



## Anomaly Detection - Going Beyond Condition Monitoring

### Introduction

Plant operating profits are a function of Thermal Performance & Reliability. In many industries like Defense, Power, Oil & Gas etc., reliability of equipment is a very important factor and it is common to see machines operating for long durations without any outage. Forced outages of any critical equipment in such industries result in huge financial losses and reduce operational preparedness.

Reliability of equipment can be maintained to certain extent by following best practices in O&M, RCM techniques etc. However, with the limitations of existing monitoring systems, industries are losing significant amounts of money every year due to failure of equipment. Statistics indicate that such losses are in the tune of millions of dollars per year in forced outages. ***It is interesting to note that the initiating factors in many equipment failures originate as minor anomalies.***

### Anomaly

Anomaly can be described as a discrepancy or deviation from an established rule or trend. Every machine/process has a unique operating profile or "signature". This signature is the response of the machine or process to various internal and external factors under given conditions. Various instruments mounted on machines (like temperature, pressure, vibration, flow, current, voltage etc.) indicate the response of the machines to such conditions.

Various types of anomalies occur in industries –

- Equipment Anomalies
- Process Anomalies
- Instrument Anomalies
- Data Anomalies

### Anomaly Detection - Predictive Analytics

Advances in data analytics give us the capability to use a combination of modeling tools and Predictive Analytic techniques to build behavioral "signatures". These signatures in turn are used to "predict" various process parameters.

Such signatures are built using Thermodynamics, Artificial intelligence and/or Statistical methods depending on the parameter we are trying to predict. They are very sensitive and are extremely accurate at modeling even complex processes.

A significant deviation between "Actual (measured) value" and "Predicted value" indicates a deviation in its behaviour. This deviation usually is the onset of an anomaly.

Proprietary algorithms differentiate between sensor issues and real anomalies and also calculate the "confidence level" of prediction to reduce false positives.

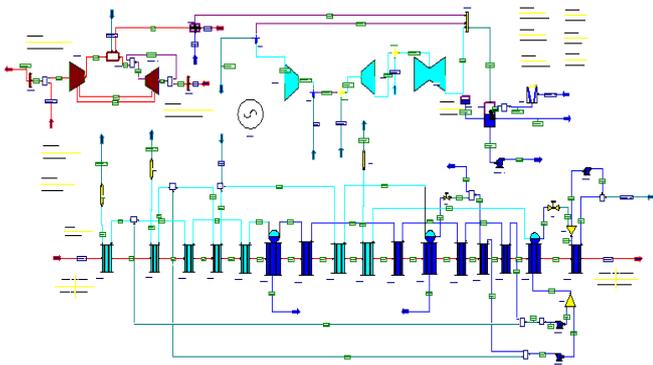


## Advantages of Anomaly Detection Systems

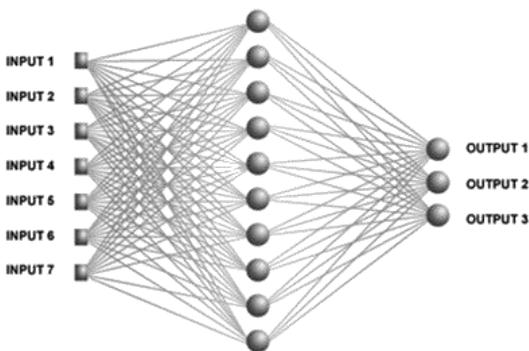
- 1. Identify problems that go undetected by normal procedures**
  - Reduce forced outages
  - Improve safety
- 2. Helps plan maintenance actions in advance & improve operational preparedness**
  - Man power planning
  - Procurement of Spares

## Hybrid Modeling Techniques

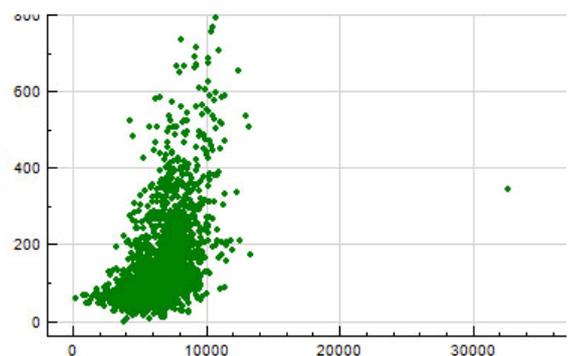
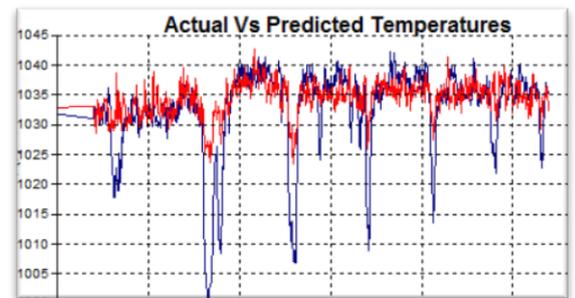
We use a combination of Neural Networks, Statistics and detailed component level Thermodynamic models to analyze data and identify anomalies. Such Hybrid models reduce false positives and provide additional information on the health and degradation of various major and minor components of any industrial equipment.



**Thermodynamic Models**



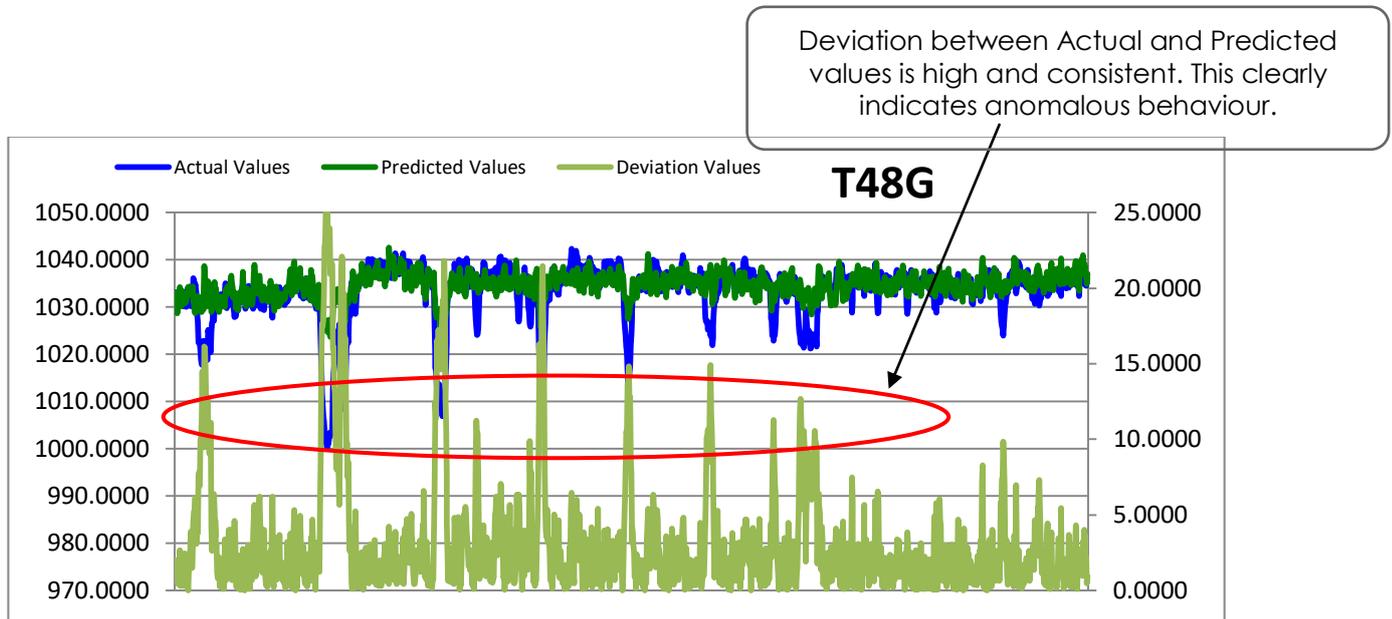
**Neural Networks**



**Statistical Methods**



## Example of Anomaly Detection in LM2500 Gas turbine driven mechanical drive



## Application of anomaly detection in Power & Oil and Gas Industry

Some examples of systems related to Power/Oil&Gas Industry that can be accurately modeled are –

1. Anomalies in Gas Turbines and Steam turbines
  - a. Bearing vibrations, Temperatures
  - b. Exhaust Temperatures (combustion related anomalies)
  - c. Disc cavity/Wheelspace temperatures (cooling flow related anomalies)
2. Boilers and Heat Exchangers (Lube oil, Cooling water etc.)
3. Anomalies in Pumps & Compressors
4. Feed Water heaters (LP & HP heaters)
5. Anomalies in Major Fans / Motors
6. Anomalies in Generators
7. Detecting Process issues (bypass stack leaks, bypass valve leaks, pressure, temperature control and recirculation valve passing etc.)
8. Condenser and ejectors issues
9. De-mineralized water system etc.
10. Emissions (combustion system related anomalies)

Predictive Analytics can be used on any data where correlations exist between variables. This means the technology can be applied to ANY power or process industry equipment.

**It is to be noted that even if a single anomaly is detected in its entire life time of the software, such an anomaly detection system would have paid for itself many times over!**