Expertise in Turbomachinery Controls

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# Knowledge in Control


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The most successful installations of turbomachinery control systems are the ones that result in the successful integration between technology, application expertise, and process know-how.

It was 1965 when Gordon E Moore made an interesting observation; he noted that the number of transistors in a typical dense integrated circuit doubled approximately every two hours. This meant that one could practically ‘cram more components” into electronic devices. In simple terms, computing power improves exponentially in very short time periods.

This phenomenon was later re-evaluated by Caltech professor Carver Mead, who coined the expression “Moore’s law,” proving that Gordon Moore’s conclusions held true over time. This technological miracle has been the engine behind innovations that touch every single aspect of our lives, including medical devices, transportation and communications. Industrial control and monitoring systems are no exception to this rule.

The ability to control plant machinery with high precision, reliability and speed, is now well known. Both Programmable Logic Controllers (PLCs) and proprietary control platforms are able to detect process changes from analog or digital field sensors, and provide responses within milliseconds. The computing power enables several million lines of code to be stored. This level of sophistication may even exceed the requirements of the most complex plant control and monitoring systems.

One could argue that advances in controls technology have far outpaced the great strides made in process knowledge and optimization techniques. An example can be seen in the advanced applications of neural network systems in process optimization. Self-learning systems help plants reduce waste, increase output, and improve overall production planning. Yet a cautionary tale remains: computing power without control and process knowledge is virtually worthless, and in some cases even counterproductive.

Almost everyone in the industry will agree that ageing control systems can provide adequate functionality for decades. However, recognized best practices tell a different story. Systems should be updated before they reach mature life for the following reasons:

- Electronic components cannot escape the pre-written destiny of the Weibull distribution curve, as their likelihood to fail increases exponentially as it approaches wear out life.1
- Old systems are far less capable than current ones. Imagine using 20 year old computer or mobile phone devices, or trying to use 1980s desktop computer while trying to function in today’s world. Technology improves quickly and owners/operators must leverage its power to run plants. There is little or no choice but to update a plant’s systems at ever shortening time intervals. This especially true for critical applications such as turbomachinery control, vibration monitoring, and safety shutdown devices.

On the other hand, owners/operators cannot rely on technological advances alone to run plants. The most successful installations of turbomachinery control systems are the ones that result in the successful integration between technology, application expertise, and process know-how. While this may seem like a basic requirement, examples where at least one of these ingredients is missing often occur, with costly consequences for the end user. When investing in a new system, it is important not to make technology the only criterion, and to remember that domain knowledge is as indispensable as ever.

To further illustrate the point, this article describes a selection of recent case histories. There are all real life scenarios, reported by Compressor Controls Corporation (CCC)’s field engineers.  Names and locations are omitted for obvious reasons. The objective of the case studies is to illustrate typical shortcomings and outline a more complete approach to turbomachinery controls.

## Involve the controls systems partner from specification to completion of commissioning

An LNG plant in Southeast Asia took a proactive approach to ensure a smooth commissioning and start-up process. The plant had new compressor configurations that had not been used before for this

particular LNG process. CCC was asked to help integrate its emulation software with the plant controls in order to predict possible process upset scenarios.
The plant's challenge was to ensure that the automated start-up and shut-down procedures of parallel units were in accordance with changing operational requirements and production. The controls emulation system contained all of the same detailed routines and instructions that would eventually be difficult feature to replicate in the overall plant simulator, so the emulator technology by itself provided excellent value. But even more important was the pre-start-up engineering support provided by the CCC field engineer. Working side-by-side with the end user and the EPC contractor, the team tested an array of start-up and shut-down scenarios as well as possible process upset scenarios, ensuring that the overall plant and machine control routines were completely synchronized prior to commissioning of the plant.

The established baseline configuration reduced the time to commission the plant, and the upfront simulation allowed the team to thoroughly test for many scenarios in multiple occasions, without any actual start-ups taking place.

The final outcome of this exercise provided a dual benefit. First, the potential risk of process upsets affecting the compressor was greatly reduced. Second, the overall commissioning and start-up procedure went smoothly without delay. Engaging the right people and using updated technology up front in the process paid off with immediate results.

## Application Knowledge

Sometimes operators have conservative control measures in place for what they believe to be good reasons. During a service visit to a refinery, CCC learned that an operator had severely damaged a fluid catalytic cracking unit (FCCU) axial compressor of two separate occasion of the plant, it was imperative to identify the fundamental cause and implement a corrective action. During the investigation, it was discovered that the plant had set parameters in place to eliminate potential operator error. While original idea was to protect the compressor at all costs, the operator did not realize that this approach was costing them millions of dollars in lost revenue.

The root of the problem originated when the plant set the surge limit line (the minimum flow point below which the compressor becomes unstable) without the required application and process expertise. This set point is critical for a plant's overall process efficiency. When an operator error led to a process disturbance, actions were taken to adjust the minimum and maximum flow control parameters very conservatively. While this seemed like a reasonable business decision, the plant did not realize that this decision would cost them in terms of lost overall efficiency. The newly adjusted control parameters had been set using baseline values that had been collected during a single surge test, and were no longer a true representation of current operating conditions.

During scheduled outage routine visit, CCC performed the step of verifying the sure line. The compressor was run on the surge control lone (SCL) between the minimum and maximum inlet guide vane (IGV) parameters. The compressor operating window was re-adjusted to be more in line with current operating conditions. This improved safety and throughput at the same time. A simple tuning exercise resulted in millions of dollars in increased production. Furthermore, 'system optimization' should be an ongoing process rather than a single event.

## Audit critical control set points

A plant asked CCC to tune its suction pressure control response after refurbishing the suction throttling valve. As part of its maintenance and observation of the running process, CCC identified a problem with a throttle valve setting. The 'low clamp' (also referred to as the minimum level of allowed valve opening) was much higher than required. This was due to the fact that the original setting was based on plant conditions that no longer existed. The low clamp setting led to excessive recycling in order to reduce discharge pressure. After calculating and reconfiguring the appropriate value for the low clamp, recycling was greatly reduced. The customer achieved significant energy savings and was surprised that a routine retuning resulted in an increased efficiency of the process.

This is another case where the system worked as designed. It provided timely response and did what it was asked to do flawlessly. Without application knowledge, the plant missed the opportunity to adapt set points when process conditions changes. Unfortunately, the static set points resulted in considerable cost unit the issue was successfully rectified.

## Utilizing features

A plant experienced a series of unwanted shutdowns due to running a critical axial compressor in choke condition for an extended period of time. This condition caused excessive blade stress and eventually led to a major machine failure, with a very significant lost production cost impact, even without accounting for the large compressor repair bill. The plant performed a root cause analysis with CCC's support. After accurately identifying the actual choke line for the compressor control system, the unit was able to return to safe operation. Tremendous expense would have been prevented had the value of the simple feature, a choke line alarm, been understood and utilized.

## Collaboration

A plant operator contracted CCC requesting assistance in troubleshooting operational and control issues in a remote location. The compressors were shipped with OEM standard controls. For the first eight months after the original commissioning date, the OEM and end user engineers had little to no success in starting up the compressor. As the platform was failing to produce tens of thousands of condensate per day, losses were beginning to stack up into tens of millions of dollars, with no end in sight.

Upon review, it was discovered that the problems affecting the platform were mainly due to lack if controls flexibility. They could have been avoided with better collaboration between the OEM, control system vendor and end user in the early design stages. The review of piping layout resulted in the addition of suction throttle valves and modifications to the controls algorithms that enabled the plant's successful start-up. Lost production could have been avoided with better design oversight.

## Conclusion

Keeping technology up to date is in plant's best interest; however, technology alone cannot effectively control critical machinery without the right application knowledge and process know-how. Combining the right expertise and the latest technology will help owners/operators achieve their safety goals and production targets.

## Reference

1. For a more detailed explanation, visit www.weibull.com

## About The Author:

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