A formaldehyde magazine from Johnson Matthey Formox

Informally Speaking

Winter / spring 2016

MEG

5 Safety principles

New plant FC1

Conferences

The FORMOX process - part 2

A different kind of year, and a better one to come

2015 was a somewhat different year. Global growth was revised downwards and fell short of OECD estimates, mainly due to slowing markets like China. Crude oil fell constantly, reaching its lowest price in more than ten years. Overcapacity and shrinking margins troubled the chemical industries, etc.

Regional formaldehyde demand, however, indicates the trend may slowly be turning. This is particularly true in North America, driven by the housing market, but also in China and Europe. In Russia we see major investments in panel manufacturing capacities, plus increased demand for formaldehyde.

This past year I had the pleasure of meeting with many customers. Despite lower demand and even recession, most expressed a very bright view of the formaldehyde market and foresee growing demand, which I certainly agree with. Globally, demand for formaldehyde (37%) could grow as much as 5 % in 2016, reaching 2.3 – 2.8 million tons annually. This should indeed improve utilization and require new capacity.

2015 was slightly different for us as well. Besides a major reorganization within Johnson Matthey's Process Technology Division, to which JM Formox belongs, we are now more fully integrated, enabling stronger synergies within R&D, production, sales, etc. With more resources, we finally launched our new FC1 plant optimized for small to middle size demand (p 4). And on the catalyst side, our CAP 3.0 concept with KH-CAP 3.0 INI CAT offering higher productivity or longer lifetime (p.12-13) has gained more satisfied customers during 2015.
With 2016 already underway, I want to wish you all a prosperous new year. And please remember to book your spot at the JM Formox Formaldehyde Asia conference in April.

Lars-Olle Andersson
Commercial Manager
Johnson Matthey Formox AB

Content

Editor: Anna Rundblad
Contributing writer: Charles Hodgdon
Publisher: Mårten Olausson
Layout: AM-tryck & Reklam, Hässleholm, Sweden
Printing: AM-tryck & Reklam, Hässleholm, Sweden
Publication: 2 times per year
Cover image: Jonas Schrewelius

Achieving safety aspirations

Everyone agrees that ensuring excellent environmental performance of our business, as well as the health and safety of our people, is important. This is why Johnson Matthey is committed to achieving our safety aspirations. Improvements have been made, yet there is still more we can do. To make our aspirations a reality, we work continuously to provide safer plants and processes. Excellent performance also depends on our people demonstrating behaviors that make our systems work in practice and promote a strong safety culture.

What is "Safety culture"?

Simply put, Safety culture is "the way we do things around here". It is often described as assumptions, values, attitudes and behaviors relating to safety, which are shared by a group of people in an organization. Industrial incidents are often associated with failures in the Safety culture. It is now accepted that a positive Safety culture is vital in order to achieve excellent safety performance. Our efforts to improve Safety culture focus on behaviors, because we can define, observe and measure them. We also have the right tools and methods to understand behavior and reinforce the behaviors we know foster a strong Safety culture.

5 Safety principles

As a part of Johnson Matthey's Safety culture focus, we have recently launched five safety principles to help our employees make health and safety their priority.
Our plants are designed to be safe and our Operating Manuals are made to ensure a safe operation. Johnson Matthey employees are urged to apply our Safety principles also when working on other companies' sites. If you have questions or would like more information about safety and Safety culture, we are very keen to help you.

Source: Johnson Matthey EHS Behaviour Standards and Johnson Matthey Safety principles

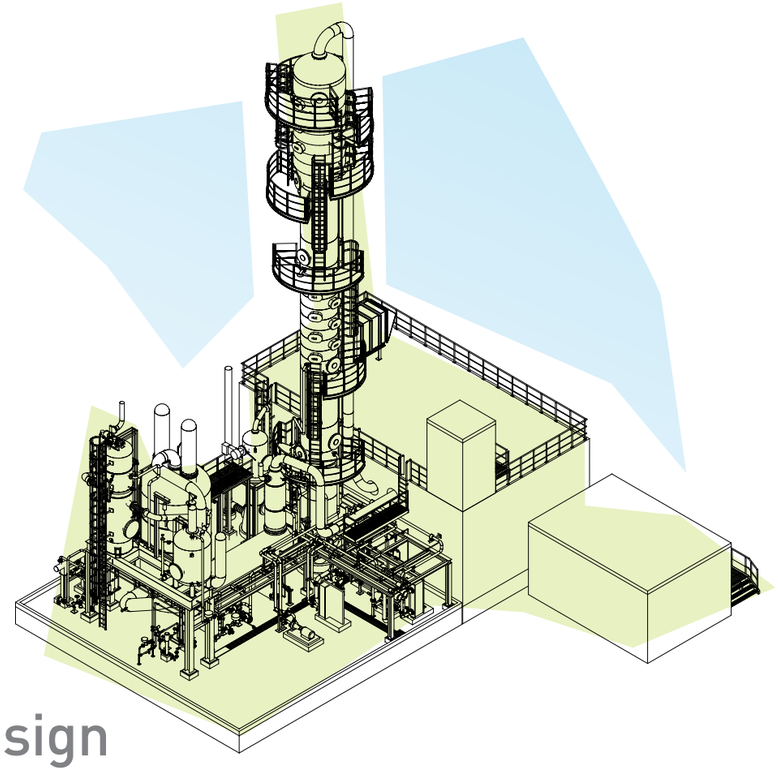
BY

Anna Rundblad,
Communications Executive,
Johnson Matthey Formox AB

Our 5 Safety principles

1. **All injuries and occupational illnesses are preventable**
   We believe all injuries and occupational illnesses are preventable. No one should get hurt or become ill from doing their job.
2. **We are all responsible for preventing injuries and occupational illnesses**
   All of us have a role to speak out about any unsafe practices without delay. If anyone sees a colleague doing something which does not follow our safety principles, we tell them and get help.
3. **Working safely is a condition of employment**
   Johnson Matthey takes a zero tolerance approach to unsafe work practices: if anyone acts in a way that ignores safety the company will take action. In some serious cases this could lead to dismissal.
4. **Lifesaving Policies and Site Safety Rules must be followed**
   Our Lifesaving Polices cover operations such as working at heights and guarding dangerous equipment. All employees must follow these policies as well as any site-specific safety rules.
5. **Johnson Matthey will promote off-the-job health and safety awareness for its employee**
   Being healthy and keeping safe is just as important at home as it is at work. That's why we at Johnson Matthey are committed to raising awareness of everyday health and safety outside of work too.

Over the last few years Johnson Matthey Formox has focused on a new plant design in order to meet requirements of specific markets. The focus has been on small to medium size capacity demand, which we have found has specific requirements and where a highly standardized product would fit. The result is the new and innovative **FC1** design.



FC1

A new plant design for small to medium capacity needs

We challenged the standard range design to see what could be improved with real benefits to the design. Some specific items have been redesigned and in the future these can also be applied within all our plant sizes. Engineers from all disciplines have been involved and external experts have also participated in the project. Other considerations have been the price of components and cost of installation, where access to equipment has been optimized to fit the purpose. The **FC1** is pre-designed for reasons of both cost and delivery time, and design options are limited. The amount of steam produced can, however, be varied, and UFC capability can also be chosen.

The **FC1** is a **FORMOX™** plant and much can be recognized from other plant sizes. Based on the standard **FORMOX** plant range, the innovative **FC1** design secures many of the same characteristics: safety, reliability, and proven equipment design.
We are confident that this product will be a new benchmark in the industry. There is clearly an interest for the **FC1** plant.

The oxide technology not only gives a lower operating cost, but also provides a very consistent product throughout the catalyst lifetime.

Consistency is a key parameter in resin and board making, and when managed throughout the production chain, it results in stable product quality and improved efficiency also at the board plant. This, together with superior operating cost and affordable installation, makes FC1 a design that will add value to the industry.

One market that we have targeted with the **FC1** is the Chinese resin and board industry, and during the last year we have been working with increased communication.

"We have experienced a growing interest from formaldehyde producers over the last year," says Huamin Zhang, Sales Manager at JM Formox Beijing. "The market is changing and we see larger producers taking a bigger market share. Also, the increasing demand on environmental issues is slowly changing the industry," Huamin continues. "The new design is exciting and I think it will be really popular in the business. It would be quite an achievement if we also could introduce UFC technology in China."

*Note: All **FC1** plants can be fitted to produce UFC (Urea Formaldehyde Concentrate) directly in the absorber tower. UFC goes mainly into two applications – coating of urea prills, and UF resins.*

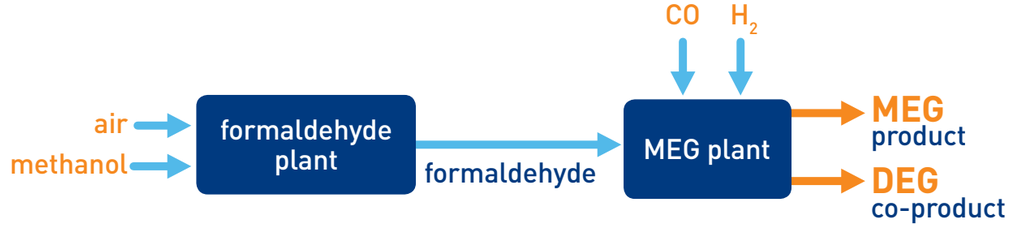
BY

Fredrik Rietz,
Global Market Manager Plants,
Johnson Matthey Formox AB

MEG

from formaldehyde

Now it is possible for formaldehyde producers to diversify their product portfolio and participate in fast growing market of Mono Ethylene Glycol (MEG).



MEG is the most common industrial diol which is used in manufacture of polyester fibre, fabrics and polyethylene terephthalate (PET) resin used for production of plastic bottles. Other industrial uses are as a coolant, heat transfer agent, antifreeze and a hydrate inhibitor in gas pipelines. Current worldwide consumption of MEG is approximately 26 million tonnes/year and has grown by over 5% per year over the last decade.

New process technology using proprietary catalyst developed by Johnson Matthey Davy Technologies (JM Davy) and Eastman enables the production of MEG from formaldehyde. This offers a unique and exciting opportunity for formaldehyde producers who are interested in diversifying their product slate.

A simplified block diagram of the novel process is shown above. The key feedstocks are formaldehyde, carbon monoxide and hydrogen and besides MEG, the process produces a small amount of valuable Diethylene Glycol (DEG).

This new technology has been developed in JM Davy's Technology Centre and demonstrated in mini-plants which are designed, constructed and operated by highly skilled and experienced professionals. Comprehensive data collection from long term operation of the mini-plants has enabled us to develop the design for commercial scale plants with MEG production capacity ranging from 200,000 to 500,000 tonnes/year.

This new technology is now available for licence. For further details please contact atul.shah-davy@matthey.com.

BY

Atul Shah,
Licensing Development Director,
Johnson Matthey Process Technologies, Chemicals

On frontpage:
Sponsoring the fight against childhood cancer

Team Rynkeby's cycling trip to Paris is all about raising money for children with cancer and their families. The money they raise comes from a variety of sources, including generous sponsors.

In 2015 no less than 5,500 sponsors donated cash or provisions to the project. Team Rynkeby donated more than € 6.45 million to the fight against childhood cancer in Denmark, Sweden, Finland, Norway and the Faroe Islands. We are proud to say that Johnson Matthey Formox is now one of Team Rynkeby's Gold sponsors, and also have employees participating in this great cycling team. The team from last summer's cycling from Sweden to Paris, France is featured on the front cover .

Photo: Jonas Schrewelius

Our conferences bring you valuable information about the market, potential growth in the industry and HSE-related topics. When attending these conferences you also receive a printed booklet containing all presentations along with information about each speaker. Our next conference will be Formaldehyde Asia 2016 in Bali, Indonesia, April 4–7.

Formaldehyde South America 2015

The Formaldehyde South America 2015 conference took place at the beautiful coastal town of Guaruja outside São Paulo, Brazil during two nice days at the end of September. Customers from all over South America were invited and we had the pleasure of meeting about 30 of you, mostly from Brazil and Argentina, but also from Venezuela and Ecuador. It was a perfect opportunity for all our customers in the region to network and to meet informally with colleagues from the industry as well as with representatives of JM Formox, and also, of course, to be updated with valuable information concerning the market, potential growth in the industry, HSE-related topics and the latest R&D news.

Atul Shah, Regional Sales Manager, welcomed us all and Lars-Olle Andersson, Commercial Manager, gave a market update to get the conference started. Nadir Chagas, Executive Secretary at ABRAF (Brazilian Association of Formaldehyde and Derivatives Producers), which works with responsible use of the product throughout the entire chain, held a presentation about the use of formaldehyde in Brazil, regulations and ABRAF's activities. As Senior Plant Process Specialist and a representative of JM Formox's R&D department, Ola Erlandsson illustrated the latest improvements in the areas of plant development, formaldehyde yield, our new plant range and the interesting CAN-concept.

Safety is one of the most important topics for us. Lars Andersson, Regional Technical Support Manager, outlined "Safety concept by JM Formox" and the 5-layer safety philosophy, both of which were much appreciated (see article p. 14, Informally Speaking Spring/summer 2014). He also spoke about the advantages our Technical Support brings. Guillermo Rizzatti, Plant Manager at Arauco Argentina Chemical Plant, shared a real life case with us: "Vaporizer incident - accumulation and fire of paraformaldehyde". The conclusion of this presentation and the discussion that followed was this instruction: "Always keep the temperature high enough to avoid para formation, and always clean the evaporator at every longer shutdown."

Also on the topic of safety, Anna Wemby-Björk, Manager Process Engineers, talked about another incident involving burning vaporizer pall rings. She outlined the chain of events that led to the incident and made recommendations on how to avoid this. Our Global Market Manager Catalysts, Ronnie Ljungbäck, explained the advantages of JM Formox's high-performance catalysts, loading service and CAP-technology, and he also gave an update on the CAP 3.0 system (read more about this on p. 12-13).

BY

Anna Rundblad,
Communications Executive,
Johnson Matthey Formox AB

Words from participants

- I think it is a good arrangement, the presentation topics are OK with clear explanations, says Nestor Rodriguez, Georgia-Pacific.

- We appreciate to share good experience about safety and Ola's new concept about CAN was interesting, says Everton Giacometti, Duratex S.A.

- Excellent! It's good to meet outside the office, says Alberto Apor, Royal Quimica LTDA.

- Good to learn and discuss with other plant owners says Ellon Siqueira, GPC Quimica S/A

- Very good to share your different levels of security, that was very interesting, says Celio Correa, SI Group Crios Resinas.

- Good organized with clear messages, says Marcelo Neri from Johnson Matthey ECT in Brazil.

Formaldehyde China 2015

The Formaldehyde China Conference 2015, organized by Johnson Matthey Formox, was held at the Xixi Hotel, Hangzhou, China in October. The conference included a comprehensive analysis and interpretation of the latest developments in the domestic market regarding formaldehyde and methanol, as well as the industry's latest development trend. It also featured a comprehensive exhibition and technical exchange highlighting the latest advancements in oxide formaldehyde technology and catalysts.

Attendees of the conference were able to learn about innovative R & D achievements by Johnson Matthey Formox in the field of formaldehyde process and catalyst. Topics covered during the event included the Global outlook for the formaldehyde market, Plant range update, Plant development and optimization, Catalyst development and CAP 3.0, Technical support as well as Correct and safe operation. In addition, representatives of Johnson Matthey Davy delivered a presentation on Formaldehyde to MEG, and representatives of Johnson Matthey Syngas held a presentation on the Methanol process and quality. We also had some external speakers who spoke about methanol, DMMn, Therminol and more. Finally, a special ceremony was held to celebrate the 20th anniversary of the cooperation between Johnson Matthey Formox and the Yuntianhua group. (see page 23)

During the gathering, we asked some of the participants about their opinion of the conference and if they had any suggestions for us.
Mr. Deng from Yunnan Yunwei said, "My purpose of attending the conference is to know the new market and the development of the **FORMOX** technology and catalyst, and how to improve the plant performance. The conference is well organized and prepared very well; we thank Johnson Matthey Formox for the hospitality. The presentations are very useful, including much information from every aspect."

Mr. Zhang from CQCF said, "The reason I participate at the conference is that I want to learn about the new development of technology and to communicate with Johnson Matthey Formox and also with other clients, and learn some experience from them. The conference is very professional, and the technical training is useful too."

Mr. Liu from Shaanxi BDO said, "My purpose of attending the conference is to know how to optimize the FA plant to reduce the operating cost. The conference is well organized and prepared very well and lots of people from other projects; it gives us a very good chance to communicate with each other and learn." A number of other customers offered additional feedback and suggestions for future conferences.

Johnson Matthey Formox's Formaldehyde China conference is held every two years. The previous one took place in Beijing in May 2013.

BY

Carlos Du,
Process Engineer,
Johnson Matthey Formox
Beijing, China

Huamin Zhang,
Sales Manager Plants,
Johnson Matthey Formox
Beijing, China

Grace Gu,
Office & Marketing Manager,
Johnson Matthey Formox
Beijing, China

Formaldehyde Iran 2015

After the "Joint Plan of Action" agreement was signed between Iran and 5+1 world powers on July 14, 2015, sanctions against the country were lifted on January 16, 2016. This will lead to a promising outlook for Iran's industrial growth in general, and for the Formaldehyde market in particular. As an old, well-known player in Iran's Formaldehyde market, Johnson Matthey Formox was honored to host a one-day conference in Tehran at the end of 2015.

On a frosty mid-December day in the capital city, more than 40 delegates – mostly from our loyal customers and new prospects – attended the seminar to listen to updates about Johnson Matthey Formox and its latest developments, challenges and services.

Experts from more than 10 companies and holding groups gathered at Parsian Azadi hotel where Lars-Olle Andersson, Commercial manager, updated them about the acquisition of Formox by Johnson Matthey, and also, of course, about the global FA market outlook.

Information regarding our plants and projects were shared by Fredrik Rietz, Global Market manager - Plants, and he also presented our latest plant range, which covers a wide range of production capacity with our state-of-the-art plant designs. An interesting topic in view of the delegates, was how we execute the projects and what is included in our scope of work.
A deep introduction to our catalysts and their performance was presented by me, Amin Mehdipoor, Regional Sales manager, where I also shared our future challenges and ongoing development projects. Our unique loading service was also presented, which caught the eyes of many delegates.

Considering the rather old age of the plants in Iran, subjects such as upgrades and technical support attracted a lot of attention as well. Delegates showed much interest to these services which were presented by Tomas Nelander, Global Technical Support manager.

Not only Formaldehyde was discussed during the day, but also Peter Roberts, Market manager at Johnson Matthey Process Technologies, gave a speech about methanol and JM's unique offers in this field.

At the end of the seminar, besides all remarkable discussions which took place throughout the whole day, we received many delightful feedbacks from delegates. Comments like "very useful and constructive" or "very well organized and informative" ensured success of the event and we hope to develop long-term business collaboration in this wonderful country.

We would like to use this chance to express our greatest appreciation to Ms. Reyhani and Mr. Mohajer and the rest of their team from Chemiye Yaran Company[1], who organized this event in it best possible way.

BY

Amin Mehdipoor,
Regional Sales Manager,
Johnson Matthey Formox AB

[1] Official agent of Johnson Matthey Formox AB in Iran

Projects & start-ups

New Projects

- A client in Asia has signed an agreement for supply of an FS3 plant.
- An agreement for an FS3 plant to Eastern Europe has been signed.
- An agreement for an FS2 UFC plant to SEA has been signed.

Ongoing projects

- Works on an FT3 plant to be located in China are proceeding well.
- The JM Formox FT3 plant to be supplied in Eastern Europe is in the engineering phase.
- The project with an FS3 plant for a client in South America is in the shipping phase.
- The construction of a new FS3 plant to Eastern Europe is proceeding well.
- The FS3 plant for Xinjiang Xinye Energy Chemical Co., Ltd, located in China, is in the installation phase.
- Works on two FT3 plants to be located in China are proceeding with installation.
- The JM Formox FT2 plant to be supplied in the Middle East is in the construction phase.
- The FS1 plant for Masnova Quimica, S.A. de C.V., a Masisa´s Company, in Durango, Mexico, is in the construction phase.
- The project for BASF PETRONAS Chemicals Sdn Bhd, Malaysia, is proceeding well with construction.
- The project with two FS3 UFC plants in Eastern Europe is in the installation phase.

Start-ups

- The project for an FT3 plant for Xinjiang Markor Chemical Industry Co., Ltd. in Korla, China, went on stream in November. This is their third JM Formox plant in Korla.
- The project for an FS2 plant in the US went on stream in November.
- One FT3 plant in the US went on stream in December.
- The project with capacity increase for a plant in Eastern Europe is back on stream. The start-up took place in December.
- The project with an FT3 plant in the US is about to go on stream after publication of this issue of Informally Speaking.

BY

Jonas Lindborg,
Chief of Projects,
Johnson Matthey Formox AB

The FORMOX CAP™ 3.0 (T) – An update

It has now been almost 4 years since we introduced our presently most advanced catalyst products, CAP 3.0 loading plan and **FORMOX™** KH-CAP 3.0 INI CAT, and in this article I would like to give an update on the experience we have gained since then. We had a short follow-up in the 2014 summer edition, where I gave a review over expected performance, some limitations, as well as feedback received up until that point. This time, I will go a little deeper into the details of our results so far.

Longer lifetime, higher yield – better performance

We stated that formaldehyde/UFC plants with CAP 3.0 could be operated at the same maximum methanol inlet as before, i.e. 10 vol% for most JM Formox plants or, for plants modified to handle a higher methanol inlet, 11 vol%. If operated at 10 vol%, the yield was said to be the same as for CAP 2.0 loading plans, but with a longer specific production and a slower pressure drop development. What we have seen and what has been reported, are improvements in lifetime as well as slower pressure drop development (lower power consumption). Moreover, we have seen an improvement in yield as well. At higher specific production the yield is in fact better with CAP 3.0 than with the corresponding CAP 2.0 load (see Fig 1).

The graph in Fig 1 is based on data received to date from some 50 loads, and will be updated as more data comes in. But I think the message from the graph is clear: If you don't need or can operate at higher productivity (inlet) you can operate as before, be it 9, 9.5 or 10 vol% in methanol inlet, and you will still see the differences in terms of improved lifetime and performance, i.e. slower pressure drop development and higher and more stable yield.

Higher productivity

In 2014 our experience of operating at higher methanol concentrations than 10 vol% was from only one plant. Today we have a handful of plants operating at 10-11 vol% and the number will increase to double digits in 2016. Since we have little data so far, and no completed loads running at up to 11 vol%, we will have to revisit this in a later edition to share the experience we will then have gained.

Possible limitations

We expressed some concerns in 2014 concerning ECS temperatures. That's because CAP 3.0 will give somewhat higher DME formation in the latter part of the run, which could lead to excessive delta temperatures in the ECS. Our experience from the loads so far is that only in very few cases has the ECS delta temperature been a concern, and in most plants a slightly increased DME loss has been counterbalanced by a lower CO loss. In these few cases, the plants have been operated at high productivity and high specific production, so for such plants and for JM Formox plants intending to operate at 11 vol% in methanol inlet, we recommend adding a layer of our **FORMOX™** PPd-47 palladium-based catalyst into the ECS reactor. For plants to be operated at 11 vol%, we also recommend conducting a study

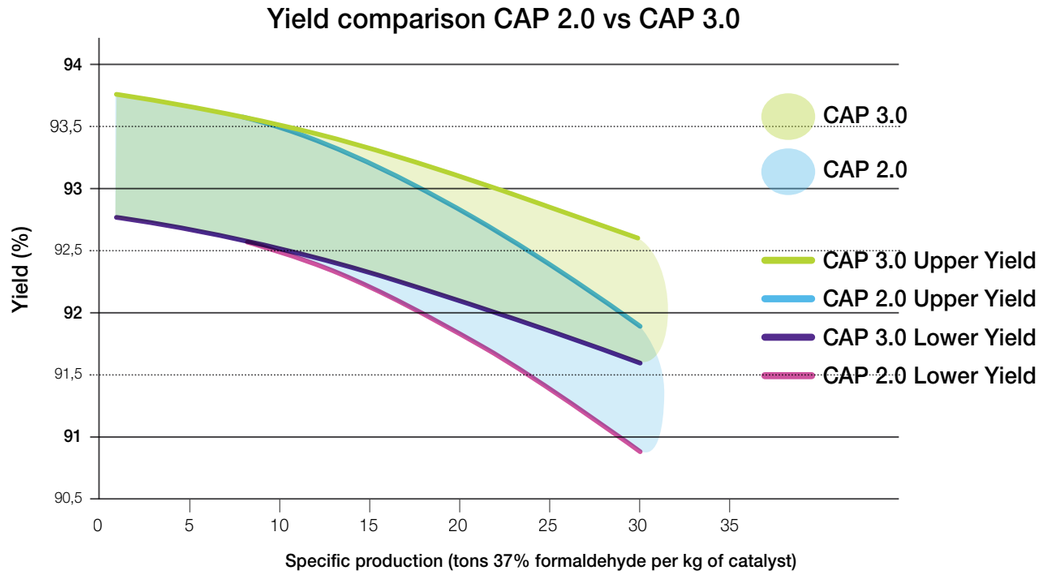


Fig 1. The basis for the upper and lower yield area is 0.3-0.5 bar g operation and 10 vol% methanol inlet operation. Variations in gas velocity, reactor design (tube ID, length), methanol in product requirements, etc., account for the range. The result is closer to the lower curve for operation at 0.5 bar g, and closer to the upper curve at 0.3 bar g.

indicating how much dilution air will be required to the ECS. These recommendations are made due to the higher concentration of carbon compounds reaching the ECS as well as to the higher DME formation in the end.

In 2014 we stated that JM Formox plants with 1400 mm tubes or longer are suitable for CAP 3.0, and this recommendation is still in place. It is of course easier to get the best out of the CAP 3.0 with longer tubes, but unless there are very specific requirements, the plant performance improves with CAP 3.0 also in plants with 1400 mm tubes. Other plant designs are suitable as well. As always, it is important to have the correct plant data, particularly regarding the reactor, when designing a CAP 3.0 load. Please contact your JM Formox representative to discuss whether or not your plant is suitable.

Sales rundown

Of the CAP 3.0(T) loads we have sold since the launch in 2012, about 15% have been for other plant designs, 25% have been for shorter tubes, 25% have been CAP 3.0T, and the majority, 70%, have been for operation at 0.5 bar g. Furthermore, we have a very high rate, 80-90%, of repeat sales.

Conclusion

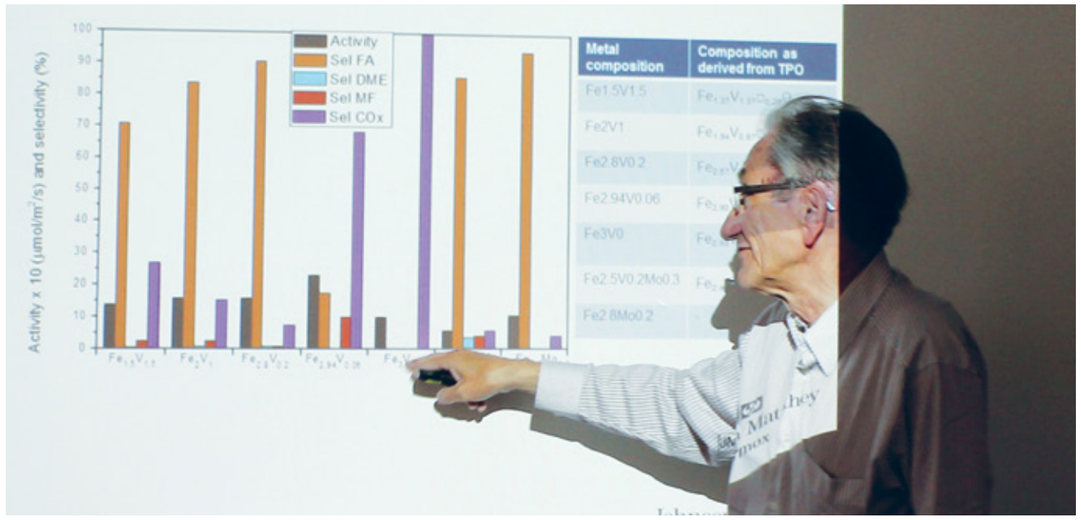
So if you're looking to increase productivity, or want to enjoy longer catalyst lifetime (longer period of operating time), higher yield and slower pressure drop development, please contact us to discuss the possibilities for applying our best fit of CAP 3.0(T)!

BY

Ronnie Ljungbäck,
Global Market Manager
Catalysts, Johnson Matthey
Formox AB

FORMOX™ CAP™ 3.0 (T)

- Catalyst concept introduced in 2012
- Uses our latest catalyst, **FORMOX™** KH-CAP 3.0 INI CAT, which allows higher productivity or longer catalyst lifetime with better performance
- Currently includes two main loading plan types:
  - CAP 3.0: standard selectivity and yield
  - CAP 3.0T: higher selectivity and yield, and lower pressure drop



Arne Andersson, Catalyst Specialist

Part 2 (of 2)

How a fourfold productivity increase has been obtained

- A survey of the developments of the FORMOX™ process from the 1950s to present time

The first plant in Perstorp for the production of formalin was built in 1907. At that time methanol and air were reacted over a copper wire catalyst to produce formaldehyde, which was then absorbed in water to produce formalin. In the 1930s, the plant was rebuilt with new reactors, and silver was introduced as the catalyst in the form of either nets or granules. Although Adkins and Peterson in 1931 [1] reported that methanol was selectively oxidized to formaldehyde over an oxide catalyst with molybdenum and iron, it was not until the 1950s that the molybdate catalyst gained commercial importance. Production in Perstorp using the new process with an iron molybdate catalyst began in 1959. Presently, global production of formaldehyde is divided roughly equally between the oxide and the silver-catalyzed technologies. The two technologies differ in that the silver process operates at methanol-rich conditions, whereas the oxide process (**FORMOX™** process) is run under methanol-lean conditions. A benefit of the latter process is that it gives a higher formaldehyde yield (~93% as opposed to <90% for the silver process). The silver process, however, gives a somewhat lower investment cost due to the higher methanol content in the feed.

Typical performance data for a number of selective hydrocarbon oxidations and oxidative dehydrogenations are presented in Table 1. Compared with other selective oxidations, the data shows that the $MoO_3/Fe_2(MoO_4)_3$ system in methanol oxidation presents outstanding selectivity (92–95%), which is achieved at high conversion (>99%). Selectivity is an important parameter because the cost of methanol is about 94% of the production cost, whereas power and catalyst costs are about 4% and 2% respectively.

Considering the good performance of the ferric molybdate catalyst, finding a more selective composition is no simple task; a position demonstrated also by the fact that the chemical composition of the catalyst is essentially the same today as when first reported in 1931. Yet in spite of this, a considerable (near fourfold) increase in productivity has been achieved. In the previous issue of Informally Speaking we looked at the developments in the process that have made such a substantial increase possible. In this issue we will look at developments related to catalysts and the volatilization of molybdenum species that occurs under process conditions – a major cause of catalyst deactivation.

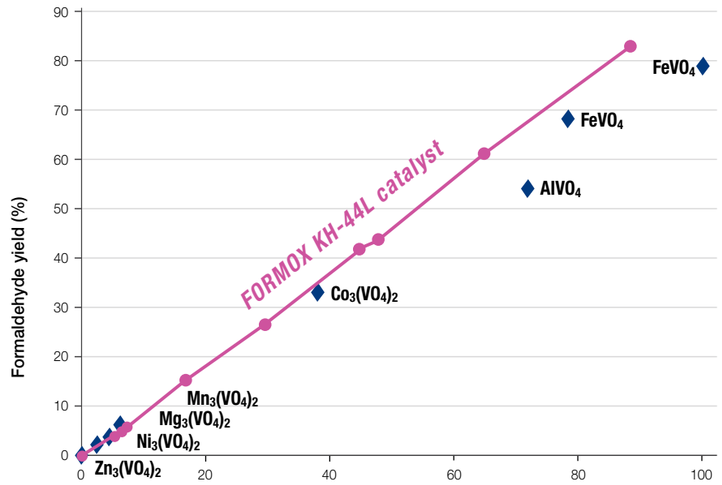
Table 1. A comparison of the performances of a selection of selective gas phase (amm)oxidations on metal oxide catalysts

Process	Catalyst	Temperature (°C)	Conversion(%)	Selectivity(%)
Methanol to formaldehyde	Fe-Mo-O	250 – 380	> 99	92 - 95
o-Xylene to phthalic anhydride	V-O/TiO_2	350 - 450	99.9	80 - 82
Propene to acrolein	Bi-Mo-O	300 - 400	< 98	83 - 90
Propene to acrylonitrile	Bi-Mo-O	420 - 450	98	80 - 83
Ethene to ethylene oxide	Ag/Al_2O_3	200 - 300	7 - 15	80 - 90
Butane to maleic anhydride	V-P-O	350 - 420	75 - 85	65 - 73
Propane to propene	V-O/MCF	550	41	68
Propane to acrylic acid	Mo-V-Nb-Te-O	350 - 400	80	50 - 60
Propane to acrylonitrile	Mo-V-Nb-Te-O	420	86	72

Catalyst development

Besides the developments related to the loading plan, catalyst particle shape and process conditions as described in the previous issue of Informally Speaking, parallel work has been carried out on alternative catalyst compositions. Here the focus has been on molybdates and vanadates as these materials are well known to be active and selective for partial oxidation, including methanol oxidation to formaldehyde. The data plotted in Fig. 1 confirms the good performance of the JM Formox catalyst, showing no vanadate or molybdate with better performance.

Although the $MoO_3/Fe_2(MoO_4)_3$ catalyst system is very selective to formaldehyde at high methanol conversion, resulting in a high yield, the longevity of the catalyst is limited in part by volatile methoxy-hydroxy-molybdenum species being formed in the reactor [2]. The depletion of molybdenum from the catalyst may cause the formation of free Fe_2O_3 at the catalyst surface, decreasing the selectivity and the yield to formaldehyde. Consequently, compared with the present type of catalyst material, any new material should not only give unchanged or better yield, but should also be less volatile. We recently patented a new type of catalyst of spinel-type that has thus far shown interesting properties on lab scale [3]. The origin of our interest for this type of catalyst is found in our previous studies of methanol oxidation on bulk $FeVO_4$ [4, 5] and supported vanadia [8, 9], which revealed that i) the triclinic $FeVO_4$ pha-



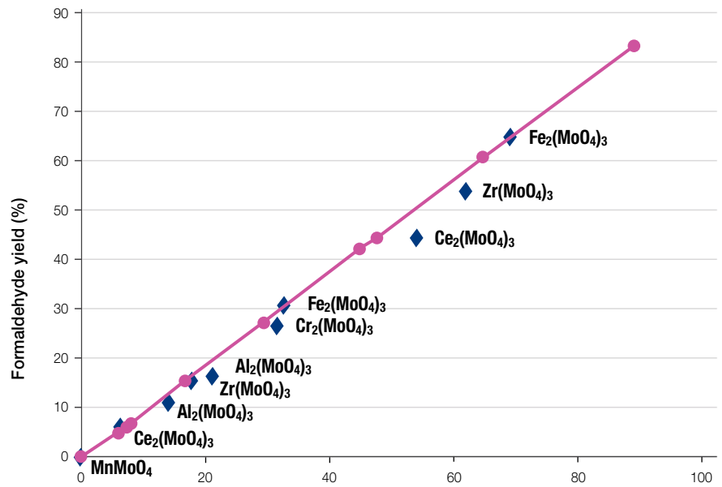


*Fig. 1. Comparisons of the yield to formaldehyde between **FORMOX** KH-44L and a) pure vanadates (lower chart), b) molybdates (lower chart). Reaction temperature: 300°C; feed composition: 6% methanol and 11% oxygen in inert gas.*

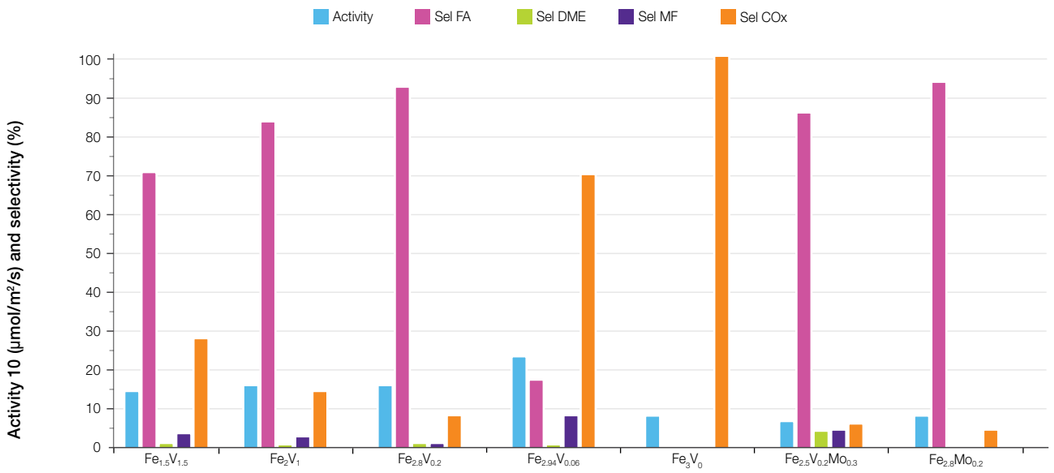


Fig. 2. Catalytic performance of spinel-type catalysts with Fe, V and Mo. Activity and the selectivities to formaldehyde (FA), dimethyl ether (DME), methyl formate (MF) and carbon oxides (COx) are shown. The data are for steady-state conditions at 300°C, feeding 10% methanol and 10% O_2 in N_2. The selectivities were measured at about 90% methanol conversion.

se, depending on the methanol concentration, is either partly or completely transformed into a spinel-type $Fe_{3-x-y}V_x\square_yO_4$ structure with some vacant (□) cation positions, ii) Fe exerts stabilization of V towards volatilization, and iii) the catalyst should preferably be in bulk form as its catalytic performance in supported form is considerably more sensitive to volatilization due to the amount of active material being relatively small. On the basis of these findings, we prepared spinel-type iron oxides replacing various amounts of the iron with vanadium [6]. Figure 2 includes activity and selectivity data for a series of spinels with V/Fe ratios from 1 ($Fe_{1.5}V_{1.5}$) to 0 (Fe_3V_0). The samples have rather similar areal activity, however, the selectivity to formaldehyde passes through a maximum with the vanadium content. The $Fe_{2.8}V_{0.2}$ sample is best, with a selectivity of about 90% to formaldehyde, whereas the selectivity sharply drops with further decrease of the V/Fe ratio. The pure Fe_3O_4 (Fe_3V_0) gives only carbon oxides. These variations suggest that an isolated vanadium center surrounded by iron is a more favorable configuration compared to polymeric vanadium and iron centers.
Considering that Mo is less harmful and easier to handle than V, we decided to introduce low content molybdenum into the spinel structure. Catalytic data for the $Fe_{2.5}V_{0.2}Mo_{0.3}$ and $Fe_{2.8}Mo_{0.2}$ oxides are included in Fig. 2. For the former sample, the selectivity to formaldehyde is about 86%, whereas the latter sample without vanadium shows selectivity above 90%. Compared to the preparations with Fe and V only, the samples with molybdenum present somewhat lower activity.

Moreover, the stability of the spinel-type catalysts was tested for methanol oxidation in lab scale measurements, showing almost no detectable volatilization of either vanadium or molybdenum. However, before any full scale testing and commercialization can be considered, more development work is needed regarding both catalyst preparation and long-term testing in pilot scale.

BY

Arne Andersson
Catalyst Specialist
Johnson Matthey Formox AB

References
1. H. Adkins, W. R. Peterson, Journal of the American Chemical Society 53 (1931) 1512-1520.
2. A. Andersson, M. Hernelind, O. Augustsson Catalysis Today 112 (2006) 40-44.
3. A. Andersson, R. Häggblad, International Patent Application WO 2011/093763 A1, applicant FORMOX AB, Perstorp, Sweden.
4. R. Häggblad, J. B. Wagner, S. Hansen, A. Andersson A, Journal of Catalysis 258 (2008) 345-355.
5. R. Häggblad, S. Hansen, L. R. Wallenberg, A. Andersson, Journal of Catalysis 276 (2010) 24-37.
6. R. Häggblad, M. Massa, A. Andersson, Journal of Catalysis 266 (2009) 218-227.
7. M. Massa, R. Häggblad, A. Andersson, Topics in Catalysis 54 (2011) 685-697.

Participating at conferences

Johnson Matthey Formox has participated at three external conferences during the autumn of 2015:

FA Association conference, Wuhan, China in November

MMSA conference, Singapore, in November

MMSA Methanol conference, Frankfurt, Germany in December.

Mo update

It has been more than a year since I wrote the previous article at the end of 2014, and during 2015 the Mo price has continued to drop. In that article I indicated that a level of 8-11 USD/lb was anticipated for 2015, but the price has actually fallen even lower. In October 2015 it was as low as 4.5 USD/lb, and since then it has increased marginally.

Why has the price dropped so low? Well, there are several reasons. One is a lower global demand, much due to a slowdown in China. Lower oil prices is another, which has delayed exploration projects. Both of these have affected the demand for stainless and special steels . On the other hand, there is a greater supply and availability of Mo on the market due to more capacity in both primary and secondary mines.
During 2015, more Mo capacity reached the market, especially from upgraded secondary mines, while some primary mines had to reduce their output or even close due to the negative price development. Reading the views of various analysts, it seems 2016 is going to be difficult to predict when it comes to the price level. The sentiment seems to be that the present low price level is not sustainable for the long term and will increase; the only question being when. There are many influencing factors – the development of the global and large local economies, possible further closures of primary mines, changes in the energy sector – which can influence the price up or down. Personally I expect the price to be within a range of 5-8 USD/lb during 2016, and that we most likely will see higher prices in 2017 than we will in 2016.

No matter what the price level, JM Formox strives to maintain reasonably stable net prices regardless of possible market changes. Your efforts to return spent catalyst in good condition according to our specifications, in combination with our efficient catalyst recycling system, help to make this possible!

BY

Ronnie Ljungbäck,
Global Market Manager
– Catalysts,
Johnson Matthey Formox AB

Trainings and meetings during autumn 2015

Kolon Plastics, Gimcheon, South Korea in August

Hexion Geismar, Louisiana, USA in September (2 groups)

Hexion Luling, Louisiana, USA in September

Metafrax, Gubakha, Russia in September (2 groups)

SADARA, from Saudi Arabia, training in Perstorp, Sweden in October

Egger, Wismar, Germany in November

Training in Perstorp, Sweden for BASF PETRONAS Chemicals Sdn Bhd, in November.

The turbocharger is a success!

Johnson Matthey Formox has successfully launched the turbocharger as a standard option in new plant projects. This green technology reduces carbon footprint by recovering available energy in hot and pressurized gas from the ECS (Emission Control System), thereby reducing the electrical power demand.

Last year, JM Formox's Regional Technical Support Manager, Simon Smrtnik, and Regional Sales Manager, Paul Walter, visited site EGGER Radauti in Romania – site of our first turbocharger supply – for an interview with EGGER's Technical Director Resin Plants, Martin Steinhagen, along with EGGER Technologia SRL's Ovidiu Petrosel (Plant Manager), Sorin Musca (Production Manager) and Mircea Ciobanu (Shift leader). This article is based on that interview.

Patented technology

The standard option of a turbocharger in JM Formox plants enables high energy savings by using the temperature and pressure of the process gas from the ECS reactor. This solution was first discussed within JM Formox when we began pressurizing the plants to 0.3 barg. With the ambition to go to 0.5 barg, it became even more interesting as power consumption increases with increased absorber top pressure.

In 2004 we began evaluating various concepts and concluded that the best option was to use a turbocharger to feed pressurized fresh air into the process. EGGER was our first customer to try it, agreeing to a pilot installation at its (then new) site in Romania. This decision was followed by extensive development work carried out by JM Formox in collaboration with the turbocharger supplier MAN in Augsburg, Germany, resulting in a patent granted in 2007.

Since the first commissioning at site EGGER Radauti in 2011, the turbocharger concept has been continuously improved to optimize process performance. We at JM Formox are very grateful to both EGGER and MAN for good cooperation and support. As a result of this collaboration, JM Formox now proudly offers this safe, cost efficient and environmentally friendly technology as a standard option for all new plant and revamp projects.

How does it differ from a "normal" plant? There are two main differences in configuration between a standard JM Formox plant and one equipped with a turbocharger. Firstly, instead of a fresh air blower, a turbocharger is connected to the exhaust gases from the ECS on the turbine side, and to the fresh air intake on compressor side. Secondly, the ECS vessels are larger with increased diameter in order to minimize pressure drops after the absorber and provide optimal power output to the turbocharger (Figure 1).

Turbocharger at site EGGER Radauti in Romania, March 4, 2015. From left to right: Paul Walter, Sorin Musca, Ovidiu Petrosel, Mircea Ciobanu and Simon Smrtnik.

Easy operation

EGGER says it finds the turbocharger easy to operate. It can start directly in pressurized mode and is easy to maneuver from the DCS (Distributed Control System). Production Manager Sorin Musca says, "It is mainly four parameters that need to be carefully monitored when operating the turbocharger: blow off valve, VTA, pressure and oxygen valve." The blow off valve balances the pressure on the compressor side while the VTA works as a brake controlling the capacity on the turbine side. The pressure and oxygen valves control the pressure and the oxygen concentration respectively. With these parameters under control, the turbocharger operation is easy. EGGER, who shifts regularly between FA and UFC production, has also found performing load changes and finding a new stable point of operation to be easy as well. Plant Manager Ovidiu Petrosel says, "The change of production is easy and the way of operating the turbocharger is basically the same."

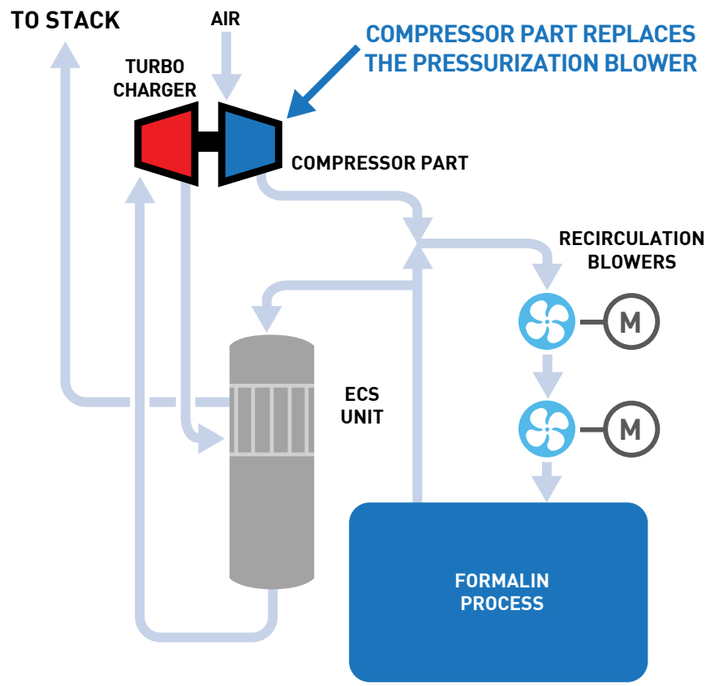


Figure 1. Schematic illustration of a plant with a turbocharger.

A green solution

The turbocharger is an efficient and energy saving solution as it utilizes energy available in the hot process gas to power the compressor unit that feeds fresh air into the plant. The demand for electrical power is thus reduced, as no electrical motor is required to run the fresh air compressor. This, in turn, reduces carbon emissions, making the turbocharger concept an environmentally friendly solution. In addition, the temperature drop over the turbine is limited and therefore steam can still be produced after the turbine with a reduction of only 4%. In 2012 JM Formox was awarded the "Innovative Energy Use Award" by the ChemInnovations Advisory Committee and Chemical Engineering Editors in New Orleans, USA, for the turbocharger standard.

The potential for reducing operational costs by installing a power-saving turbocharger is thus substantial. How much electricity a customer will indeed save depends on various factors, but considering the current guarantee point for JM Formox standard – full load at 0.5 barg and 10.0 vol% inlet – the savings are 20 kWh/MT. The number of kWh will of course vary depending on plant size and number of operating days per year. For an FS3 size plant operating at full capacity 350 days per year, the savings will be close to 3,000,000 kWh/year. At an electricity price of €0.1 per kWh, this amounts to annual savings of €300,000.

As Martin Steinhagen, EGGER's Technical Director Resin Plants, concludes, "I would recommend the turbocharger if the energy recovery situation provides that this solution is most optimal from a site perspective. It is definitely advisable if there is no other way to utilize the energy efficiently."

BY

Andreas Magnusson,
Global Product Manager plants,
Johnson Matthey Formox AB

Simon Smrtnik,
Regional Technical
Support Manager
Johnson Matthey Formox AB

Blower silencers – check status to avoid too much pressure drop!

Those of you using Roots type blowers normally also have a silencer installed directly after the machine. While the blower itself has its maintenance schedule, the silencer is often neglected and left unattended. Over time the silencer and its strainer can become clogged and corroded. In worst case, the silencer's internals can become lose and distorted. The risk is that an unnecessary and costly pressure drop is created.

Recommendations:

- Check the pressure drop over the unit at least once a year.
- Inspect the silencer for corrosion damages, preferably also on the inside.
- If applicable, inspect the integrated strainer in the silencer and remove any blockages. It is not unusual to find residues of oil and paraformaldehyde.
- Example: In a plant producing 300 MTPD FA37, an extra unnecessary pressure drop of 0.03 bar will cost you 120-150 MWh per year.

Boiler feed water blow down – Why and how?

Depending of the quality of the water used, steam producing vessels in the boiler feed water system are more or less contaminated with salt and other substances left as residues when the water is evaporated. Blow downs, both continuous and discontinuous, are necessary for maintaining boiler feed water quality.

- Continuous blow down should be used to constantly remove dissolved solids. This consists of constantly extracting small amounts of boiler feed water, and is preferably done through sample coolers.
- Shock (or discontinuous) blow down creates a turbulence that is necessary for removing accumulated salts and sediments in the bottom part of the vessel, and should be performed once every shift. The quantity, however, will depend on the quality of the boiler feed water.

Tips from Technical support

Methanol valves

– Make sure you can stop the flow when you need to!

A leaking methanol control valve can be a serious risk in your plant. Remember that the purpose of the methanol control valve is to regulate the methanol flow, but it should not be trusted as a shut-off valve.

Recommendations:

- Test the control and shut-off valve function and tightness regularly.
- Always close a manual isolation valve in the methanol line during shutdowns.
- To avoid methanol accumulation caused by a leaking valve, always open the low point drain in the process gas pipe before starting the plant after a longer shutdown.

Q&A | 5 quick tips about the absorption profile

The formalin concentration in the absorption tower(s) should gradually decrease upwards. If there is any disturbance in the concentration profile, this can most likely be adjusted by considering these five points:

- The main cooling should be performed in the middle section. If, however, the concentration of formalin is climbing upwards in the tower, then the cooling should be reduced somewhat as too much water has been condensed.
- Any excessive foam formation will deteriorate the absorption process as entrained formalin from the section below will disturb the concentration profile. The foam can be caused by several factors, but mostly it is due to additional organic compounds in the methanol feed or process water, high packed section circulation flow, or high process gas flow.
- Methanol is disturbing the absorption and also facilitating foam formation. If the methanol concentration in the product is high, then the conversion of methanol in the main reactor can be increased by increasing the HTF temperature, i.e. the reaction temperature.
- The wetting of the absorber internals is important in order to avoid any dry sections that will generate paraformaldehyde formation. Ensure correct level in distributors, and also that the level is the same all over the distributor. Any formed paraformaldehyde blocking a section in the distributor should be removed during the next plant shut down.
- Adding some caustic in the absorber is helpful as caustic enhances the absorption. It is recommended to maintain a pH of 8.5 to 9.0 at the absorber top tray

Great partnership for two decades, looking forward to a brilliant future

A ceremony was held at the 2015 China Formaldehyde Conference, hosted by Johnson Matthey Formox, to commemorate the 20th anniversary of the start of cooperation between Formox and Yuntianhua. Eddy Lee, Johnson Matthey Formox's Regional Sales Manager for the Asia Pacific region now working in Singapore, gave a speech.

"It was winter when I first came to China in 1995. When I got off at Yuntianhua, I indeed felt like coming back to my own home, as everyone was so nice and thoughtful to me. We had a great time working together in loading catalyst, operator training and the commissioning. As a result, Formox's first plant in China was started up very successfully!"

"In 2003 I was repatriated to my Asia Pacific position in Singapore," continued Eddy. "Although I left, I'd always remember the three most respected persons. They are Mr. Li Xin Hua, then Site manager of Yuntianhua, Mdm. Sun Zhen Feng, the party secretary and Mr. Zhu Ming Song, the general manager. I would like to take this opportunity to express my gratitude to these three great persons, under whose leadership our two companies have built a solid friendship; and based on this strong foundation we have together, hand-in-hand, achieved 20 years of brilliancy! Last, but not least, I would like to wish an even more prosperous business at Yuntianhua. Let's join hands for a brighter future!"

At the Formaldehyde Conference in Hangzhou, Eddy Lee, together with Johnson Matthey Formox's Plant Sales Manager for China, Huamin Zhang, and Marketing Manager for China, Grace Gu, were able to interview Mr. Liu Chunwen, Director of Yuntianhua, and Mr. Lei Qiang, Manager.

What do you think of our plant design?

-First of all, JM Formox's plant is well designed in terms of safety. We are not worried at all in operating it. Secondly, it is easy to install and trouble-free to operate. The minute the plant is installed, it's ready to be up and running.

Are you happy with our service and cooperation?

-You provide good communications. JM Formox technicians are just a phone call away and very fast in response on solving our problems.

We'd like to ask a little more about today's conference. In general, what is your opinion of this conference?

-I see you are making improvements with the spirit of innovation. At Yuntianhua we set up a reward system to encourage innovation. For example, if an idea is adopted by the company, bonus points are rewarded. In this regard, our spirit of innovation coincides with yours at JM Formox.

20 years of partnership - Yuntianhua and Johnnson Matthey Formox

New...

Fredrik Bengtsson,
Mechanical engineer

Elias Sjölander,
Mechanical engineer

Åsa Yhlen,
Process engineer

Peter Balog,
Financial controller

Sven-Arne Svensson,
Operations

Thomas Olsson,
Operations

Maria Svedinger-Andersson,
Process engineer

Beijing:

Carlos Du,
Process engineer

Bolin Qu,
Process engineer

...& left

Camilla Eklund, Process engineer

We are very glad to have had you as our colleague and wish you the best of luck in your coming challenges.

A formaldehyde magazine from Johnson Matthey Formox AB

The newsletter Informally Speaking aims to provide information about formaldehyde in an informal forum and is published twice annually by Johnson Matthey Formox AB for its customers and contacts in the formaldehyde business. The information included herein is part of our customer service and in no way entails or implies any undertakings, legal responsibilities or liabilities.

JM
Johnson Matthey
Formox

Johnson Matthey Formox AB
SE-284 80 Perstorp, Sweden. Phone: +46 435 380 40
e-mail: formox@matthey.com www.formox.com