WHITE PAPER

Digitalization and the Chemical Plant of the Future

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From device to cloud, digital solutions promise an answer to some of the industry's biggest challenges.

The chemicals sector has seen a wave of investment in recent years, particularly in China (a continuation of the industry's development there) and the U.S. (a result of persistently low prices for natural gas). However, the industry also faces serious challenges on multiple fronts. Digitalization, a long-term trend affecting every segment of the economy, represents both a challenge in itself but also the means to address many others.

A 2017 report by Accenture and the World Economic Forum projects digitalization to deliver approximately $310 billion to $550 billion in value between 2016 and 2025. [3] Benefits are anticipated across the enterprise, from R&D to plant operations, supply chain management and workforce performance.

This paper examines some of the mega-trends impacting the chemicals industry and how leading producers are applying digital technologies to gain competitive advantage.

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"The chemical industry has an intrinsically sound business model," McKinsey researchers observed in a March, 2017 report. "The industry as a whole is… positioned to profit from a wide range of trends, from sustainability to e-mobility, from commodity demand surges to major changes in consumer behavior."[2]

Market trends

Before we delve into digitalization itself, it's important to identify certain market realities. The first is declining growth in demand. Despite recent capital investment in boosting capacity, the fact is that most of that investment has been directed toward meeting local, often domestic, demand. [1] The impact of this is visible in the Middle East where fading energy advantages and an increasingly self-sufficient Chinese market are putting pressure on the region's chemical firms.

U.S. and EU demand growth actually slowed in the decade between 2006 and 2015, according to Deloitte's "Chemical Multiverse 4.0" study. [1] China has offset that decline, but now is moving to slower but more stable growth as the domestic industry matures. McKinsey projects the growth rate in China's chemical sector to be 0.5 to 2.0 percentage points lower over the next ten years.

There is also considerable uncertainty in end user markets. The automotive sector, for example, has relied increasingly on specialty chemicals to reduce vehicle weight, but declining car production—driven by the rise of shared services and a decline in new drivers—may eat into that demand going forward.

The specialty chemicals segment in particular faces serious challenges. The conventional wisdom of growing profits by moving downstream to more specialized products is now in question, and there have been few new specialty products of note in the past ten years. [2] Deloitte notes that profitability in specialty chemicals is now more a function of the number of players in the business than of the products they offer.

Globalization, overcapacity and consolidation all play a role too, and they are interrelated. New entrants, notably from China, are pushing up capacity, increasing competition, but industry

consolidation could still accelerate. A PwC Strategy report notes that the average size of M&A deals in the chemicals sector in 2017 dropped 66% to $136m, 53% below the three-year average, but the number of deals increased 6%. [4] This suggests smaller, more targeted M&A with lower potential savings from reduced overhead, new product development, etc. [4]

In the U.S. the recent build-out has largely run its course. Producers are now more likely to look to getting more out of existing assets than investing in new facilities. There are more plants today, and more ways to arrive at a given end product, and this has leveled the global playing field. Raw materials represent 50 to 80 percent of commodity chemical revenues (20 to 60 percent for specialty products), so as feedstock prices have normalized and supply chains have become more global, advantages formerly associated with “feedstock-blessed” regions have moderated.

Finally, there is the threat of regulation. Bans on plastics could blunt demand or force manufacturers to use more recycled content, further reducing demand for chemicals used in conventional production. [2]

All of these trends point towards a near future in which chemical manufacturers have less headroom on the demand side and more competition on the supply side. That means they will have to drive profitability by looking inward, reducing costs and boosting productivity.

Digitalization: moving beyond early adopters
Like other mature industrial sectors, the chemicals industry is adopting digital technologies, but at a measured pace. Accenture reports that “40 percent of chemical companies are using digital technologies to increase efficiency and 32 percent are applying digital technologies to drive growth. Only 11 percent are doing both.” [6]

The focus has been largely on automation, analytics and data capture, but there remains significant uncertainty around realizing value from digital investments. Only half of chemical industry executives surveyed in Deloitte Global’s inaugural Global Digital Chemistry Survey in 2016 said their firm had a digital transformation strategy. This despite 4 in 10 saying they expect their company to be “more digital” than their competitors in the future. [6]

Elements of digitalization

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Sensors and devices. The “things” where information originates, such as a pressure or temperature sensor, but also radio frequency identification (RFID) technology that uniquely identifies an object.

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Edge computing. Often data needs to be processed at the edge to achieve speed or safety, like a compressor anti-surge loop, a safety integrity loop (SIL) or an electronic lock. Edge computing may happen in the device itself or across multiple devices. In process control, this is the distributed control system.

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Connectivity is what ties the devices, edge and cloud together across many standards and systems into one homogeneous system. It may be integrated with the cloud such as with the ABB Ability™ cloud based on Microsoft Azure.

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Analytics are the many applications that process data to deliver information about equipment diagnostics, logistics, inventory, and trends.

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The cloud is the secure but open central repository where all information is stored, accessible to users and applications

Areas of digital intervention

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Figure 01. Reducing operations and maintenance (O&M) costs as a target for digitalization investment.

Note: Percentage of respondents who ranked an area as '1', '2', and '3' have been summed together. Source: Deloitte Touche Tehmatsu Limited 2016 Global Digital Chemistry Survey. December 2016 as reported in Deloitte's "Digital Transformation: Are chemical enterprises ready? January 2017.

The Accenture study also looked at current spending levels. Not surprisingly, 85 percent of respondents expected spending on digitalization to increase over the next 3 years. That spending is likely to be directed at two priorities above all others: planning and scheduling, and materials/ supply chain management. The former was cited as the #1 concern by 23 percent of respondents (52 percent put it in their top-3), and the latter by 18 percent of respondents.

Figure 1 depicts the findings of the 2016 Deloitte study, which shows a strong focus on reducing operations and maintenance (O&M) costs as a target for digitalization investment.

Case study

BASF

The global chemical leader wanted to move beyond checking non-critical low-voltage motors and pumps only on routine maintenance cycles. These checks provided a snapshot of the equipment's condition, but provided little insight into the likelihood of a failure. BASF explored together with ABB an end-to-end solution including wireless sensors, data collection and advanced analytics to get a real-time picture of equipment conditions. Key data is fed to an enterprise dashboard covering a fleet of LV motors and pumps and supports the company's predictive maintenance program.

Drivers for digitalization

There are myriad reasons for chemical firms to pursue digitalization. McKinsey suggests companies can improve their EBIDTA by 8-13 percent with digitalization when applied across the enterprise [2] but the specifics fall into one of two broad categories: internal processes and external competitiveness.

The first group includes things like managing complex projects, improving fragmented communication, addressing an aging workforce and improving safety. The second speaks more directly to the firm's performance with things like avoiding downtime, which can cost upwards of $1 million per day, the cost for a major cracking facility in the U.S..

Cost and schedule deviations are another problem for the industry. Cost overruns of 20 to 30 percent are common and most projects report schedule delays. Digitalization can address these challenges, and industry analysts have begun to document the benefits. In a 2018 report entitled "Industry X.0 - Unlocking the power of digital in plant operations," Accenture found that using technology to increase operational efficiency could save an average (globally) of $91,261 per chemical company employee. [6] Nearly all respondents (92 percent) said they were satisfied with the results of their digital investments, with 76 percent having already seen a 5 to 15 percent operational improvement and nearly a quarter reporting an increase of more than 20 percent in profits.

These are compelling figures, and it's likely that more companies will invest in digitalization going forward. Sensors, communications and computing power have all advanced in capability while declining in price. The increasing viability of secure cloud-based solutions will accelerate this trend, bringing digitalization's benefits within reach of more industry players.

Case study

Lion Elastomers

Formerly Lion Copolymer, this U.S.-based firm had observed reduced performance when the company expanded into new product lines. To uncover the reasons why, they implemented a range of digital solutions. First, the company benchmarked performance and identified trouble spots using ABB's Loop Performance and Transition Fingerprint services which provided data collection, model identification, feedback tuning, feed-forward tuning and controller simulation. Lion then implemented ongoing loop monitoring with remote monitoring and service to sustain enhancements made to the production process. The result was an estimated $1 million per year in increased production and reduced off-spec waste byproducts.

Doing digitalization right

Each company must chart its own digitalization course, but there are several broad imperatives chemical firms should observe to realize the benefits noted above.

Having an enterprise-wide approach to digitalization is essential, but it's best to move toward the goal of complete digitalization in stages. It's also essential to have the support of executive leadership, specifically that of the CEO. This will ensure a common vision across the organization about what digitalization means and how to implement it.

The convergence of information technology (IT) and operational technology (OT) is a long-running trend, but it becomes acutely important in the context of digitalization. To a large extent, chemical firms are already doing this. Eighty-one percent report having merged their IT and OT groups to "create an integrated governance structure," and the bulk of the remaining 19 percent are considering doing so. [6] The use of open, secure systems allows data to be more easily and effectively shared throughout the firm's digital ecosystem. Similarly, where appropriate, companies need a way of securely moving that data to the cloud in order to obtain an integrated, near real-time overview and performance visualization of one or more facilities.

Simplification and standardization is another imperative, and this too is a trend in its own right. Utilities, for example, drastically reduce civil work and commissioning on site by using substation components that are built and tested at the factory. Chemical firms can do the same. Standardizing wherever possible lowers initial costs by simplifying designs and enabling onsite integration to expedite factory acceptance testing and cut deployment time. It also makes facilities easy to maintain going forward (e.g., standardizing procurement of motors around a few key sizes rather than buying and maintaining a multitude of units).

One imperative that impacts all the others is developing long-term partnerships with suppliers, not merely vendor-client relationships. In many cases, these companies can bring expertise and experience to bear that the chemical firm does not have in house. This helps to realize cost savings, for example, by engineering a new production line holistically, integrating control, power, safety and other elements from the outset. This largely eliminates the need for re-engineering as unforeseen conflicts come up during construction and commissioning because they have been worked out on paper in advance.

What's coming as digitalization matures

The business case for digitalization has been made in the chemicals industry for a variety of applications and is likely to expand even further. High-fidelity simulations (i.e., digital twin), AI-driven analytics, augmented reality and integrated process optimization are all on the menu. We're likely to see more massive, super-efficient sites like Sadara (see sidebar) along with an increasing reliance on non-proprietary open architectures as firms chase economies of scale.

In the short run, digitalization investments in these areas should bring better visibility and control over process variables, improved energy management and optimized maintenance of key equipment. These benefits will in turn yield lower O&M costs, better adherence to schedules and reduced overall risk, both in expansion projects and steady-state operations.

Case study

Sadara

With annual output of 3 million metric tons of plastic and high value-added chemicals, Sadara is the world's largest petrochemical complex. It uses 18 control systems with 260 workstations and 150,000 I/O devices. A single distribution system runs more than 50 fully automated production lines, and a single operator is able to take on a range of complex, interlinked tasks central to the efficient operation of the facility. A holistic Main Automation Contractor approach during design and construction reduced engineering costs by 25 percent compared to a traditional multi-vendor approach. In both its design and operation, Sadara stands as a template for the digital mega-facility of the future.

Endnotes

[1] Duane Dickson, Krishna Raghavan, Aijaz Hussain, Bob Kumpf, Deloitte, “The Chemical Multiverse 4.0,” 2017.

[2] Florian Budde, Obi Ezekoye, Thomas Hundertmark, Manuel Prieto, and Theo Jan Simons, McKinsey & Company, “Chemicals 2025: Will the industry be dancing to a different tune?” March 2017.

[3] Accenture & WEF, “Digital Transformation Initiative – Chemistry and Advanced Materials Industry,” January 2017.

[4] Jayant Gotpagar, Matthias Bäumler, Andrew Horncastle, Iris Herrmann, PwC, “Chemicals Trends 2018-19,” 2018.

[5] ABB data.

[6] Accenture, “Industry X.0 - Unlocking the power of digital in plant operations,” 2018.

[7] Deloitte, “Global Digital Chemistry Survey,” December 2016.

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