EMBEDTEK

Intelligent Analytics Solve a Piston Valve Guessing Game

EmbedTek recently worked with a leader in steam turbine manufacturing to design a cohesive and intelligent system that monitors valve health in real time. We accomplished this by leveraging our embedded systems expertise and our understanding of their market and business needs to develop a fully functional and reliable solution.

In a power plant, steam turbines carry high pressure steam from a boiler to a generator that converts it into power. Piston valves controlling the flow of steam in a turbine are critical to the operation. Valve failure is not an option for plant operators because the fallout could be costly, or even catastrophic. With no tool to predict when a valve will fail, power plant operators proactively remove and rebuild steam turbine piston valves every few years. This process is expensive, time-consuming, and often premature.

A steam turbine manufacturer recognized this and set out to improve its end user experience by developing a system that monitors piston valve health. The system connects to a variety of sensors including thermal, position, and vibration sensors that are time synchronized and logged for analysis when the valve actuates. Once applied in a power plant, operators can rely on intelligent analytics to know if a valve is functioning properly, or if it is operating in a degraded state. Then, when needed, they can plan for maintenance or a full replacement accordingly.

System Design Considerations

To ensure the system is fully functional, "hardened" and designed for manufacturability, our engineering team took into consideration:

- Systems Environment
- Component Availability
- Second-source Availability
- Component Lifecycle
- System Diagnostics
- Testing

The OEM enlisted EmbedTek's help once its internal R&D team had completed a proof of concept. The original prototype used a combination of off-the-shelf consumer grade components and some industrial components. EmbedTek set out to redesign the system to ensure that it is fully functional, "hardened" and designed for manufacturability. Our engineering team took into consideration the systems environment, component availability, second-source availability, component lifecycle, system diagnostics, and testing.

> "Just like the piston valve cannot fail, neither can the monitoring system."

Device Consolidation

The original proof of concept prototype consisted of multiple discrete sensor interface development boards connected to a commercially available processor board. This provided a method to rapidly prototype a system with a wide range

of sensors including accelerometers, thermocouples, pressure transducers and other sensors. Although this was a great approach for a proof of concept, it was not designed for high reliability in a challenging environment.

EmbedTek designed a solution that consolidated the various interface development boards and processor into a single board that could connect to all the required sensors. This provides a high reliability design by minimizing components and interconnects as well as allowing the selection of parts properly rated for the environment.

Our software engineers optimized the data acquisition drivers allowing high speed data capture while maintaining compatibility with the latest embedded operating system Board Support Package (BSP). The custom acquisition driver seamlessly integrated with the existing customer application allowing the device to communicate with a server or a PC located within a power plant.

Our engineers used pieces from different projects as building blocks to solve this challenge. EmbedTek has created multiple sensor and data acquisition systems for its work in medical devices, security, material handling, and simulated training industries. A processor from an industrial door controller helped get the team to the core of what was needed for the piston valve monitor, with the addition of more sensors. Our engineers leveraged a Power-Over-Ethernet implementation used for an automated license plate reader to provide data and power in the new system.

Long-Term Reliability

In order for the new design to meet all of the design goals, it needs to withstand the environment where it is installed, and manufacturing needs to be supported by a reliable supply chain.

The enclosure for the piston valve monitor was designed to both accept the heat generated by the board and operate in temperatures ranging from 176 Degrees F and 194 Degrees F (80-90 Degrees C). The enclosure is rated Ingress Protection (IP) 67 to prevent dust and water from getting inside.

EmbedTek recommended a specific 32-bit ARM processor SKU because it provides the necessary peripherals while maintaining a controlled, long product lifecycle. The prototype from the manufacturer used a general purpose development board and build of the operating system that was not designed to provide long term stable and deterministic behavior which is required by a true embedded product.

Our software engineers built a custom tailored Linux based OS and the updated data acquisition drivers to ensure stable performance. The software is designed to continue running without interaction for potentially years.

Cost-Effective Solution

Plant operators will be able to communicate with the piston valve monitoring system at any time to know it is on and responding. When the valve actuates, they collect the data allowing them to understand the health of the piston valve.

The OEM's goal is to work with all of its existing and future turbine customers to install the valve monitor because it is a more cost-effective solution, and ends the guessing game of rebuild and replace.

> **"The cost of sensors, processing units, and other intelligent analytics have been driven down over time. Ten years ago, this technology solution would not have been feasible."**

EmbedTek partners with OEMs and ISVs to develop IoT solutions by combining imaging and sensor technology with intelligent analytics. We have spent decades developing application specific computers, integrated displays, and custom I/O solutions for OEMs. Our expertise has expanded to include cameras, sensors, analytics, machine learning, and AI. Throw any challenge at us, from demanding environment and ergonomic requirements to High Level Assembly and nonstandard I/O. We'll evaluate it, carefully attack it, and solve it.

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