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THE CUBICAL

June 15, 2023 - EHS & The Future of Manufacturing

What is *Process Intensification*? And Why Should You Know About It?

Over 20 years ago, my attention was captured by an article that appeared in the January 2000 issue of *Chemical Engineering Progress* (a monthly publication of the American Institute of Chemical Engineers, or AIChE). This article, entitled "Process Intensification: Transforming Chemical Engineering" and authored by Andrzej I. Stankiewicz and Jacob Moulijn, described a fascinating vision of the manufacturing plant of the future. The authors envisioned smaller manufacturing plants that could achieve efficiencies in production, energy usage, and waste generation through the use of novel techniques such as selective catalysts for reaction processes or combined multiple unit operations. (An example of the latter would be for chemical reaction and distillation processes to be combined into a single step.) All this made me wonder whether a chemical, steel, or pulp & paper manufacturing facility built in the 20th Century might start to look more like a semiconductor chip manufacturing facility by the middle of the 21st Century.

The concept of process intensification, or PI, has actually been around for quite some time. The energy crises of the 1970s forced refiners and manufacturers to design or retrofit their facilities to use energy more efficiently. In addition, advances in process control and simulation technology allowed engineers to model more complex systems. Although I underappreciated the fact at the time, I was exposed to some of these concepts early on in my career. As a young engineer at an oil refinery in the late 1980s, I had the opportunity to work around highly integrated process units that maximized

energy efficiency by transferring heat from hotter effluent streams to cooler feed streams. Prior to that, as an engineering co-op student, I was once assigned the task of evaluating a process simulation module that modeled chemical reactions occurring during distillation and other separation processes.

As we fast forward to the present, activity in PI remains strong, even if the priorities associated with this concept, as well as the definition of the term itself, have evolved. The concept of process intensification 20 years ago was primarily about making manufacturing plants smaller. Today, as the efforts to transition to a low-carbon economy accelerate, PI is more closely associated with maximizing energy efficiency to reduce carbon footprints. This evolution will have a significant impact on the intersection of environmental policy and regulation, and the drive to create the manufacturing plant of the 21st Century.

Author's Note: For those who are interested in further reading on process intensification, AIChE has a number of interesting resources, including more articles in Chemical Engineering Progress and other publications. In addition, the Department of Energy (with AIChE's participation) established the Rapid Advancement in Process Intensification Deployment (RAPID) Institute in 2016. To learn more about RAPID, you can visit their website by clicking here.

Process Intensification and M&A

Process intensification may present a number of interesting and potentially lucrative opportunities for investors. Manufacturing businesses that have achieved energy efficiencies by getting ahead of the PI curve may present strategic and financial buyers with opportunities to extract value and achieve ESG and sustainability goals at the same time. Such investors may also be attracted to the prospect of leveraging technological innovations associated with PI across their respective portfolios. Financial buyers who lack manufacturing experience may be enticed to wade into manufacturing sectors by pursuing businesses that have already reduced environmental footprints through PI initiatives.

While the intersection of process intensification and environmental policy might present investment opportunities, it may also present hazards to the unwary. Poor execution associated with process intensification efforts may create more problems than it solves. In addition, getting too far ahead of the PI curve may negatively impact a business's value proposition. Among other things, financial buyers may be scared away by the inability to leverage PI technology across other portfolio companies.

A number of environmental due diligence and negotiating issues are likely to arise in the course of efforts to acquire businesses that have engaged in process intensification efforts. First and foremost on the minds of the buyer will likely be issues of valuation. If the claimed environmental benefits of intensified processes are a significant part of the value proposition, then the prospective buyer will want to confirm that such benefits are actually being realized. And, even if such benefits are being realized, the buyer may have a different opinion with respect to their valuation. To the extent that there are any data gaps, the prospective buyer will likely want to seek representations, warranties, and/or other guarantees from the target business regarding any claimed environmental or other benefits associated with PI technology.

The prospective buyer will want to determine whether the target business has obtained

any regulatory relief in exchange for committing to process intensification efforts. If such relief has been obtained, the prospective buyer will want to confirm that the target business is in compliance with any conditions to which it has committed in exchange for such regulatory relief. Depending on the significance of the regulatory relief and associated conditions, as well as the novelty of the operations, the prospective buyer may want to seek representations, warranties, and other guarantees that go beyond the customary and usual environmental compliance representations and warranties.

The prospective buyer will also want to determine whether, and to what extent, intensified processes are contributing to the target business's ability to achieve its ESG and sustainability goals. Similarly, the prospective buyer may also want to analyze the energy efficiency, water usage, and other key environmental performance indicators associated with the intensified processes to identify any potential synergies associated with the prospective buyer's efforts to achieve its own ESG and sustainability goals.

Process Intensification: Build a New Facility? Or Expand Existing Capacity?

The drive towards process intensification may have a significant impact on the question of whether to build a new facility, or to expand existing capacity. There are a number of factors that finance managers and operations managers must weigh with respect to this question. Similarly, environmental professionals must weigh a number of factors when considering the regulatory implications of whether to build or expand.

As an example, consider the case of a chemical manufacturing business that would like to transform its operations from a traditional configuration of reactors, distillation columns, heat and energy generation, and storage of raw materials, product, and intermediates, to a new configuration utilizing combined unit operations and minimal intermediate storage. Intuitively, one would think that it would be easier to develop such a transformative operation by building a new facility. However, a suitable site may not be easy to find. In addition, efforts to develop a new facility may run into opposition from the local community. Similarly, regulatory objections may be raised on the basis of considerations of environmental justice if the facility is being built in an area that regulators consider to be unduly burdened. Finally, the regulatory burdens associated with building and operating a "new source" may be significantly greater than the regulatory burdens associated with expanding an "existing source."

On the other hand, expanding existing capacity, rather than building an entirely new facility with *intensified processes* might be less of a burden from an environmental regulatory standpoint. However, challenges associated with "fit" may still exist. Technically and operationally, an expansion consisting of intensified process units may just not fit very well if they are radically different from process units at an existing facility. A poor fit may negate at least some of the benefits associated with capacity expansions that have reduced materials, energy, and logistics footprints.

The decision of whether to build a new facility or expand existing capacity will likely be driven primarily by the economics of competing project alternatives. However, these economics may be impacted by the environmental considerations noted above (i.e., building a "new source" versus modifying an "existing source"). Some of these environmental considerations (i.e., considerations of environmental justice) may be significant and complex enough to warrant consideration independently of the economics of competing project alternatives. Finance managers, operations managers,

and environmental professionals will need to be cognizant of these considerations when evaluating process intensification opportunities.

Process Intensification: Permitting & Compliance Considerations

Given its potential role in the drive towards a low-carbon economy, one might reasonably expect the opportunities associated with process intensification to outweigh any potential environmental permitting and regulatory challenges. The most immediate such benefit might be realized in the area of process safety. Processes that consume smaller amounts of raw materials and energy, have fewer steps, and have unit operations with smaller numbers of rotating machinery and equipment are likely to be safer than more traditional processes. Since process safety management is regulated by both OSHA and EPA, engaging in process intensification efforts may enhance a facility's overall OSHA and environmental compliance performance. It may also reduce the regulatory burdens associated with process safety management compliance. This may be of particular importance when considering how much stress EPA has placed on concepts such as inherently safer technology (IST) and safer alternatives analysis in efforts to reform its process safety management regulatory program, the Risk Management Planning (RMP) Rule.

Incorporating process intensification into capital expansion projects may also eliminate or at least minimize any potential permitting hurdles associated with such projects. Reduced amounts of water consumption associated with such processes may reduce the burden associated with the need to obtain permits to NPDES permits. Similarly, reduced amounts of emissions and energy consumption may reduce the burden associated with the air permitting process.

Looking a little further down the road, intensified processes that have been widely adopted may eventually become the basis for applicable technology-based standards. In addition, if policymakers begin to see the benefits associated with process intensification, they may offer incentives to engage in process intensification efforts. Such incentives may include participation in alternatives to traditional regulatory compliance programs, along the lines of OSHA's Voluntary Protection Program (VPP) model. Finally, now that Supplemental Environmental Projects (SEPs) are back in vogue, settlement opportunities may emerge for businesses embroiled in significant enforcement disputes with EPA if such businesses are willing to commit to process intensification initiatives.

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