Modular Construction Encourages New Applications

The efficiency and cost effectiveness of modularity provides advantages for small- and large-scale projects

When the right conditions exist, the benefits of modular construction — from laboratory scale to large scale — are plentiful and allow single-source, cost-effective and efficient construction of new or expansion projects in the chemical process industries (CPI). Furthermore, these same advantages lend themselves well to many emerging applications, permitting new processes to be explored, proven and scaled up so they can get to market faster.

What is modular construction?

Modular construction is a method by which a plant or single process, including all the required process equipment, instrumentation, valves, piping, components, controls and electrical wiring, is fabricated and mounted within a structural steel skeleton, known as a module. Modules are designed, built and tested at an offsite fabrication yard or facility and then transported by truck or barge to the final location, where they are set in place. A module may stand alone or multiple modules may be connected to each other or to existing infrastructure. A module may be a small, single skid with laboratory-scale equipment, a single truckable process module or there may be multiple modules that are joined almost like Legos to form a large process system or an entire plant.

Wood

FIGURE 1. It is not the size of the project that makes it a good fit for modular construction, rather it often has to do with the complexity of the project. Shown here is a complex module designed and built by Wood

When modular makes sense

"There are several advantages to modular construction versus traditional, stick-built construction if it is done in the proper way and with the right approach," explains Giampiero Trivella, senior vice president of process and chemicals, Europe & Africa, and site operations director with John Wood Group plc (Wood; Aberdeen, Scotland; www.woodplc.com). "It is not necessarily the size of the project that makes it a good fit for modular construction, rather it often has to do with the complexity of the project. There are cases where, regardless of the size, it is usually beneficial and less expensive to go with a standard stick-built approach" (Figure 1).

Grant Girouard, business engineering manager with Zeton (Oakville, Ont., Canada; www.zeton.com), agrees: "Modular is not always suitable. For instance, a simple project, such as adding an instrument rack or a system for flow distribution of a chemical that requires just control valves, flowmeters and piping, is something that can be more easily and cost effectively installed on site. In cases where it is not complicated enough to warrant modular construction, you lose the value of going modular."

Additionally, if a project is too large, it may not make sense to go modular. "For truckable modules, the diameter of columns, vessels and tanks must fit within a 12-by-14-foot footprint in order to fit on the truck," says Mauricio Villegas, business development manager with Koch Modular Process Systems (Paramus, N.J.; www.kochmodular.com) (Figure 2). "However, if the project really lends itself to modularization except for the diameter of a column or a vessel, we can find a way to incorporate it into the design and ship these for placement next to the module so they may be tied into the process. This is what we call a hybrid module."

Koch Modular Process Systems

FIGURE 2. The components in truckable process modules, including columns, vessels and tanks, should remain within a 12-by-14 foot footprint in order to fit on the truck for transportation to the site. Shown here is a process module designed and built by Koch Modular Process Systems

The location of the fabrication yard is also an important consideration, notes Wood's Trivella. "Going modular can be more costly or less expensive, depending on the location of the fabrication yard and the cost of labor in that area," he says. "There may be high transportation costs, especially when ships are required for overseas transportation of megamodules. There are times when the cost of labor may be low in the area of the fabrication yard, but the transportation cost to the location may be high, or vice versa, so there is a cost balance that needs to be assessed

DeDietrich Process Systems

FIGURE 3. Thoughtful evaluation of all factors is a necessity when considering modular construction for any size project. Shown here is a modular filter dryer system with integrated contained discharge designed and built by DeDietrich Process Systems

in the early stages when considering a modular project."

Another consideration, especially when dealing with adding a modular process to an existing facility is whether there are site restrictions, says Todd Pollack, engineered systems business unit leader with DeDietrich Process Systems, Inc. (Mountainside, N.J.; www.ddpsinc.com). "You need to be able to bring an entire module into the facility, so if there is not sufficient access, then bringing the equipment in as multiple modules or piece by piece and stick-building it in place may be more appropriate."

He continues to say that thoughtful evaluation of all factors is a necessity when considering modular construction for any size project: "People think they are getting a skid that is dropped off and they just push a button to get started, but that's not realistic, especially with larger systems. There is a defined boundary of scope and other design issues, such as electrical, controls, structural, installation and startup on modular systems, that need to be understood between all parties," says Pollack. "There is no single question to answer to determine if it makes sense to go modular. Every project has different goals, objectives and prioritizations" (Figure 3).

The advantages

Still, experts are quick to point out that in the cases where modular construction is a good fit, if it is properly carried out and makes financial sense, there are several significant advantages.

One of the greatest benefits is the fixed price, says Koch's Villegas. "Modular projects offer a fixed price very early in the design stage that is plus/minus zero for a complete modular system, whereas stick-building projects can be cost reimbursable or convertible to a lump sum halfway through the detailed engineering stage, which can be as far as six months into a project," he explains. "It has been reported that an estimated 25% of stick-built projects fail due to cost overruns. Because modular offers a fixed price, it reduces the risk of cost overruns."

Another noteworthy benefit, says Wood's Trivella, is safety. "Modules are done in a fabrication yard, which is specifically arranged for construction activities and, as such, to be a safer environment than building on site in facilities. Because safety can be more easily managed, laborers are not exposed to the process environment where other units may be in operation and nor are they at great heights."

In addition, using a fabrication yard may also reduce costs. "Because the yard is a controlled environment, it is not exposed to, or at the mercy of, weather and has a consistent workforce. This means you are not bringing in craft labor from different regions, putting them up in camps and paying them per diem, so it is possible to greatly reduce costs. We see an average of 30% overall project savings," says Villegas.

And, because the construction is handled at a dedicated fabrication yard, not on site, it permits a "parallel path," says Zeton's Girouard. "When stick building, the order of operations and logistics can be quite complicated and includes getting permits, preparing the site, coordinating procurement and delivery of equipment and then coordinating the labor. Modular construction allows more flexibility," he says. "You can be in the design stage while permits are obtained, then while the site is prepared, the modular builder can procure and receive equipment and coordinate construction in the fabrication yard, while also condensing the schedule and crew required for construction. Typically, all this can be coordinated

A WORD ABOUT CONTROLS

While the control of modular projects was previously a challenge, automation providers and modular construction firms have stepped up their game, making this concern a thing of the past.

"Conventionally, process engineering systems were set up to precisely control a plant or a process," says Thomas Bertsch, head of process industries, North America, with Festo (Islandia, N.Y.; www.festo.com). "On the plus side, this means they are precise, but on the minus side, it means they are not flexible. The principle of traditional automation works if the required product remains the same in terms of quantity and characteristics. It also means that when new products or processes are introduced, changing conventional control systems takes a lot of time, so in these cases and in the case of modular processes, it makes sense to use a different approach."

Today, he says, experienced automation experts rely on standardized communication between individual modules, which allows a "plug-and-produce" approach. "Think of it like today's consumer electronics, where you have a computer and connect a mouse or keyboard without installing drivers or software. This concept is similar to today's automation for modular designs," says Bertsch.

He explains his company's four steps to automation of modular plants as follows:

- First, process engineering is broken down into sub-processes and a Process Equipment Assembly (PEA) that includes all the mechanical and automation technology components for autonomous operation are defined for each sub-process.
- Step two involves modularizing the automation. Each PEA consists of a decentralized controller, remote-I/O components and pneumatic controls with all field functionalities pre-programmed.
- The PEAs are interconnected to form a process system and each of them provides its specific functionality via an interface that is standardized according to Module Type Package (MTP), which serves as a standardized software interface between the PEA's controller and the process control system of a modular plant. A lean Process Orchestration Layer (POL) coordinates the functionalities in the overall system, while the MTP facilitates smooth and fast integration of the equipment.

Using the modular approach described above, systems can be built according to preferences and current requirements. The Festo MTP-compatible library provides not only all the function blocks defined in the MTP standard, but also some specific pneumatic functionalities. All these functions bring the visualization symbols needed to monitor and the faceplates needed to operate the equipment and help simplify the process of defining complex services. ❐

FIGURE 4. Modular construction firms typically have project managers, procurement, project designers and engineers in various disciplines on site, so anything that needs to be adjusted can be handled in the fastest and most seamless way, which means there is a significant reduction in time to market. Shown here is a turnkey modular system that EPIC designed and built for installation at a customer's facility

so that we are ready to deliver when the site has been prepared."

Koch's Villegas continues to say that this arrangement also provides greater efficiency and productivity during construction. "A typical modular project — including detailed engineering, fabrication and delivery — takes an average of 10 to 15 months to execute, depending on scope and complexity, while the same project, if field constructed, can take 18 to 24 months. So modular construction can typically shave six to eight months off a project's timeline," he explains.

Thanks to parallel scheduling and single-source responsibility, modularization often allows processors to bring projects to market faster, says Kenny Reekie, vice president of sales and marketing with EPIC Systems, Inc. (St. Louis, Mo.; www.epicsysinc.com). "In addition to sequential scheduling and building, modular construction firms typically have project managers, procurement, project designers and engineers in various disciplines on site, so anything that needs to be adjusted can be handled in the fastest and most seamless way, which means there is a significant reduction in time to market" (Figure 4).

Encouraging new applications

The ability to bring a project to market faster and at a lower cost with fewer risks makes modular construction very appealing to new applications, such as those in the sustainability field, which is growing rapidly due to governmental regulations and corporate sustainability initiatives.

"We are seeing a lot of activity in the decarbonization and sustainability space," says Koch's Villegas. "These are small to mid-sized projects, so all the columns and tanks fit within the required space constraints for transportation via truck. In addition, they are looking for the fastest time to market."

Biofuels, bio-based chemicals, recycling of plastics and battery technologies are very popular applications that lend themselves well to modularization. "In addition to being of the right size and offering the required time to market, many of these products compete with an existing hydrocarbon-based product, so there's usually a narrow gap on whether or not the projects are commercially viable," says Villegas. "The margins are thin, but going modular with its cost savings gives them the needed cost advantage to make it work."

In addition, many sustainability-based projects are emerging technologies that are not yet ready for full-scale production, says EPIC's Reekie. "They are interested in modular construction because it makes it possible to cost effectively scale up from R&D to pilot scale and beyond," he says. "As they come out of R&D laboratories, they want to make sure they have the process refined and can make it at scale without sacrificing the integrity of the product, so they must go through the intermediate step of pilot scale before full-scale production. Many of these projects rely on modularity because it not only allows speed to market, but also provides the flexibility to move the process to different locations and gather data from the process if it is automated properly, which can help further refine the process before going to full-scale production, which can also be accomplished modularly."

FIGURE 5. For applications that have a high-value/low-volume output, such as designed drugs and semi-conductor chemicals, going modular addresses the need for cost effectiveness and when done via a pre-validated, standardized process module, such as Zeton's ContiUnity technology, it allows a continuous process

Koch's Villegas adds that modular construction is attractive in emerging applications with potential for growth because it also provides repeatability. "Going modular allows performance benefits related to scalability and repeatability. Because many modular designs are made to be interconnected like Legos, we can design systems to be initially delivered as small-scale facilities to meet the current demand and then, as demand increases, we can deliver additional modules that can be bolted on to increase capacity. This is an important advantage in a circular economy and where sustainability projects are concerned."

Modular construction is also beneficial for applications that have a high-value/low-volume output, such as designed drugs and semiconductor chemicals, says Zeton's Girouard. "Not only does going modular address the need for faster time-to-market and cost-effectiveness in these applications, but when done properly with a pre-validated, standardized process module [Figure 5], it allows high-value products to be made in a continuous process, versus as a batch, which is not only more efficient, but also reusable, transportable and contained within a smaller footprint."

With today's current economic challenges and sustainability initiatives, chemical processors of established products, as well as those with emerging products and processes, may find that, under the right conditions, modular construction provides significant advantages. ■

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