Industry 4.0 and the Chemical Industry in China

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"Industries 4.0" (Industry 4.0) is a German term given to the expected increase in automation and data exchange of manufacturing. While its exact definition is still evolving, the key point is the direct communication between machines, enabled by improvements in information technology.

Adding to the potential for confusion, China has started the initiative "Made in China 2025", which is sometimes stated to be directly inspired by Industry 4.0. However, this is somewhat misleading. "Made in China 2025" focuses on improvements in innovation and quality of manufacturing rather than on communication of machines, reflecting the lower starting point of the average Chinese manufacturing company. To be clear, this paper is about Industry 4.0, not about "Made in China 2025".

A study by the well reputed Fraunhofer Institute names the chemical industry as one for which Industry 4.0 has the highest potential, with a predicted annual additional growth of 2.2%. Similarly, the German Chemical Industry Association states that Industry 4.0 offers substantial opportunities for the chemical industry. However, these optimistic statements somewhat obscure the fact that little clarity exists about the individual aspects of Industry 4.0 and their impact on the chemical industry. To quote one industry observer, "Industry 4.0 is currently more of a vision than a reality".

The aim of this paper is twofold:

- To identify the aspects and potential aspects of Industry 4.0 which may be relevant for the chemical industry in general
- To examine the specific issues for implementation of Industry in China

One additional note. Many of the individual aspects and applications of Industry 4.0 are already being used in the chemical industry, as described below – often without having in the past been described as such. The paper will include these applications as the isolated components form the basis for a broader, company-wide utilization of Industry 4.0.

Applications of Industry 4.0 in the chemical industry

As stated earlier, key to Industry 4.0 is the intensive communication between machines. Machines are both able to handle a much larger amount of data than humans and to react to much more subtle changes. This can be utilized in a number of ways to improve the chemical production process and the adaptation of chemical products and services to specific customer requirements. Here are examples:

Process control: As even minor fluctuations in process conditions (e.g., changes of temperature or concentration) can be detected and reacted upon, batch consistency and product quality both are improved.

Preventive Maintenance: Most equipment failure does not happen out of the blue but has some early warning signals, though these may be subtle and hard to spot for human operators. However, the large increase in data collected and in data processing capabilities associated with Industry 4.0 allows identification of possible failures at an early stage, enabling effective preventive maintenance which can substantially reduce downtime.

Supply Chain Planning: As the marginal cost of passing information on within the supply chain decreases to practically zero (no humans are involved), it is theoretically possible that a can of paint sold in a DIY shop in China triggers the production of a new can in Europe. Almost all routine supply chain planning tasks can be fully automated once Industry 4.0 is implemented.

Customized Products: The example for supply chain planning given above can be extended to customized products. So, in principle the customer in China can also configure a customized painting formulation, which is then automatically and without human interference produced in a plant in Europe or elsewhere (the choice of plant may also be determined by the system depending on given parameters such as production costs, logistics costs and current capacity utilization). BASF is already allowing customers for its soaps to customize their products, which are then produced at the BASF plan in Kaiserslautern, Germany without human intervention.

Chemical services instead of products: In the last 20 years, the often-anticipated switch from chemical companies as producers of products to providers of chemical services has been relatively slow to materialize. Industry 4.0 may change this. Once the equipment is sufficiently digitized and networked, an employee at a company formerly selling water treatment chemicals may well turn into an employee who from his computer is responsible for running 20 different water treatment plants for customers all over the world.

Vendor Managed Inventory (VMI): This may be one of the applications related to Industry 4.0 that already are utilized to the largest extent. Industry 4.0 does not change the basic concept of VMI but allows even further automation of the necessary supply processes, to the point where the emptying of a tank at a

customer triggers the whole production and shipping of replacement product at a chemical company.

Virtual Plant: By creating a virtual model of existing or planned plants, retrofitting and testing of such plants can be improved. For example, with the help of the Fraunhofer institute, BASF used a virtual plant to retrofit of a nitric acid plant. BASF actually states the ambition of having a virtual model of each of its plants in the future. Sinopec, in their Ningbo IGCC (Integrated Gasification Combined Cycle) plant, utilized a customized simulation provided by GSE.

Virtual Training: Similarly, a virtual plant allows to train operators in advance, at much lower cost and with the opportunity to go through simulations of particularly dangerous situations.

Safety: Given the drastically increased number of data points and data analysis tools in an Industry 4.0 environment, this will also lead to improvements in safety performance. In particular, it will become easier to provide early warnings in case of slight deviations from the safety optimum, and correct automatically. It will also be possible to incorporate a much larger number of peripheral parameters such as the outside air temperature into safety modelling.

3D Printing: While 3D printing is already coming of age on its own, it also may play an important role in an Industry 4.0 environment. Customized products produced by 3D printing do not only require suitable technology, but also the communication between different machines (such as the computer on which the design is made, and the actual 3D printer) and potentially between the customers of 3D printed products and the operators of such printers. This points to a clear role of increased communication between machines to fully leverage the potential of 3D printing.

Forecasting: Industry 4.0 allows forecasting that incorporates a much larger range of parameters, from point-of-sales data to weather reports, oil prices or stock indices, as the underlying correlations can be detected ideally directly by the system without major involvement of human labor.

Logistics and Storage Monitoring: In particular, for hazardous goods, logistics monitoring and storage can be made substantially more detailed and thus safe. Given availability of suitable low cost sensors, a system may indicate not only the exact current location of each chemical good, but also the conditions such as temperature at each location. Further analysis of this data then may point out specific risks, e.g., from storing two reactive chemicals close to each other.

Flexible use of multiple resources: Once sufficient data is available, an Industry 4.0-enabled plant should allow optimized use of all potential combinations of raw materials, reactor vessels, energy sources etc.

As stated at the beginning of this paper, Industry 4.0 currently is more vision than reality. While this holds true in Germany, it is even more relevant in China. Examining the individual applications of Industry 4.0 as listed above, it becomes apparent that in China frequently even the groundwork is missing. The Tianjin explosions showed that a whole chemicals warehouse was misused, and there was widespread uncertainty about which chemicals were located in which place – obviously, such a situation is very far from an Industry 4.0 environment. Or to put it differently, an implementation of Industry 4.0 in China will likely encounter bigger difficulties than in Germany, even for a Western chemical company.

So what can be done in such a situation? A few preliminary pointers:

◆ Do not be too ambitious (though this advice sounds strange coming from a consultant). Even in advanced economies such as Germany, implementation of Industry 4.0 has just started. It is not realistic to expect a companywide adaptation of all aspects of Industry 4.0 in China within a few years time

◆ Instead, examine the individual components of Industry 4.0. To what extent is there already a groundwork available which just needs to be brought to a higher level - perhaps VMI? Which components may bring rapid value in the current situation – perhaps tight and automated monitoring of hazardous good in the current climate of tighter environmental regulation in China? Which aspects may bring particular opportunities to race ahead of the competition – perhaps the provision of services in areas that are only of peripheral importance to the clients? At the moment, focusing on these individual components will bring more benefit than striving for an unobtainable holistic solution. Besides, there is no clarity yet how this holistic solution will eventually look like, not even in advanced companies in advanced markets. But working on the individual components will keep you in the race

◆ When hiring staff, keep the growing importance of Industry 4.0 in mind. Certain capabilities in programming, IT etc., but also good old project management may increase in importance. Make sure you have the right human resources once needed.

◆ Most Western companies are still more likely to make new investment in production capacity in China rather than in the older markets. Ensure that in such cases, the relevant elements of Industry 4.0 are already incorporated in the planning stages. Obviously new processes offer a chance to benefit from Industry 4.0 to a much larger extent than the retrofitting of old processes.

◆ Ensure to clarify local needs – they may differ from those in Western markets. For example, clients may have lower requirements for customized products but may be more willing to accept services in areas in which they have very limited knowledge

Chemical companies are not always the most advanced when it comes to taking up new technologies, which may hold particularly true in China. On the other hand, to successfully compete with domestic chemical companies, multinationals will have to rely on their superior processes. Industry 4.0 is a very promising approach to achieve these and thus should not be neglected by chemical companies in China. ■