CUSTOMER CASE STUDY

Prevention intervention: Using predictive models to detect anomalies in gas turbine compressors

Pampa Energia - www.pampaenergia.com
Industry - Power Generation

Goals

- Create a predictive maintenance algorithm to detect deviations. Alert operators to issues to enable them to take preventative action prior to a major event occurring

Challenge

- The control system could not detect anomalies in gas turbine compressors before catastrophic failure

Solution

- AVEVA™ PI System™

Result

- Quickly identified potential issues, performed necessary maintenance, and avoided massive expenses associated with asset breakdown
- Given the success of the project, the company is working to leverage these predictions for its other critical assets

At 12:30 a.m. on August 14, 2018, one of Pampa Energia's operators at Genelba Thermal Power Plant detected a step change in the vibrations inside a compressor bearing casing. The velocity in the 17-stage gas turbine unit moved from 2.1mm per second to 2.8mm per second and power decreased by .5 MW. While this behavior was unusual, no alarm appeared in the control system. After shutting down the unit to perform a full inspection of the compressor and turbine sections, they found that the material on the stage 14 inner ring was damaged and on the verge of breakdown. The operator's expertise not only prevented the asset from failing, the company avoided a $7-million-dollar repair bill.

Pampa Energia was fortunate the operator caught the anomaly, but the absence of any alarm from the control system was troubling. Rather than rely solely on operators to prevent catastrophes, Pampa Energia decided to use PI System data to create a predictive maintenance algorithm to detect deviations and take preventative action.

The intersection of IT and OT

Pampa Energia is the largest independent energy company in Argentina. The company operates upstream and midstream oil and gas operations, a downstream refinery, and thermal power plants, hydro power plants, and wind farms. After the near-catastrophe in the gas turbine unit at Genelba, it was clear they needed to bolster digital transformation efforts by aligning IT and OT. "OT and IT alignment reduce risk for an organization. Not only do you get better data access, but you also get the stability and virility of an IT infrastructure for an OT environment," said Gabriela Maria Romero Dutruel, system engineer at Pampa Energia, during the 2020 PI World Online conference.

Starting with the Genelba plant, the process team built predictive maintenance algorithms using operational data from PI System and leveraged IT tools to take preventative action.

Efficiency calculations using PI System data

As a first step, the process team analyzed PI System data before and after the bearing vibration step change incident. Root cause analysis identified a slight, yet irreversible decrease in compressor efficiency two days before the operator found the fault. Isentropic efficiency of a compressor is defined as a ratio of energy that would be transmitted in an ideal process to the energy supplied in a real process. At the time of the failure, Pampa Energia didn't have an online isentropic calculation for the compressor. However, even if they had the calculation, it would not have detected the failure in advance because the decrease was only 0.4%.

Next, the team built the online efficiency calculation using PI Explorer and analytics. They then performed a backfill for all of 2018 using PI System data to ensure it detected performance anomalies. This allowed Pampa Energia to calculate efficiency values and develop parameters. Next, they built predictive models in Python and Panda and trained them using PI System data. They enlisted polynomial features and multivariable linear regression models to calculate efficiency based on active power, compressor inlet temperature, and inlet pressure.

The resulting graphs showed calculated-versus-predicted efficiency, any correlation between the two variables, and unit temperature and pressure.

Upon analysis, they discovered that the model coincided with the calculations in the days before the failure occurred. However, after the failure, the calculated efficiency decreased, departing from original model's calculations. "So the next question is: how can we capitalize on what we have learned, and what can we do so that a failure of this type does not happen again?" said Walter Adad, process engineer at Pampa Energia. "The answer is PI."

Predictive models to avoid future catastrophe

Once the models were built, engineers imported the coefficient containing the efficiency calculations from the Python models into PI Asset Framework (AF), the contextualization layer of the PI System. This enabled them to calculate efficiency, predictions, and view any deviations within a two-day window directly in AF. This functionality gave users an easy way to evaluate gas turbine compressor behavior.

The PI Integrator fit this need and has enabled productionising of a machine learning app allowing the development of advanced predictive analytics. The machine learning app uses open source software and is combined with Microsoft Power BI to visualise the results.

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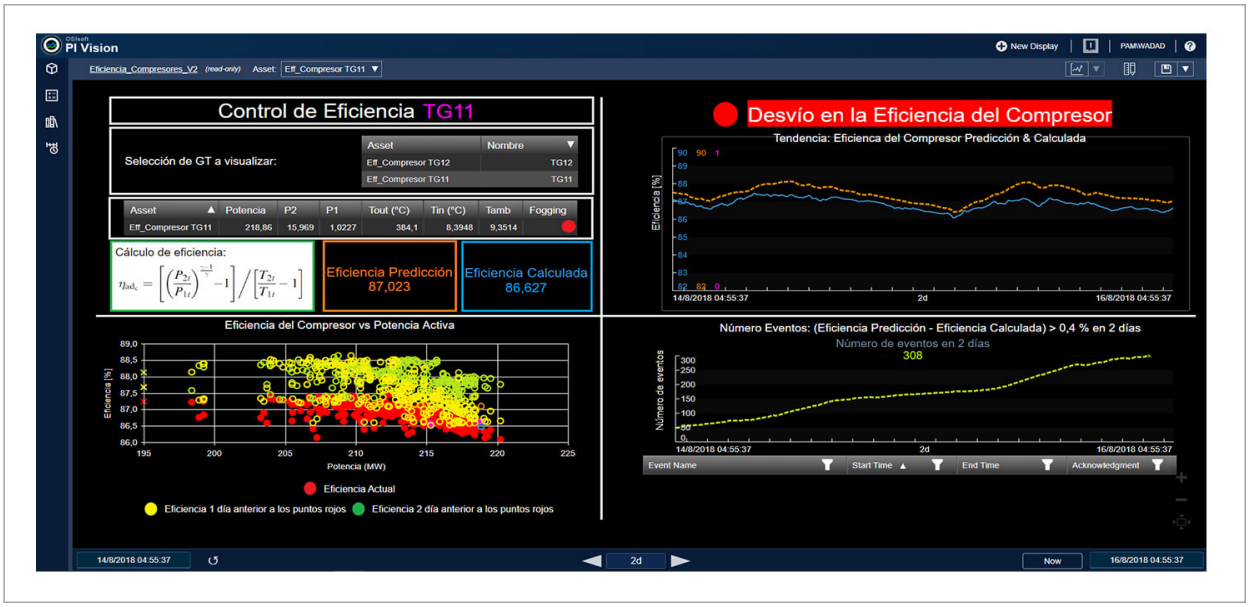
> **Walter Adad**
> Process Engineer at Pampa Energia



Rapid Visual Analysis: PI Vision screens highlight asset health and predictive outcomes, quickly enabling operators to make data-driven decisions.

Once the backfill was performed, the process team used AVEVA™ PI Vision to visualize calculated and predicted efficiency as a function of time. The system automatically sends alerts if the number of anomalies exceeds set thresholds and the PI Vision screen shows a green, yellow, or red header depending on the state of the units. Operators and other stakeholders can now quickly identify when calculated efficiency deviates from predictions and see the number of anomalies that have taken place over the past few days.

With this solution, they can detect even the slightest deviation and would have been able to identify the 0.4% decrease just prior to the initial failure.

Thanks to AVEVA PI System, Pampa Energia successfully implemented a predictive algorithm that helps operators make better decisions and avoid catastrophic failure. Given the success of the project, the company is working to leverage these predictions for its other critical assets.

For more information about Pampa Energia and AVEVA PI System, please visit: **aveva.com/en/industries/power-utilities/power-generation**

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