing system in the upper bottom of the sieve and different method of tube fixing in the sieve bottom. A significant reduction of condenser corrosivity is envisaged to be the result of this modernization.

The application of selective NO_x reduction and the modernization of boiler system and whitening column as well as the increase of NH_3-air relation allowed for an increased plant load due to decreased pressure in absorption loop and directing larger amount of air for ammonia oxidation process. Boiler system modernization consisted mainly of the use of circulation pump of a higher efficiency and the change of circulation tube system. During whitening column modernization hydraulics of liquids and gases flow was improved due to tray and weir modernization, which allowed for the 40% reduction of the air necessary for nitric acid whitening.

Fig. 5. Condensate separator from tail gases

After additional modernization of turbine set rotors (adjusted shapes of blades and the application of a different method of fixing blades to the rotor disks) the increase of the plant load up to 122% and even up to 125% temporarily became possible with a co-existent energy efficiency improvement. The results of modernization discussed here are presented on Fig. 6 and 7.

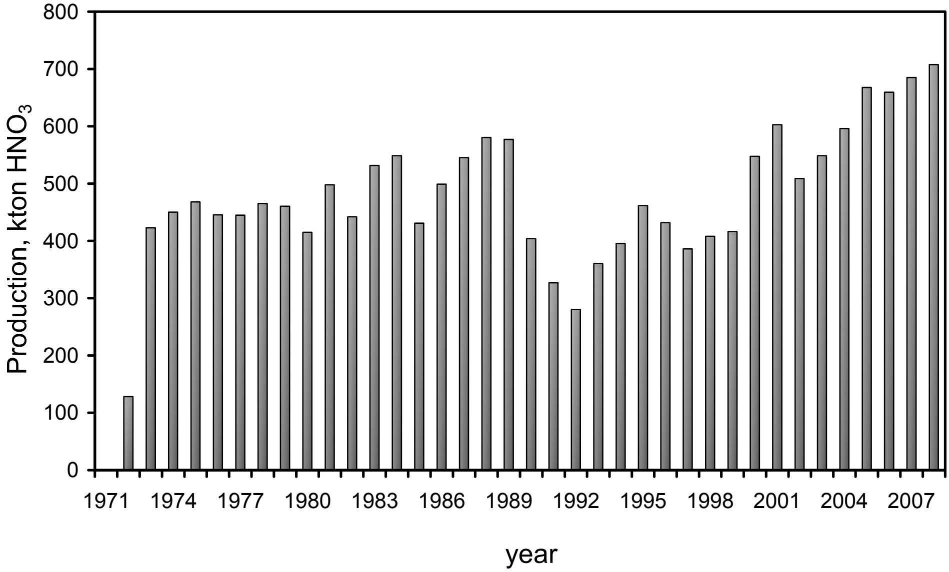

Fig. 6. Annual production of nitric acid in ANWIL SA

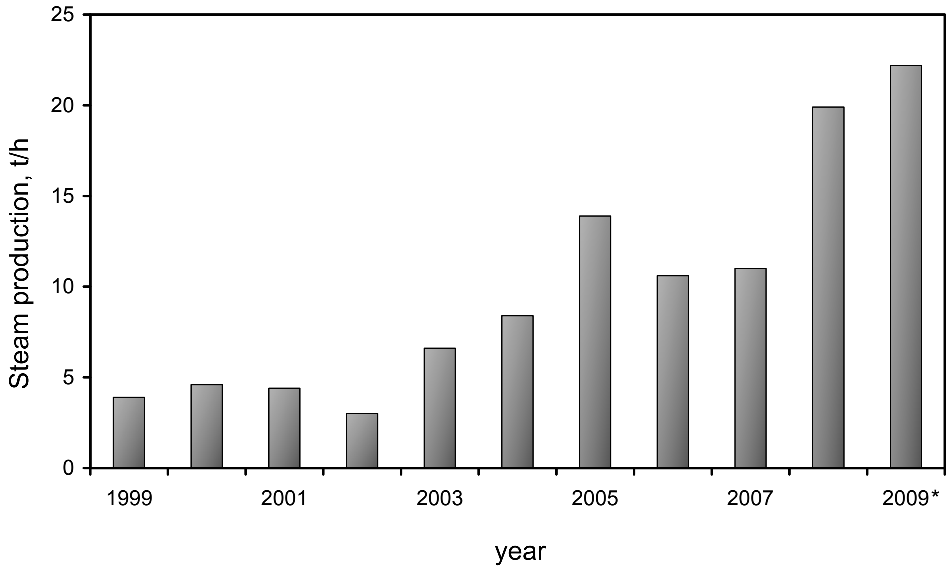

Fig. 7. Generation increase in steam carried away to the plant system

The modernization of ammonia oxidation reactors consisted mainly of built-up of special catalytic baskets, which were delivered by Johnson Matthey. This allowed for the installation of the catalyst for a high temperature nitrous oxide decomposition within JI project. The catalyst developed by Fertilizers Research Institute was applied in one of the plant trains. The modernization of NH_3-air and hydrogen distribution made the plant safer during start-up and protected catalytic gauzes (of PtRh-Pd alloy) against contamination and damage.

4. Summary

Nitric acid plants modernization performed by AZOTY Tarnów and ANWIL SA Włocławek increased stability and reliability of these plants and improved their energy efficiency. The possibility of significant intensification of production capacity and exploitation level was achieved. A nominal production capacity was increased up to 130% in AZOTY Tarnów and up to 125% in ANWIL SA.

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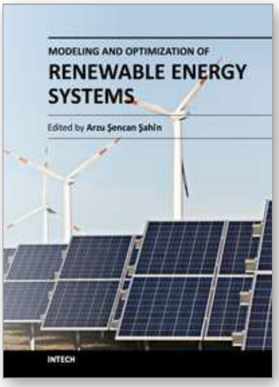

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This book includes solar energy, wind energy, hybrid systems, biofuels, energy management and efficiency, optimization of renewable energy systems and much more. Subsequently, the book presents the physical and technical principles of promising ways of utilizing renewable energies. The authors provide the important data and parameter sets for the major possibilities of renewable energies utilization which allow an economic and environmental assessment. Such an assessment enables us to judge the chances and limits of the multiple options utilizing renewable energy sources. It will provide useful insights in the modeling and optimization of different renewable systems. The primary target audience for the book includes students, researchers, and people working on renewable energy systems.

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