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Production of the catalyst and catching systems for ammonia conversion, according to the technology of Umicore AG&Co.KG company

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The platinum catalyst gauzes have been applied since the development of ammonia catalyst oxidation process for the obtaining of nitric and hydrocyanic acid. The catalyst gauzes are usually made of platinum or its alloys with rhodium and palladium. These precious metals have the peculiar properties, which makes it possible to use them as ideal catalysts for acceleration of the reaction of ammonia and oxygen. Such a catalyst is a key component in the production of a wide range of materials in the modern world. In 2008, Scientific and Industrial Complex "Supermetal", in collaboration with Umicore AG&Co.KG company, launched a joint high-tech line for the production of catalyst systems from platinum alloys, used for the ammonia oxidation in the production of weak nitric acid. The catalyst systems consist of the various types of several gauzes. These systems are made on the modern equipment, i.e. the flat-bed knitting machines. This makes it possible to vary the configuration of the catalyst and select an optimum composition of the system, which meets the customer's requirements. The Scientific and Industrial Complex "Supermetal" also produces and offers the modern catching systems, which makes it possible to find the best decision for each individual case, from the economic point of view.

Key words: catalyst systems, selectivity, MKSprecise^{TM}, catchment, irretrievable losses, precious metals, conversion level, ammonia consumption.

The nitric industry is one of the basic parts of chemical industry. It supplies various chemical production lines with raw materials and reagents. However, first of all, the nitric industry supplies the agricultural enterprises with mineral fertilizers. Therefore, the agricultural progress depends on the efficiency of nitric industry. The nitrogenous fertilizers account by 58% of the world consumption of fertilizers.

Scientific and Industrial Complex "Supermetal" (SIC "Supermetal") is a well-known Russian manufacturer of equipment for the fiber glass industry. It has a wide experience in and around the production and processing of the precious metals` alloys. In 2008, the enterprise launched the production of the catalyst systems, made of the platinum based alloys, used in the process of ammonia oxidation for the production of nitric acid. The production line was organized by SIC "Supermetal", in collaboration with Umicore AG&Co.KG company (Fig. 1).

The new production line is the result of a long-term cooperation of Umicore AG&Co.KG and SIC "Supermetal" under the motto: "Combining Competences for the Process Excellence". This project combined the knowledge and experience of the specialists from Umicore AG&Co.KG in and around the production and exploitation of the catalyst systems, and the experience of the specialists from SIC "Supermetal" in the processing of secondary raw materials of precious metals and the production of high-quality ingots of platinum alloys.

Nowadays, the production of catalyst and catching systems is mastered. According to this, there are produced the catalyst gauzes of Platinit® Type 3, Multinit® Type 6 and Type10, as well as the catching systems, based on the woven gauzes of Type 1, Type 1A, Type 2, and Type 3.

Materials and technologies, which are used in the catalysis of ammonia oxidation process

The usage of platinum alloy catalysts is the best for the selective ammonia oxidation to the production of nitric oxide.

During the selective process of ammonia oxidation to the nitrogen monoxide, the efficiency of the platinum alloy based catalyst is characterized by the selectivity, losses of precious metals, and the run time. Besides, the catalyst should ensure a sufficient time of the reagents contact for the maximum level of ammonia conversion into the nitrogen oxide NO (II) and the prevention of unreacted ammonia slippage, which may be the result of the formation of explosive ammonium nitrite and ammonium nitrate.

Fig. 1. The working area of the Industrial Catalysts Department

The temperature dissociation process of NO imposes the serious constraints on the geometrical characteristics in the designing process of the catalyst configuration. The formation selectivity of intermediate products (such as NO) reacts during the increasing of mass transfer extent of reagents and reaction products through the boundary layer, near the catalyst surface and the optimization of contact time.

Besides, the catalyst must keep its exploitation properties during the required time. Due to the high-temperature exploitation, the catalyst gauze material (Pt–Rh alloy), undergoes the process of restructuring. The volatile oxides are obtained on the surface of Pt–Rh alloy (PtO_2, mainly). According to this, the mechanical strength of the gauzes decreases, along with the measurement of the rhodium content on the surface and decreasing of the catalyst`s activity.

According to the losses of precious metals, there should be defined, that besides the significant influence on the selectivity, the gas distribution and contact time, the structure and configuration of catalyst are the extremely important essential factors in the process economy. Taking into account the initial working conditions, the resultant gradient of temperature distribution determines the level of losses of precious metals. The temperature gradient is a function of heat, formed on the different layers of gauzes in the catalyst pack, and a function of the heat conductivity level between those layers. In this connection, the recent achievements in the oxidation of NH_3 are connected with the catalyst embodiment (in particular – the configuration of catalyst gauzes).

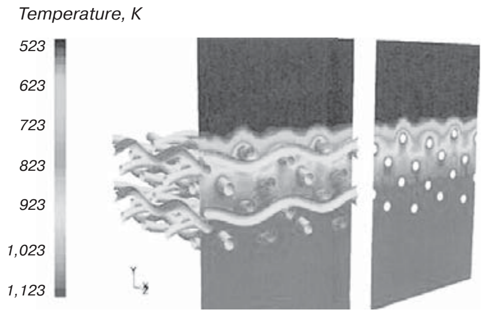

Fig. 2. The distribution of temperature in the 4-layer pack of woven gauzes

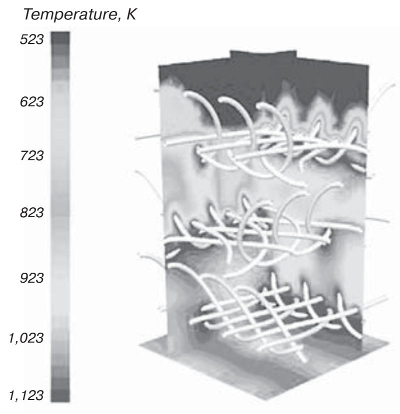

Fig. 3. The distribution of temperature in the 3-layer pack of the PLATINIT® catalyst gauzes

The woven gauzes

The woven gauzes with the specified dimensions of wire and specific weight ensure the lowest porosity among all catalyst gauzes. The most part of ammonia oxidation process to NO (II) takes place on upper gauzes, where the concentrations of O_2 and NH_3 are high (Fig. 2). During the run time, the upper gauzes activity decreases gradually; therefore, the zone of the basic reaction moves down to the next layers of gauzes. Frequently, for the purpose of the maintenance of the high yield of finished product, more gauzes are installed in the catalyst pack, than it is necessary for a high conversion level at the initial exploitation period. The disadvantage of such usage consists of the increased number of gauzes and, therefore, the increased loss of precious metals.

Unlike the traditional mass production of standard gauzes, the new technology makes it possible to fabricate each gauze individually in any required modification (knitting type, gauze/wire diameter, density and alloy composition). As a result, if necessary, placing of the catalyst pack for a certain burner can be easily and quickly changed.

The SIC "Supermetal" offers a unique complex of Platinit® and Multinit® type gauzes. These gauzes make possible the quick adaptation to any required modification.

Due to the MKSprecise™ system, Umicore AG&Co.KG has a unique capability to deliver the modern catalyst systems with a special and precisely selected composition. This capability makes it possible to reduce the total costs by the minimizing of real losses of platinum, significantly decreasing of the ammonia consumption, improvement of the conversion level, extending the service life and run of gauzes, and optimization of the financial investments in the platinum group metals.

The knitted gauzes

The PLATINIT® gauzes have a structure with more open cells. The porosity of these gauzes is three times higher than the porosity of the woven gauzes. Due to the 3D geometry, these gauzes have the advantages before the woven gauzes, such as an increased run time and a lower amount of losses of precious metals, with a similar yield level of NO.

The PLATINIT® gauzes have a more open structure. However, their specific weight is similar to the specific weight of woven gauzes. The higher porosity of the pack of PLATINIT® gauzes ensures a more uniform temperature profile in the catalyst (Fig. 3). A better distribution of heat makes it possible to reduce the metal loss, especially in the upper layers, and, hence, to extend the run time and improve the selectivity.

The pack of woven gauzes usually consists of a large number of gauzes, placed in order to compensate a gradual deactivation of the upper layers. But this is not typical for the PLATINIT® gauzes, because the amount of real loss of precious metals is less in this case, and the activity of catalyst is prolonged.

A unique 3D spatial structure of the MULTINIT® catalyst gauzes has two dense layers with a distance between them. The layers are joined by means of so-called "binding" threads (Fig. 4).

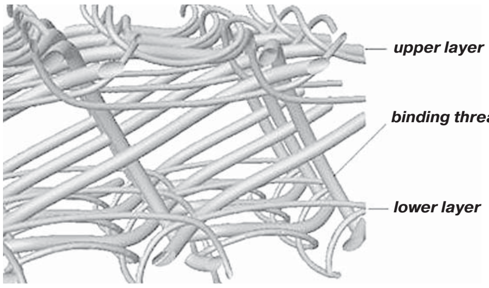

Fig. 4. The graphical structure of MULTINIT® catalyst gauze

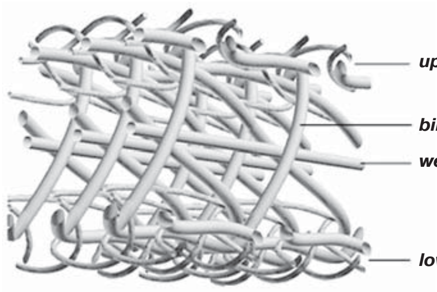

Fig. 5. The graphical structure of MULTINIT® Type 10 catalyst gauze

Due to a low porosity of upper and lower layers, a higher reaction rate is reached in comparison with the traditional knitted gauzes. At the same time, a low thermal conductivity between the layers prevents a sharp temperature jump in the catalyst cross-section. Hereupon, the MULTINIT® catalyst gauzes are characterized by a high conversion coefficient, high selectivity, and low loss of precious metals.

The flat-bed knitting technology, used in the production of the PLATINIT® and MULTINIT® knitted catalyst gauzes, makes it possible to reduce essentially the amount of recirculated metal, production time, and resources of labor and energy.

The type, quantity and configuration of gauzes in a catalyst bundle have a great influence on the conversion efficiency, amount of loss of the precious metals, and the level of N_2O formation. The operation of the catalyst and optimum usage of precious metals can be improved by the designing of catalyst, which meets particular service conditions of an individual installation. It is necessary to take into account the characteristics of each gauze in the pack. A certain combination of different types of the PLATINIT® and MULTINIT® gauzes in the MKSprecise™ modular catalyst system makes it possible to obtain a homogeneous distribution of the gas flow and temperature, and to obtain a uniform reaction zone on the catalyst.

A high cost of the precious metals and serious restrictions, related to the emission of N_2O in the nitric acid production, set certain economic and ecological requirements for the catalyst gauzes on the basis of platinum alloys. The traditional catalysts, which are nowadays used in the industry, do not meet such requirements.

The basic characteristics of an improved catalyst gauze are the reduced amount of the precious metals, an increased selectivity of NH_3–NO conversion, and a certain reduction of N_2O emission. The new MULTINIT® Type 10 catalyst gauze meets the foregoing requirements.

Fig. 6. The production process of woven gauze, Type 3

The advantages of the new MULTINIT® Type 10 gauze consist of a combination of high woven gauzes activity and low loss of precious metals in the knitted gauzes. Unlike the traditional MULTINIT® structure, there are the “weft” threads in the center area of the gauze, forming the third, dense and highly active layer (Fig. 5).

Thereby, there is obtained the combination of improved efficiency of the catalyst and reduced loss of precious metals, which means a significant extension of the run time and reduction of the amount of precious metals.

The catchment system

More and more attention has been recently given to the decreasing of irrevocable losses of platinum and rhodium. It is connected with the high prices of precious metals, in comparison with palladium. Nowadays, Umicore AG&Co.KG and SIC “Supermetal” offer a modern catchment technology, successfully used in various production lines all over the world. The interconnection between the catchment extent and the position of gauze in the pack and service conditions are taken into account in the technology, which allows to choose the best solution for each case from the economic point of view. The catchment mechanism is based on the continuous regeneration process of the surface and, owing to this, allows to catch up to 85% of primary loss of platinum. The catchment systems consist of various configurations of woven gauzes, fabricated by rapier-type wire-cloth looms (Fig. 6).

This allows to hold the quick production of any configuration of catchment systems. The knitted catchment gauzes are now developed and tested. This makes it possible to reduce significantly the amount of metal, which is necessary for the manufacturing of catchment systems; run the process continuously; improve the catchment efficiency of platinum and rhodium; shorten the idle time of ammonia-oxidation reactors; and reduce the cost of repair.

Conclusion

The usage of high engineering and production technologies of catalyst systems makes it possible to improve the selectivity of ammonia-oxidation process; to extend the run time of the systems and to reduce the amount of the recirculated metal, which is necessary for the manufacturing of catalysts. At the same time, the usage of the offered catchment technology allows to reduce essentially the irrevocable losses of precious metals. NFM