Not Quite World Class Yet: Process Optimization Potential at Chinese Chemical Producers

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Even though Chinese chemical companies are already global leaders in the production of a large variety of fine chemicals, their production processes often lag behind world standards with regard to yield, quality, safety, waste and other aspects. As both cost pressure and environmental regulation are increasing, Chinese chemical companies are increasingly looking at optimizing their production processes. We have identified several areas in which Chinese companies can improve their processes, often with only limited investment and huge and rapid savings. While these opportunities need to be identified individually for each company, our paper highlights some common areas which we have found to have optimization potential in a large number of companies.

Air pollutants: This topic will become more and more relevant as China will implement an environmental tax starting 2018, replacing the current emission fees and increasing the burden on heavy polluters.

There are several methods for controlling NOx emissions to low levels. Gas scrubbing with sodium hydroxide is the most common treatment, however, only the absorbed NO_2 is being converted to Nitrite and Nitrate while NO is not being removed due to its chemical properties. In addition, the salts then frequently present a wastewater disposal problem. Alternatively, there are scrubbing processes available to oxidize NO_x with oxygen and hydrogen peroxide and convert it to nitric acid. Another approach is to decompose the NO_x to nitrogen, water and carbon dioxide in the presence of urea and sulfuric acid as scrubbing media.

Another example for exhaust treatment is gas pervaporation, a membrane process. In a specific case in which this method was implemented on a large production scale, removal ofdichloromethane and methanol to levels meeting official requirements were easily met and the previously used carbon tower could be replaced at a low investment.

Waste Water: In cases in which wastewater or specific process streams pose a problem due to non-biodegradable components, a pretreatment by the LOPROX (Low Pressure Oxidation, Bayer) process may be a solution. This process uses elevated temperatures and pressure in combination with oxygen, an acid and a catalyst to break down contaminants into biodegradable waste products. Ultrasonic treatment of problematic waste water may be another solution, particularly when the waste water contains biosolids. Companies such as Sonotronic offering this technology claim a reduction in the cost of waste water treatment of up to 50 %.

Disposal of gaseous hydrogen chloridegenerated as a by-product in chlorination processesis becoming an environmental problem and may substantially add to the overall process costs. Often disposal is going along with additional costs. In order to solve this problem, the Deacon process has been rejuvenated, which comprises the catalyzed oxidation of hydrogen chloride to chlorine as a route to recover chlorine from HCl-containing streams in the chemical industry. In addition, there is a new and economical electrochemical membrane process,which is leading to the formation of hydrogen and chloride, the latter of which can then be reused / recycled.

Automation: A higher automation level and introduction of a distributed control system (DCS) can lead to process cost reduction, better process control and much improved documentation. It also increases the stability of the process and consequently

enhances product quality. As the Chinese government is promoting a shift towards "Industry 4.0", the trend of automation and data exchange in manufacturing technologies, the installation of DCS can be seen as a first step in this direction.

Process Type: Switching from a batch to a continuous or quasi continuous process (if possible) usually also leads to a better controlled and more robust process, better quality and lower investment and operation costs. As labor costs in China keep rising, such a switch may in the future be the only way for some Chinese chemical manufacturers to stay competitive. In addition, continuous processes tend to have lower environmental footprints, another advantage which will be increasingly important as environmental regulation in China gets stricter. In petrochemicals and basic chemicals, continuous processes are already very well established, resulting in high efficiency with substantially reduced waste. In contrast, in the production of fine chemicals batch processes are still widespread and will always play a larger role due to their higher versatility. Still, a shift to continuous processes should be considered, particularly as the chemical industry in China consolidates and is forced to move into chemical parks, offering an opportunity for changes in the production process in combination with an increase in production scale.

Membrane Processes: Many Chinese production routes have been developed in the laboratory, and have never been properly optimized for large-scale use. This includes underutilization of modern chemistry such as catalysts, ion exchangers and also membrane processes. However, the introduction of a membrane process can lead to elimination or reduction of environmental problems, and reduce costs. For example, recovery of acetic acid from aqueous streams (salt or free acid) is an important industrial separation that is high cost and energy intensive when performed by distillation. Using a membrane process will lower energy costs by more than half, though identifying a membrane that is both suitably selective and chemically and thermally stable is a challenge.

Yield versus Production Cost: As many Chinese processes for the production of fine chemicals were developed in the laboratory rather than being optimized for production, the key target variable tends to be overall yield rather than production cost. For example, many batch reactions run in Chinese chemical companies have rather long reaction times (e.g., 48 hours) even though in the last 24 hours of the reaction the yield increases only marginally (e.g., from 80 to 90%). Once overall production capacity or other costs related to the running time of a reaction (e.g., salaries, energy) become more important, it may well be advisable to run such reactions for shorter timesin order to increase throughput, particularly if the non-reacted starting material can easily be recovered andreused in a subsequent batch.

Use of catalysis: Many reaction steps employed in Chinese chemical companies are stochiometric rather than catalytic. However, more recent developments in catalysis often allow replacement of stochiometric by catalytic processes, leading to substantial savings in raw materials costs, reduced waste and often improved product quality.

Continuous Process Optimization: In our work with Chinese chemical companies, we rarely observe a continuous process development work which is a standard feature in Western chemical companies. A better understanding of the key parameters of their own production processes – for example obtained via slight but controlled modifications of reaction conditions from batch to batch – could lead to substantial process improvements in the longer run.

Material and corrosion issues: When visiting Chinese chemical companies, a frequent first impression is the widespread corrosion which can be observed on the part of the equipment. While this is partly an indication of lower investment and thus lower costs, it may also lead to interruption of production or contamination of products. A better understanding of equipment corrosionand its avoidancecan therefore lead to a reduction of manufacturing issues.

Quality and Safety: Apart from being beneficial on their own, optimizing existing processes with regard to these two parameters will be highly relevant once a Chinese company aims to supply to Western chemical companies. These companies tend to have rather high safety and quality standards, and when partnering with other players will audit their suppliers. As a consequence, quality and safety of processes need not only be established but also be documented transparently.

In conclusion, there are many factors which will force Chinese chemical companies to improve their production processes including cost pressure, environmental regulation and increasing quality standards. Fortunately, in our opinion there is substantial optimization potential in this area. A particular opportunity for Chinese chemical companies may be to work with older/retired Western chemists and chemical engineers with expertise in selected areas, as they often are both highly experienced and very willing to share this experience with qualified companies. ■