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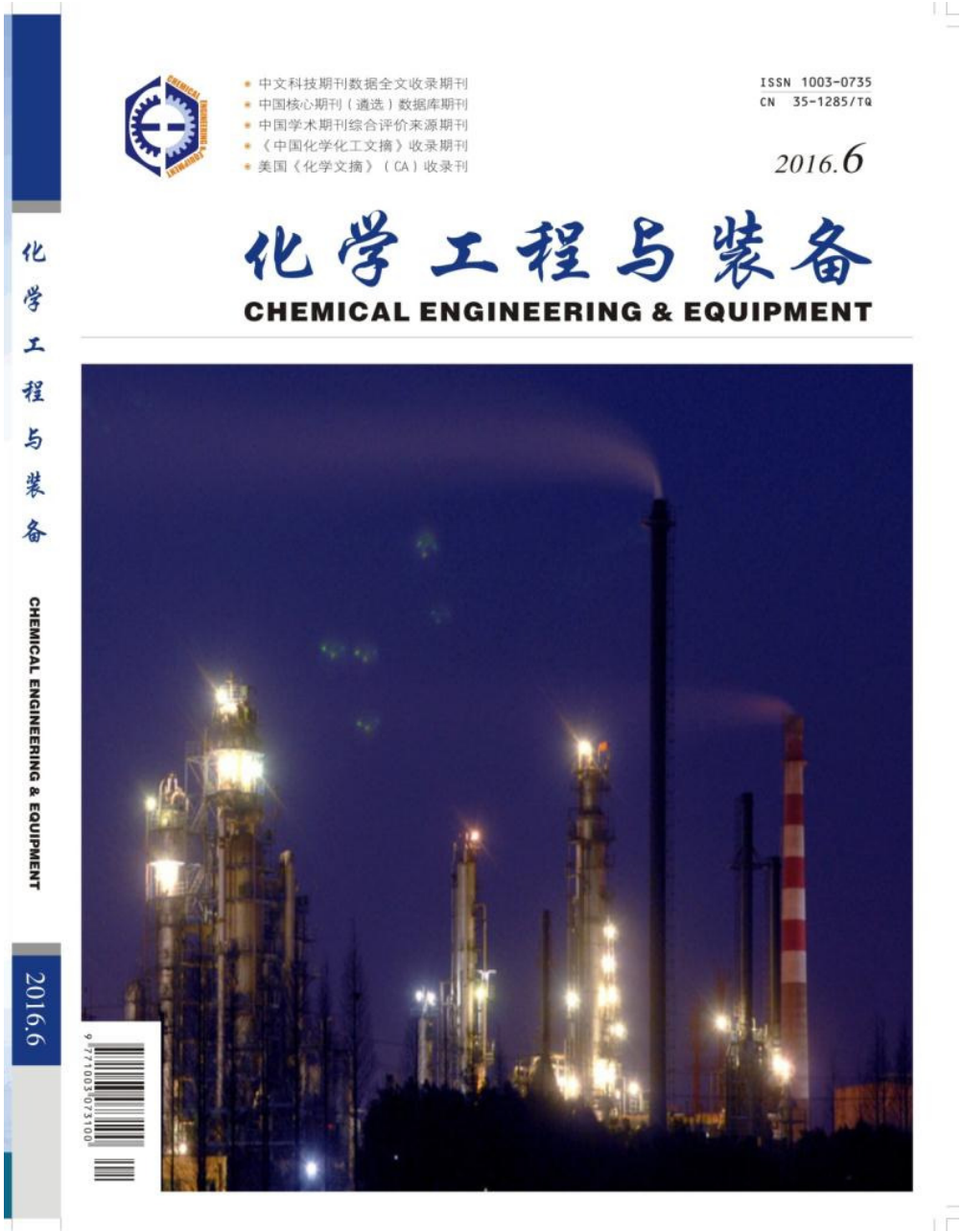
CHEMICAL ENGINEERING & EQUIPMENT

June 2016

Chemical Engineering and Equipment (China) – Develop a model based culture to optimize chemical production.

Co-attributed to VP Rob Howard and BC Dr Jimmy Zhu, this byline highlights how a model-based culture can help bulk chemical firms improve production performance in a competitive marketplace. (See appendix for full byline.)



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开发基于模型的决策支持系统 优化化工生产运营

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摘 要：降低成本对于基础化工产品生产厂商是非常重要的。通过采用基于模型的流程决策支持系统，实现工厂数据可视化，便可对过程工艺变量进行预测，灵活地处理运营中遇到的问题，以实现缩短代价较高的停工期、提高产能、改善产品质量和优化产品收率。

关键词：优化化工生产；基于模型的流程决策；数据可视化；卓越运营

引 言

化工是日常生活的基础。当今世界正经历着工业化和城市化的飞速发展，化工产品的需求正在形成日益激烈的竞争格局。为了应对市场的波动和严格的政府规章条例，化工产品生产厂商必须通过整合下游价值链以同时适应本地及国际竞争。这就要求生产厂商具有高运营效率、快速响应流程和卓越的技能，以从生产运营中获取更大的价值，满足客户需求。

为了保持盈利，许多大宗化工产品生产厂商专注于实施高效的运营措施，比如节省能源及使工厂装置的产能最大化。生产厂商采用基于模型的决策支持系统，利用最前沿的技术，即可灵活地处理运营中遇到的问题，获得最直接的效益。通过使用强大的工具，生产厂商可以缩短代价较高的停工期、提高产能、改善产品质量和优化产品收率。

1 从大宗化工产品生产中实现效益最大化

大宗化工产品行业为能源密集型产业，如生产的产品包括氨、硫酸、氢氧化钠、氯和乙烷等，其特点是产量高而利润低。这个行业成本中的约 60%为用于化工产品生产过程使用的原料或原材料。多数大宗化工产品作为中间产品，用于生产其它最终产品，如塑料容器或肥料等。大宗化工产品大体上分为四大类：有机化工产品，树脂、合成橡胶及纤维类化工产品，无机化工产品和农业化工产品。

根据美国能源情报署（EIA）的预测，到 2025 年，大宗化工产品的装运量价值将上升到 4290 亿美元。就这点而言，全球的化工产品行业在过去的十年中已经得到了飞速的发展，尤其在像中国这样的新兴国家。许多行业专家预测在未来十年中前十名的化工企业至少有一半来自中国和中东。繁荣的页岩气开发可降低原料成本，因此美国的化工行业也会保持相当强势。但是，激烈的竞争使得欧洲许多化工厂面临关闭威胁，其行业发展将持续低迷。

对于基础化工产品生产厂商而言，降低成本是非常重要的，业内的领先者已经达成了共识，认为技术可以显著地帮助提高工厂整体的运营效率。比如，普华永道最近对近 1800 位高级管理人员完成了一项“突破创新与提升”的调查，来自 12 个国家的 50 多家化工企业参与了这项调查，95%的化工行业参与者表示可以预见到未来三年里他们所在的公司将会应用创新的数字技术，50%的人期待着突破性或革命性的进步。

2 采用精确模型支持生产运营

优化软件上的投入可为生产和供应链管理提升运营可靠性、降低成本、并产生更优的运营效率。采用先进的集成化软件方案可帮助工作人员优化生产运营，同时捕捉市场机遇。为了应对运营中遇到的挑战， aspenONE 软件包能提供集成化解决方案，用于解决工艺设计、计划、调度和工厂运营全过程中的端对端的低效问题。部署了这些创新软件的生产厂商在一年内一个厂就能够创造数百万美元的效益，并且在几个月内而不需等待多年就可实现投资回报。艾斯本的解决方案为化工生产厂商带来在产量、质量、能源利用、运营成本和工艺灵活性等多方面的综合效益。其技术包括：采用先进过程控制系统（利用 Aspen DMC3 实现的 aspenONE APC）来控制生产过程；采用生产执行系统（具有实时优化功能——RTO 的 aspenONE MES，Aspen Infoplus.21，aspenONE Process Explorer）收集并分析工艺生产过程数据；采用集成化模拟软件（包含 Aspen HYSYS 在线模型的 aspenONE Engineering）模拟生产过程；改善供应链、同时用于工厂内外供应链管理优化的软件（aspenONE SCM）及提升过程工艺的软件（采用 aspenONE Engineering）。

对于工厂工程师来说，面对运营问题，能快速容易地找到根源是非常关键的。例如，采用 Aspen Simulation Workbook（ASW），工程师和操作员可以在他们所熟悉的

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Excel 界面使用严格的流程模拟软件。通过该软件，工程师可以在不干扰工厂运行的情况下确定变量的灵敏度，对不同工艺操作过程建立情境模拟，以处理生产过程中的不确定性。也可使用 ASW 来检测设备性能(如换热器、反应器和塔)，轻松确定最优的维修保养安排。一家领先的拉丁美洲化工公司近期在乙醇胺工厂采用 ASW，蒸汽使用量降低了 15%。

3 建立模型

当开发基于模型的决策支持系统时，其关键是实现工厂数据可视化并可对过程工艺变量进行预测。通过全方位的数据可视化，能知晓生产情况，即可对问题根源产生获得更深入的认识。过程工艺模型对工厂运营而言是非常有价值的，如果模型足够精细化，还可在与过程工艺数据相关的一定范围内可靠地预测工厂的真实性能。根据执行环境不同，可自行对数据进行处理以消除测量误差，模型可以请求式、日程式或事件驱动式运行。

使用艾斯本的集成化工具，工艺工程师可以对工艺装置建立模型，利用来自生产工程师的数据或工厂历史数据验证该模型。该模型可以用来确定不同的工艺操作条件。为工艺装置模型建立一个 ASW 界面，并将其在 Excel 中与工厂数据位号相关联，化工生产工程师就可以利用这个模型确定不同的操作条件。下一步是在线运行时调节模型。历史数据将被记录下来，这样生产工程师能够立即了解该模型在一段时间内的变化。在采用实时优化（RTO）对模型进行每周七天、每天 24 小时不间断的部署后，模型可每天自行校正，并把已优化的设定值提供给控制系统。由此工厂可以达到并保持高出以往的性能，并解放了工艺工程师大量的时间。使用 Aspen Custom Modeler 可以简便地创建独特而精确的过程工艺和设备模型，并能根据精度及简易性需求调整。该软件可为模型生成自定义的表格和趋势图，因此能够容易地展示对工程师有用的数据。

值得一提的是，艾斯本的实时优化 RTO 技术已在中国石化的燕山石化乙烯全装置全流程上获得了成功的应用。乙烯是一种重要的中间产品，优化乙烯生产过程可以帮助石化企业提升竞争力。

化工行业集成化软件采用一致性的模型和数据，支持跨功能协同。通过装置机理模型推动工艺改进和设计创新，企业可以：

（1）提高产能，节能降耗

（2）提高收率、产品质量和利润

（3）节省投资和运营成本

（4）提高工艺工程设计效率

（5）以较高的投资回报更快地将新产品和设计引入市场

4 模型带来的卓越运营

随着市场东移，化工企业持续面临商品价格的波动和日益激烈的竞争。许多全球性的化工企业即便在供给和需求方面面临着来自本地企业的强大竞争，他们仍努力拓展新业务。

需要采用整体性方法实现资产优化，应对瓶颈问题及克服运营方面的复杂性，以较低的成本生产高质量的产品，并提高产量。更好的运行策略可以缩减整体成本，该策略包括更优的能源使用、公用资源成本优化、运营工作流程的效率提升和维修保养成本降低，这些均能使生产厂商获得更高的盈利。运用领先技术建立在基于模型决策支持系统的大宗化工产品企业将提升端对端的生产性能，在不确定的市场中保持竞争力。

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于是质控管理以及数据的分析和应用，因此，环境监测人员不仅要熟练掌握监测的技术规范、方法以及原理，还要树立主动学习的观念，在日常管理过程要储备并且及时更新自动监测系统异常的诊断和处理，在日常工作中要做到认真观察、及时总结、探索规律，确保监测全过程处于受控状态，保障数据的客观性、有效性。

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APPENDIX

Developing a model-based culture – Optimising chemicals production

Chemicals are the cornerstone of everyday life. In a world witnessing increasing industrialisation and urbanisation, the demand for products is creating an increasingly competitive landscape. Against a backdrop of market volatility and stringent governmental regulations, chemical companies must adapt to both regional and global competition through the downstream value chain. This requires operational efficiencies, streamlined processes and appropriate skills to get the most value from the operation and to meet customer demand.

To remain profitable, many bulk chemical companies are focused on implementing operational efficiency measures, such as reducing energy and driving maximum throughput of plant assets. Those businesses which adopt a model-based approach to manufacturing, utilising cutting-edge technology, have the flexibility to address operational issues and achieve the most immediate benefits. With powerful tools, companies can minimise costly downtime, improve quality, increase throughput and optimise product yields.

Getting the most out of bulk chemical plants

The bulk chemicals industry is energy-intensive, producing products, such as ammonia, sulphuric acid, sodium hydroxide, chlorine and ethane, in high volumes and at low margins. Approximately 60 percent of energy use in the bulk chemicals industry is for feedstocks or raw materials used in the manufacturing process of chemicals. Most bulk chemicals are intermediate products used to produce final products, such as plastic containers or fertilizer. In general, bulk chemicals fall into four groups: organic chemicals; resins, synthetic rubber and fibres, inorganic chemicals and agricultural chemicals.

According to the Energy Information Administration (EIA), the value of bulk chemicals shipments is expected to grow to $429 billion in 2025. As such, the global chemicals industry has witnessed rapid growth over the past decade, particularly in emerging countries like China. Many industry experts predict that at least half of the top ten chemical companies in the next ten years will come from China and the Middle East. Taking advantage of the shale gas boom resulting in cheaper feedstocks in the US, the chemical industry there is also strong. On the other hand, Europe will continue to experience slow growth with the on-going threat of chemical plant closures due to strong competition.

Reducing production costs is important for basic chemical producers and there is a strong recognition amongst industry leaders that technology can help significantly in driving the overall operational effectiveness of plants. For example, PwC recently completed its Breakthrough Innovation and Growth survey of nearly 1,800 C-suite executive-level respondents, including some 50 chemicals industry participants from 12 countries. 95 percent of chemicals industry respondents said they foresaw digital technology innovation at their company over the next three years and 50 percent expected breakthrough or radical advances.

Supporting operations with rigorous models

Investments in optimisation software can increase reliability, reduce costs and create greater operational efficiencies in production and supply chain management. Embracing advanced integrated software solutions empower staff to optimise operations and take advantage of market opportunities. The aspenONE software suite addresses operational challenges by providing integrated solutions that tackle inefficiencies end-to-end throughout engineering, planning and scheduling and plant operations processes. Companies deploying the innovative software are able to generate millions of dollars of benefits per year per plant with payback in months instead of years. AspenTech's solutions bring broad benefits with respect to yield, quality, energy use, operational costs and process flexibility. This includes controlling the process with advanced process control (aspenONE APC with Aspen DMC3), collection and analysing data from the process with manufacturing executions systems (aspenONE MES with real-time optimisation – RTO, Aspen Infoplus.21, aspenONE Process Explorer), modelling the process with integrated simulators (aspenONE Engineering with Aspen Plus, models online), improving the supply chain, inside and outside the plant (aspenONE SCM) and improving the process (using aspenONE Engineering).

Making it easier to quickly get to the root cause of operational issues is vital to plant engineers. For example, with Aspen Simulation Workbook (ASW), engineers and operators have the benefits of using a rigorous process simulator through a familiar Excel interface. This helps engineers tackle process instability by determining variable sensitivity and creating what-if scenarios of different process operations without needing to disrupt the plant. Using ASW, it is also easy to determine an optimal maintenance schedule by monitoring equipment performance (i.e. heat exchangers, reactors, columns). A leading Latin American chemical company recently enjoyed 15% reduction in steam use in an Ethanolamine plant by using ASW.

Building the model

Being able to visualise plant data and predict values of process variables is essential when it comes to developing a model-based culture. Viewing contextual data alongside process data to show what is happening in production delivers greater insights into the source of problems. The process model drives value in plant operations and by being detailed enough can robustly predict real plant behaviour over an expected range of conditions linked to process data. The data itself is conditioned to smooth out measurement errors with an execution environment to run the model whether on-demand, scheduled or event-driven.

Using AspenTech's integrated tools, the process engineer can build a model of the unit and validate it against plant data from the production engineer and the plant data historian. The model is then used to identify alternate operating conditions. Building an ASW interface to the plant model and linking it with plant data tags in Excel, the chemical production engineer can use the model to identify alternate operating conditions. The next step is to reconcile the model as the model runs online. Data is then saved in the data historian, so the production engineer can see immediately how the model changes over time. After using Real-Time

Optimisation (RTO) to deploy the model 24/7, the model calibrates itself daily and provides optimised set points to the process control system. The plant is then able to reach and maintain capacities higher than ever previously seen and frees up significant time for the unit engineer. Using Aspen Custom Modeler makes it quick and easy to create unique process and equipment simulations that can be customised with accuracy and ease. The software helps to build custom forms and plots for customised models, so it is easy to lay out data in a way that makes sense to the engineer.

Interestingly, AspenTech's RTO technology has been successfully deployed at the Yanshan Ethylene Plant under Sinopec. With ethylene being the most important intermediary production process, optimisation is essential in helping petrochemical enterprises become more competitive.

Integrated software for chemicals supports cross-functional collaboration through the use of consistent models and data. By driving process improvements and innovative designs through rigorous plant models, companies can:

- Increase capacity and decrease energy
- Improve yield, product quality and margins
- Reduce capital and operating costs
- Increase engineering efficiency
- Bring new products and designs to market faster at a higher return on investment

Model for success

Chemical companies continue to experience volatility in commodity prices and increased competition with much of the market shifting eastwards. Many global chemicals companies are striving to tap into this booming business, even though they face strong rivalry from local companies in supply and demand.

Addressing asset optimisation needs to be done in a holistic way to tackle debottlenecking issues and overcome operational complexities to produce higher product quality and yields at reduced costs. Better operating strategies can reduce overall costs, which include better energy usage, utility cost optimisation, improving operating work process efficiency and lowering maintenance costs to help manufacturers be more profitable. Those bulk chemical firms that implement a model-based culture using cutting-edge technologies will improve end-to-end production performance and remain competitive in an uncertain marketplace.