Modules and Connectors Cut Construction Costs

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Rising energy prices make efficiency a primary objective for many industries, particularly power generation. One of the fastest growing power generation technologies is the high efficiency gas turbine (GT).

In many utility systems, GTs are used to provide power on demand. Unlike relatively larger coal-fired and nuclear base load generation facilities, the power output from GTs can be ramped up and down very quickly. This characteristic is especially important in modern electrical power systems for two reasons.

First, utilities need peaking power that can be ramped up rapidly to temporarily satisfy high demand, typically experienced on the hottest summer days. Second, utilities need a power source that can be quickly ramped up or down to compensate for the intermittent nature of renewable power sources such as wind and solar.

To satisfy peak power demands, utilities worldwide are increasingly turning to GTs, but these versatile power sources have an Achilles heel. The power output from a GT decreases as the outside ambient air temperature and humidity increases, so peak power may not be available when it’s most needed (Chart).

Fortunately, there’s a solution: If the inlet air of the gas turbine is cooled, the output power lost due to high inlet air temperature can be recovered.

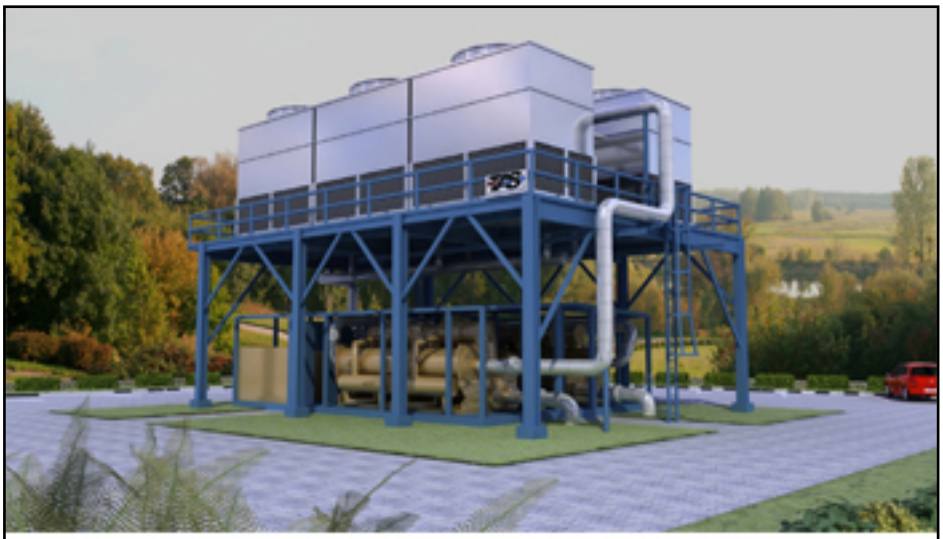

Figure 1. Turbine inlet chilling systems are constructed in modules like these and shipped to the site. The total system is split-up into container-size modules for transport, cutting and conveyance costs.

To accomplish this air cooling, turbine inlet chilling (TIC) was pioneered in the mid-1980’s in commercial and industrial markets by the company that I work for, TAS Energy (TAS, www.tas.com [1]), and is now used by power producers worldwide to increase the output and efficiency of power generating GTs.

Our turbine inlet chilling systems correct the derate effect caused by high ambient temperature and humidity. By cooling the inlet combustion air, GT output is increased by 12-30%, depending on the GT model and the climate conditions.

Modules Make Sense

As the demand for power increases, current infrastructures are often found inadequate to meet energy needs, and site-built infrastructure solutions tend to be costly and time intensive. We had to make our existing systems not only more efficient, but we had to build in the shortest and most economical time frame possible. Modular construction was the solution, provided via packaged TIC systems built by our company in our Houston facility.

These TIC systems are provided for gas turbine, commercial HVAC and data center applications—and for organic Rankine cycle systems for low temperature industrial and geothermal power generation. All of these systems are packaged in single or multiple modules designed to reduce total costs, decrease total schedule and leverage the advantages of standardization available in a factory environment.

Our TIC systems are constructed with each system having a maximum size, and therefore capacity, limited only by shipping constraints. Each module is a self contained chiller plant, and when extra capacity is needed, we simply add more modules. This approach allows us to standardize TIC module construction, and provides many benefits to our customers.

Many industries are turning to modularization as an improvement to traditional on-site construction, and power generation is no exception. With modularization, components and subsystems are built and tested off site, typically at the OEMs facility, then shipped to the site. Once on site, these modules are interconnected with other modules and with components and subsystems constructed on site.

Modularization has many advantages over on-site construction. Construction safety is a huge issue for commercial industrial facilities, and a great way to reduce the number of OSHA-recordable incidents is to cut on-site construction hours. Not only do modules shift construction hours off site, they also increase overall safety because module construction can be performed in a controlled shop floor environment.

Labor efficiency is another reason for off-site module construction. Operating facilities introduce a host of inefficiencies including security gate check in, compliance with union work rules, work permit procurement, and coordination with plant operations and other crafts. Off-site craftsmen can devote more hours to actual work, and are often more efficient because they work on the same types of systems day in and day out.

When subsystems must be added to existing installations, modules are often the best alternative as total space requirements can be reduced, and as downtime can be cut to an absolute minimum.

With modules, there is a definite alignment of interest between the OEM and the client as both parties favor comprehensive off-site skid testing. It is much cheaper for a module builder to perform shop testing and minimize on-site commissioning and start up effort. This dovetails with client desires to have delivered systems up and running as soon as possible.

Because modules are completely tested before arriving on site, power plant operators gain single source responsibility for any issues, not always the case with the inherent complexities of on-site construction.

When fully tested modules arrive at a site, the main remaining task is connection to on-site utilities and to other subsystems and components. Reducing the time required to complete this task is a primary goal of TAS, and it’s one of the main reasons why we make extensive use of power and signal connectors.

Making Connections On Site

Installing our TIC systems on site can be a challenge, particularly as many systems are retrofitted and must often be shoehorned into existing facilities. Consequently, we’re constantly looking for ways to simplify and expedite on-site installation, with modularization of the TIC systems being the preferred solution.

TIC modules require three types of connections: process, power and signal. Process connections are primarily chilled water piping from the module(s) to the GT and condensing water piping to onsite-cooling towers.

A hardwired three phase connection is required from the existing plant utility system to provide primary operating power to the modules. For projects with multiple modules, the bulk of our TIC systems, the modules then need to be connected to each other for primary three phase power, secondary single phase power and control signals.

On each TIC multi-module system, we designate one module as the primary power source, and this master module’s Motor Control Center (MCC) is hardwired to the plant’s power source. Primary three phase operating power is then hardwired from this master module to each of the other modules.

Secondary single phase power for module utilities such as air conditioning and lighting is also distributed from the MCC to each module, and this secondary power distribution among the modules is accomplished using Phoenix Contact (www.phoenixcon.com [2]) Pluscon connector systems.

The master module also contains the programmable logic controller (PLC) needed by each TIC system to provide control and monitoring. Wiring to and from this PLC is distributed to other modules as needed, also using the Pluscon connectors.

At the site, it took about three days for the module connections to be re-terminated, with a couple of days more to clear out any improper connections before final commissioning could take place. This on-site activity is undertaken by an outside

contractor, and time and cost became issues.

Using connectors considerably reduced the time it took to reconnect the modules, down to about a day or less, from five days or more using hard wiring. In addition, the connectors greatly reduced the incidence of incorrect wire terminations. Finally, on-site contractor costs were substantially reduced.

Figure 2. Power and signal connectors mate to junction boxes mounted on Turbine Inlet Chilling modules, cutting on-site installation and costs.

Before selecting the Phoenix Contact connectors, we evaluated competing solutions. At the time of selection, we were already using Phoenix Contact terminal blocks and were pleased with their performance, so it was natural for us to consider the company as a connector supplier. Taking into account the different types of signal wiring as well as our power needs, we found that no other supplier offered industrially rugged connectors that could meet our requirements.

There were some design challenges, including identifying the higher ampacity connectors with the correct size hub to accommodate the increased cable sizes. Also, we were initially using too many different types of connectors and complicating our designs, but since then we've been able to standardize on just three (3) types: 6-pin, 12-pin and 24-pin.

Finally, we also needed to ensure that all power sources would always end with female rather than male connectors, as this guarantees that connectors are still touch-safe in the event of an accidental disconnect while power is live. If a power source ends with a male connector and the same situation occurs, an OSHA-reportable incident would likely occur due to the presence of unprotected live connector pins.

Now that our connector design is standardized and implemented, we're realizing multiple benefits in addition to the aforementioned installation advantages. Once the connections are tested at our shop, splitting the modules is clean and easy, and

on-site reconnection is quick and accurate. Connectors lend themselves to spare capacity, so future additions have become much easier to wire.

Pluscon connectors are robust, heavy duty and well suited to our application. Termination unto the male/female pins requires extra hours at our shop, but the reduced time needed in the field during installation and start up more than compensates.

We’re seeing new customer demand that will require us to develop non-standard products, both smaller and larger in overall total system footprint. For larger capacity projects, that translates to more modules and more split points, further driving the need for expanded use of connectors.

TIC systems help our customers run more efficiently. Delivering these systems as modules provides a host of benefits to our customers, and also helps our company control the construction process more closely while reducing costs. Using connectors to link these modules at our customers’ sites provide further benefits to our company, and most importantly to our customers.

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[1] http://www.tas.com
[2] http://www.phoenixcon.com