GE Oil & Gas

Steam Turbine Model-Based Control (MBC)

Next-generation, condition-based performance optimization enabled by Steam Turbine Digital Twin

Our advanced system continually records, analyzes and visualizes data to enable online control, optimization and monitoring of the steam turbine's performance.

The Model-Based Control algorithm, stemming from Steam Turbine Digital Twin, is embedded in our new units, and can be applied to any existing reaction steam turbine installation.

BETTER CONTROL FOR HIGHER PERFORMANCE

See reverse for more details on these valuable tools:

- Rotor stress control
- Predictive control of inlet & extraction valves
- Adaptive pre-positioning of bypass valve
- Life counters & steam swing
- Speed measurement & diagnostics

Rotor stress control

This control software package is designed for applications where startup time and power optimization are critical to overall plant performance — particularly in discontinuous operations such as solar power, combined cycles, etc.

As a significant improvement over the traditional approach where steam turbine startup is controlled with a predefined and fixed set of loading curves, alarms and trip settings, our Model-Based Steam Turbine Smart Governor 2.0 (ISTG 2.0) continually computes rotor stress by monitoring operating parameters and sensors data (e.g. casing temperatures and differential pressures) to automatically optimize control parameters and trip limits based on the turbine's actual dynamic conditions.

For cold starts, the system enables an average 15% higher energy output, and 20% faster loading. For warm starts, the typical power increase is 5%, depending on casing temperature. The software can also increase or limit power during regular operation — to continually optimize performance while avoiding excessive stresses and trips.

Our new units can all be equipped with the required sensors to enable dynamic stress control. On existing installations either operational parameters estimation by Model Based control or retrofitting by minimally invasive instrumentation can be considered to enable this functionality.

Predictive control of inlet & extraction valves

In applications where the turbine is designed to control multiple process variables, traditional proportional/integrative/derivative (PID) controllers need long and complex tuning to minimize the interaction between the control loops of inlet and extraction valves. That setting is condition-dependent, and might need to be tuned again if the process changes significantly.

Our innovative ISTG 2.0 system uses a much simpler approach with an intrinsic robustness to the variability of boundary steam conditions. The controller uses the digital twin's input and output predictions to regulate the multiple process variables. At each control cycle, the commands applied to the valves are the result of an optimization algorithm on the multiple target set-points and process measures.

This method allows fast responses with reduced overshoot. It minimizes undesired deviation of controlled process variables (flow, pressure, power, or speed) and reduces erosion of inlet and extraction valve components.

Adaptive pre-positioning of bypass valve

Traditional bypass valves are configured at installation, and are not able to account for any process variability.

ISTG 2.0 enables fast pre-positioning of the turbine bypass valve during fast transient events. The valve takes just two seconds or less for full stroke run under control signal.

Steam Turbine Digital Twin provides the feed-forward control loop with a reliable model of inlet and extractions to estimate the actual steam flow at the given working conditions — ensuring a smooth, bump-less control in case of trips or load rejections. Thanks to the model-based control, the bypass valve is quickly set to keep a constant consumption of the steam mass flow as the one recorded just before the event.

With this new adaptive action, header pressure can be quickly re-established — 2X faster than currently possible. The new functionality reduces risk of undesired upset on main header steam flow and pressure as consequence of the turbine shutdown or load rejection. It also helps avoid a domino effect on other plant equipment.

Life counters & steam swing

By monitoring life counters and steam swing, the digital twin software can alert plant operators when machine behavior exceeds IEC/NEMA indicators — providing early alarm detection, and the ability to prevent alarms with proper system tuning.

The life consumption of a steam turbine can be monitored based on key indicators such as the number and type of starts, turbine condition (hot, warm, cold), running hours, and factored operating hours. The digital twin system collects data monthly, and up to 25 years of data can be saved with full historical view capability in the dedicated HMI summary screen.

The software also monitors and records variations in the steam temperature and pressure at the turbine inlet while in operation. Alarms and trips are generated based on the operability and monitoring rules defined in IEC60045 or equivalent NEMA SM 23. The alarm criteria is based on one year of temperature and pressure calculations, the data for which are stored in non-volatile memory so no information is lost in case of a PLC power outage.

Speed measurement & diagnostics

The steam turbine and its load are instrumented with dedicated speed probes for control and protection actions. The ability to detect any potential anomalies in the probes configuration settings results in quicker control panel installation and machine maintenance checks — as well as more robust calibration and over-speed system test.

In addition to traditional diagnostic functions, ISTG 2.0 compares the values acquired by the probes with the estimates generated by the digital twin model using the steam inlet/outlet conditions (pressure and temperature) and commanded inlet valve stroke. This additional diagnostic function enhances the ability to identify potential anomalies, to avoid abnormal critical conditions and associated time loss.

Online monitoring of the installed probes continues during normal operation, and any potential discrepancies in their readings will be quickly and easily identified on the new dedicated HMI.

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