



A Novel Multifunctional Product Family of Umicore's MKS Concept: Beyond a Mere Solution for N₂O Abatement

by

Dr. Sven Jantzen & Dr. Jürgen Neumann

Umicore AG & Co. KG

Hanau, Germany

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1. Introduction

The steadily increasing economic and ecological demands towards today's ammonia conversion processes do substantially trigger the necessity for more sophisticated products, better conceptual solutions and more comprehensive considerations than ever before. Not only the rising costs of raw materials, the increasing prices for precious metals and the strong demand from the financial markets, but also the more and more stringent environmental and safety considerations substantially determine the role of all participants in this business. Finally, the competitive pressure in these segments due to a globalised market generates further necessities to develop innovative and new approaches. Hence the producers of catalyst products for the Ostwald process need to distinctly change their mindsets and are forced to refocus their activities from former (raw) materials suppliers towards system providers today.

This development is perfectly in line with Umicore's overall corporate strategy. Looking back on a long history once rooted in the mining & refining of non ferrous metals the company has gone through major changes and has evolved to a provider of systems, advanced materials and technology products and services today. The Platinum Engineered Materials division of Umicore has developed a unique system that is meanwhile well established and appreciated in the nitric acid and related markets.

This paper will highlight new product modules of this system and will furthermore explain about service modules that are indispensable in order to comply with the true requirements of today's players operating installations to oxidise ammonia.

2. MKS Modulares Katalysator System™

Depending on the various – and partially very specific – requirements, sophisticated system solutions need to be designed by making use of a wide range of modules: products, technologies, engineering, and services along with a sophisticated philosophy and executed by a competent team of people.

Umicore started already long time ago to consider an engineering approach towards this topic rather than an isolated view on catalyst gauzes. Consequently the focus was steadily directed on the complexity and interactivity of the various process aspects and hence lead to the modular system concept that supports our commitment:

“Combining Competences for Process Excellence in ammonia conversion”

To strive for Process Excellence means to provide the best possible process performance to our clients ! We have learned during the numerous years in this business that only with joint forces the desired results can be achieved: by combining our various competence factors with those of our partners and clients we will achieve efficient and successful results. Consequently we are a system provider with a remarkable number of tools to comply with these requirements, not simply a supplier of gauzes. The task is ac-



tually to manage complexity instead of focussing on isolated aspects of the value chain. Closing the loop in this business is of utmost importance – and actually we are talking about two loops: the materials loop spanning everything from metals over products till refining, and the experience loop, that enables a successful co-operation.

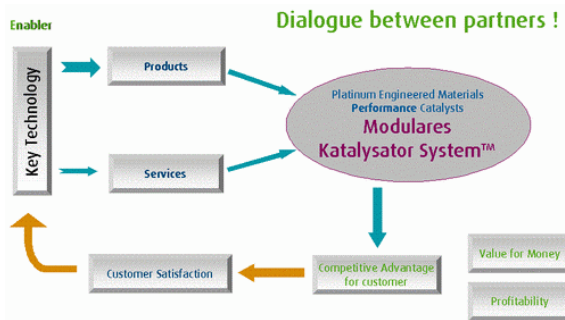


Figure 1: Experience Loop

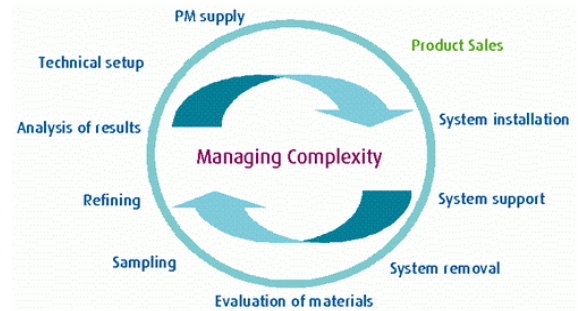


Figure 2: Materials Loop

What is now unique about MKS ?

We think it all starts with the right software - and hence in our heads ! Famous scientist Max Planck once stated: *"If you never challenge what's established within your discipline, you will never ever be able to bring a substantial contribution to your field of science. From time to time one needs to think in an upside down manner"*.

Advanced and innovative products and technologies need to be based on an advanced mindset. And the complex nature of this business makes it even more fascinating – and generates the necessity to challenge orthodoxies. So in terms of soft skills, the philosophy is the starting point and the prerequisite for an excellent business approach. So let's now address to the hardware:

At first, our most striking and unique capability is our **Engineering**: no other gauze producer in the marketplace can offer something comparable. We can go far beyond technical support and provide solutions based on real process engineering - like manufacturers of operations do.

Secondly, our Flat-bed Knitting **Technology** is unique in the marketplace: it allows individual manufacturing of tailor-made catalyst gauze structures in essentially any desired modification in contrast to conventional mass production of standard gauzes. Thus we can meet any set of operating parameters in ammonia oxidation processes.

Last but not least, our new **Multifunctional Ceramic Modules** perfectly round off our package, being it for improving the gas flow behaviour, or to selectively decompose nitrous oxide in order to reduce emissions and to participate in today's global emission trading.

Conclusively, this tremendous portfolio of possibilities, combining excellent products and sophisticated services based on an advanced way of thinking, forms our main asset: **Technology Leadership !**



In the following section we will emphasize and further elaborate on the highlighted modules:

2.1 Engineering

According to our definition this means to fine-tune and/or to modify the process conditions in a given reactor to reach the maximum performance. The catalyst gauzes alone will never be able to achieve the best possible results, only by providing the perfect environment for them they will be able to do their job in the way it is desired.

2.1.1 Process Simulations & Gas Flow Control: Making the reaction visible

By means of computational fluid dynamics (CFD) Umicore has developed a wide range of model calculations for any type of burner and pressure setup and can nowadays quite easily simulate even difficult and highly complex burner setups including filter systems, distribution plates and other specific features of the burner design. This way we can detect weak points of the process and develop strategies and perspectives to tackle these problems together with our customers. It is even possible to determine the temperature distribution and hence the activity within defined layers of the gauze pack which offers further important information on the process characteristics.

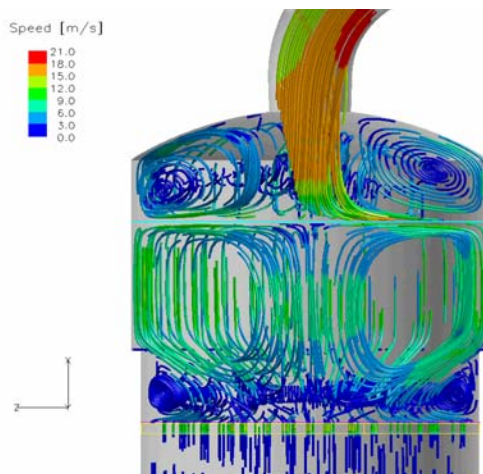


Figure 3: Gas Flow Distribution

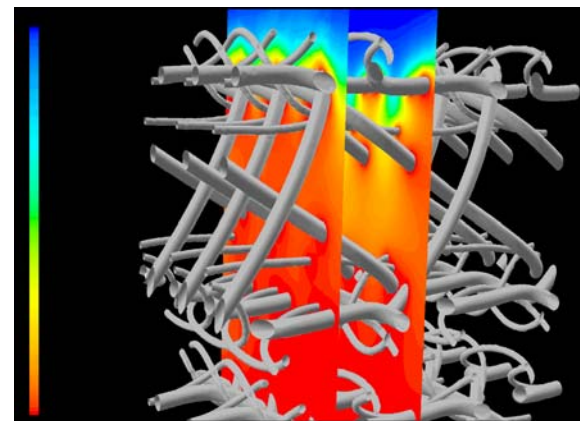


Figure 4: Temperature Distribution within Catalyst Gauze

These unique process simulations are operated by sophisticated model calculations with specialised programs that are based on theoretical parameters (like selected thermodynamic and physico-chemical parameters) as well as practical results obtained in more than 60 different operations. Furthermore the calculations are taking into account both, the convective and the diffusive gas velocity.



2.1.2 Reactor Design Modifications: Fine-tuning of Design & Geometry

According to the findings analysed by our simulation tools we can offer different engineering elements to comply with the specific issue, like calculation of distribution plates, defined and targeted pressure control above and below the catalyst system, or the installation of our ceramic systems. Furthermore, installation of other tools to optimise the gas flow behaviour can be offered.

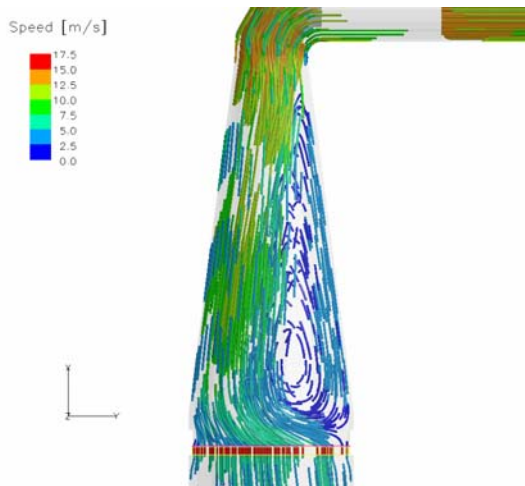


Figure 5: Original Gas Flow in HP Process

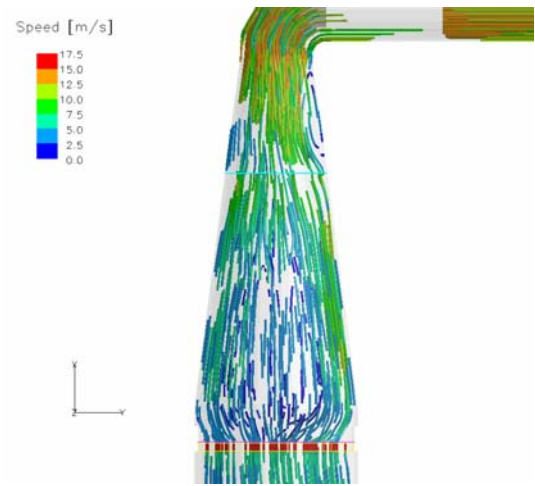


Figure 6: Gas Flow after Design Modification

2.2 Key Enabling Technologies

Next to the Engineering capabilities our various enabling technologies are key to a successful product portfolio. Here we want to illustrate the following:

2.2.1 Flat-bed Knitting Technology

In contrast to conventional mass production of standard gauzes this technology allows us to manufacture each gauze individually in any desired modification (knitting type, diameter of gauzes and wire, density, alloy). Hence a catalyst pack that is calculated for a specific burner can be manufactured within very short time, and can easily be modified as well. This flexibility is unique in the market.

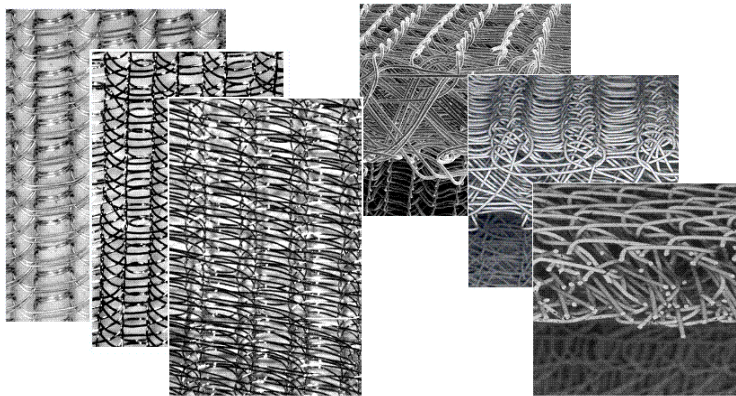


Figure 7: Portfolio of Platinit and Multinit Gauze Types resulting from the Knitting Technology

2.2.2 Catalyst Technology

In more than 6 years of intensive research on kinetics and chemical reactions on the catalyst surface the most crucial aspects for the catalyst technology – alloying, wire drawing, surface formation – could be optimised:

- Influence of alloy types and compositions on the mechanism of primary and secondary reactions during ammonia conversion (adsorption, chemisorption, desorption processes and nature of fragments on the wire surface)
- Formation of surface structure and impacts on the catalyst performance
- Nitrous oxide formation mechanism and preventive countermeasures

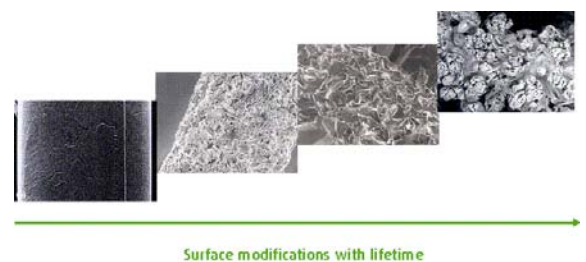
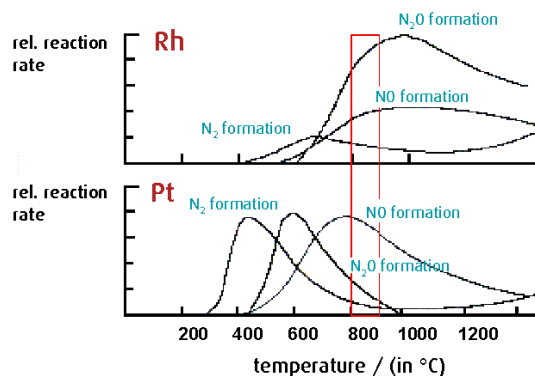


Figure 8: Selectivity Dependence of Alloy Type Figure 9: Ageing Effects with Campaign Length



2.2.3 Getter Technology

Minimizing net losses of Platinum and Rhodium has recently gained increased attention regarding the tremendous costs of Platinum and Rhodium compared to the price of Palladium. Here we offer a highly sophisticated catchment technology that was originally developed by Umicore and has meanwhile been steadily fine-tuned. The technology reflects the strong correlation between recovery rate, gauze position and operating conditions and allows to identify the best economic solution for each individual case. The getter function itself is based on the continuous mechanism of surface regeneration and hence allows to recover up to 85% of each getter gauze weight of the Platinum primary losses. This way we can easily adjust the desired overall process recovery rate.

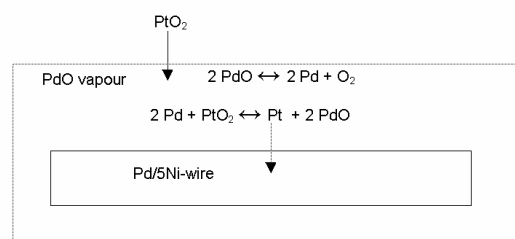
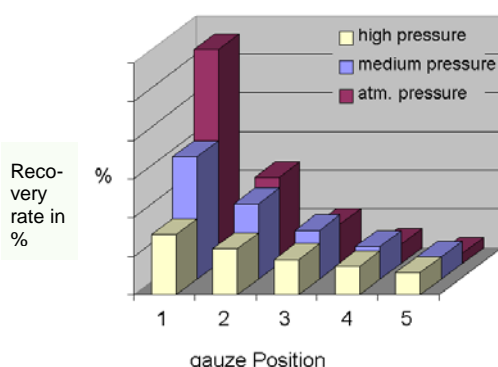


Figure 10: Gauze Position and Recovery Rate Figure 11: Surface Reactions

2.3 Ceramic Honeycombs

Our latest product innovation was certainly also triggered by the strong demand for N₂O emission control, but should not be seen as a solution to this issue only. Our new multifunctional ceramic product family can serve the purpose to selectively decompose N₂O. Depending on the process characteristics it can also work on aspects of gas flow behaviour as a non-catalytically active product line.

2.3.1 MultiComb Green Line

The reduction of N₂O emissions in the nitric acid industries will considerably contribute to comply with the targets of the Kyoto Protocol. Umicore – as one of the world’s largest manufacturers of automotive catalysts – has developed a tailor-made catalyst technology for the ammonia oxidation process by taking advantage of this internal synergy. This new non-precious metals based honeycomb system assures the selective decomposition of N₂O pollutants into environmentally harmless gases. It is located within the high temperature zone directly below the Platinum based catalyst gauzes. Reduction rates depend on the process characteristics and amount up to 90% of the emissions under comparable conditions without nitrous oxide catalyst.

This concept of honeycomb catalysts for N₂O abatement with well defined structures and geometries is expressed in the **MultiComb Green Line** and reveals a comprehensive consideration of all relevant process requirements: design, operating conditions, individual technology.



Figure 12: Green Line at Work

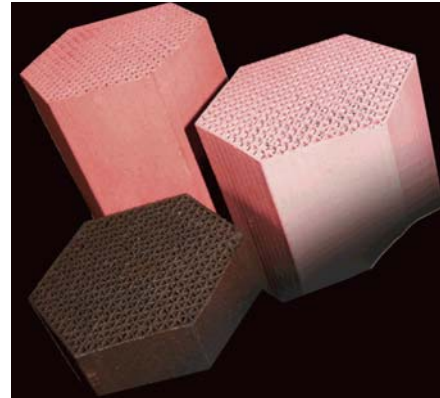


Figure 13: MultiComb Green Line

2.3.2 MultiComb Dynamic Line

A uniform impingement of the process gas on the precious metals gauze assembly strongly supports an improved product selectivity, reduced precious metals losses and an increased lifetime of the catalyst. Despite usage of guide plates in the pipe bend cross sections or perforated plates in the cylindrical transition section of the burner hood, the process gas shows a tendency to formation of turbulences in the delay zone below the perforated plate. This non-uniform flow distribution considerably limits the economy of the process.

The moulded ceramic honeycombs of the **MultiComb Dynamic Line** do generate a well defined pressure drop below the gauze pack in order to ensure a uniform adjustment and control of the gas flow distribution and thus generatig a very homogeneous and excellent process.



Figure 14: Dynamic Line at Work



Figure 15: MultiComb Dynamic Line

The MultiComb Dynamic Line has already achieved substantial successes in a number of industrial runs with savings in PGM inventory of up to 20% installation weight, increased campaign lengths of up to 20%, and lower ammonia consumption of 1-2%.

Both product lines, MultiComb Dynamic Line and Green Line are available in various shapes and geometries as well as in different porosities. They can easily be installed,



possess a very high thermo shock resistance (usage at least for 2 campaigns), are totally inert towards the process itself and are completely based on materials that are not containing any precious metals. Hence this product family – which is suitable for any kind of reactor – is a highly flexible system, just like all the other members of the MKS family.

Conclusively, there are many different possible definitions of MKS. Making use of this potent toolbox will provide substantial benefits:

- The competent combination of excellent products & sophisticated services along with a strong engineering focus
- The maximum flexibility due to our modular approach & our special knitting technology
- The long lasting experience in catalyst applications due to internal synergies with other divisions like Automotive Catalysts
- Unique solutions due to our maximum adaptability (no standard offers - unless desired)
- Proximity to our partners due to reliable cooperations & local presence
- High degree of transparence due to high level of explanations (no black box offers)
- The solid financial background of a well recognized and strong global player

This comprehensive approach generates a competitive advantage for our customers (value for money) and can hence provide the degree of satisfaction that they deserve. Sustainability in this sense will then lead to savings in

- Energy
- Materials
- Emissions
- Any other resource that is precious (Time, Labour, Efforts)

Furthermore, it generates key process characteristics like

- Stability
- Safety
- Efficiency