IMPROVING PLANT EFFICIENCY THROUGH THE INSTALLATION OF TecSOLCEP ONLINE MONITORING SYSTEM

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ABSTRACT

In February 2016, Nuclear Energy Institute (NEI) launched its "Delivering the Nuclear Promise (DNP)" strategic plan with the objective of reducing electric generating costs by 30% across the nuclear power industry by 2018. Improving efficiency has been addressed as one of the strategic focus areas in the plan. In nuclear power plants (NPPs) there is room for improvement in main components efficiency and TecSOLCEP is a software tool that has proved its value for that purpose.

TecSOLCEP is a software tool for monitoring, diagnosing and quantifying performance deviations in Power Plants. It faithfully follows the methodology of ASME standards. Over 15 years of success stories in more than 50 electric power plants of different technologies worldwide, justify the benefits for the plants. The implicit concept in TecSOLCEP is "Benefit based Maintenance" (BbM) as complementary to usual maintenance strategies like time-based, condition-based or predictive. These maintenance strategies are oriented to obtain the Safety and Reliability goals shared by all the electricity generation technologies. BbM is oriented to get the maximum economic benefit by Efficiency care, which historically has not been a priority, especially in nuclear plants.

BbM applied with the help of performance monitoring tools like TecSOLCEP, is called to play an important role to improve efficiency which, in plants mainly operating at full power, is equivalent to increase the maximum power. Nuclear power plants that intend to extend their lives may also take advantage of identifying and quantifying inefficiencies in equipment to better address necessary investments.

Key Words: Efficiency improvement, O&M Cost reduction, Online monitoring, Digital I&C, Maintenance

1 INTRODUCTION

TecSOLCEP was born in 2000 hatched by PMSA with the collaboration of the utility Endesa. PMSA was a small Spanish firm led by Pablo Moreno, a Man and Engineer with a capital letter: Nuclear Engineering and MS from MIT, PhD from UPM, member of the Thermal-Hydraulic Committee of the American Nuclear Society, the NY Academy of Sciences and the Sigma-Xi Scientific Research Society. A few months before his death, in 2014, PMSA engineers and assets were hosted by Tecnatom where they have encountered a home and a place to continue developing their skills, integrating them with the world-wide recognized Tecnatom capabilities in the energy and nuclear fields.

TecSOLCEP is a software tool for monitoring, diagnosing and quantifying performance deviations in Power Plants. It faithfully follows the methodology of ASME standards [1]. Although it was initially created to be applied in coal plants, its scope has been extended to combined cycles, concentrated solar power and

nuclear plants; and the focus on heat rate now also covers maximum power. TecSOLCEP is now running in 54 plants over the world, where 16 years of successful stories have become economic benefits for the plants.

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In February 2016, the Nuclear Energy Institute (NEI) launched its "Delivering the Nuclear Promise" strategic plan [2], with the objective of reducing electric generating costs by 30% across the nuclear power industry by 2018. Improving efficiency has been addressed as one of the focus areas of the plan. So, BbM applied with the help of performance monitoring tools like TecSOLCEP, is called to play an important role to improve efficiency which, in plants mainly operating at full power, is equivalent to increase the maximum power.

Along with BbM, TecSOLCEP also takes care of Operational Optimization which is particularly important for plants operating at variable loads, with different configurations and fuels, or even starting and stopping regularly.

BbM should say us when a maintenance action, restoring the efficiency of an equipment, is beneficial from the economic point of view. This equation has three terms: first, the losses associated to deviations; second, the cost of maintenance or equipment substitution actions, which may also include the need to stop the plant; and third, the estimated degradation rate after restoration. TecSOLCEP gives information about the first and third terms, helping to take the best decision. The second term, in nuclear plants, can be evaluated and programmed well in advance because maintenance actions must be taken only during refueling shutdowns.

Nuclear power plants that intend to extend their lives may also take advantage of identifying and quantifying inefficiencies in equipment to better address necessary investments.

2 TecSOLCEP MONITORING TOOL

2.1 TecSOLCEP Aims

The main purposes of performance monitoring tools like TecSOLCEP for nuclear plants (although they are shared by all electricity generation technologies) are explained below.

The first aim is to obtain a quantification, as accurate as possible, of the current plant situation using only the process instrumentation. This includes the thermodynamic state and mass flow rate at every relevant point of the circuits. In nuclear plants, only the non-measured steam quality at the steam generators outlet is assumed as a constant parameter. It should be determined yearly by a test (i.e. by calorimeter or tracer methods).

Thermodynamic states and flows are obtained using a power balance in the turbine axis along with global and partial mass and energy balances in the Rankine cycle, heaters and MSRs, with a minor assumption about the last drain fraction. All these balances are nested and solved iteratively.

Real-time or historical data are read from the existing monitoring and control systems at the power plant. In the most common case, OSIsoft PI mirror server in the corporate network is the data source. Cyber security is a fundamental aspect of TecSOLCEP installation strategy as plant critical digital assets (CDA) shouldn't be exposed to threats.

Non-instrumented flows are estimated from control valve opening, taking field measurements or conducting specific tests.

Also, key performance indicators (KPIs) of equipment and plant, which are used in the diagnostic process, are obtained. Figure 1 shows briefly the calculation scheme.

The second aim is to determine, as precisely as possible, individual target values of every parameter, equipment and system, which affect net heat rate and maximum power.

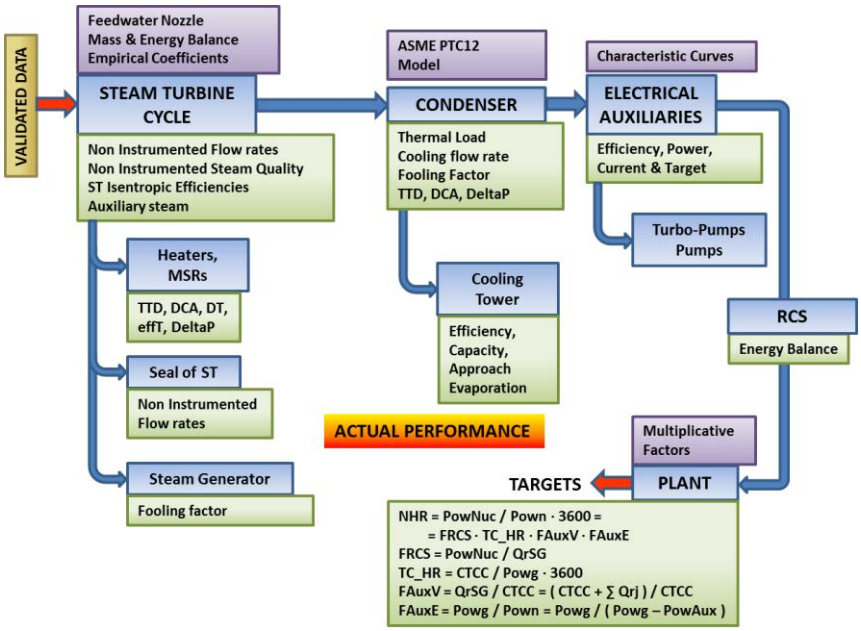

Figure 1. Plant Status Calculation Block Diagram

Target values are obtained from many sources: steam turbine design data, design balance of plant, acceptance tests, equipment design data and characteristic curves, statistical regression of historical data best records (i.e. electric auxiliaries or make-up water), and small simulation models (condenser, cooling tower, etc.).

Target values also consider non-recoverable degradation of existing equipment or plant modifications with new and more efficient equipment, being the steam turbine the main of them. It is recommended to review target values after every overhaul and especially after a turbine overhaul.

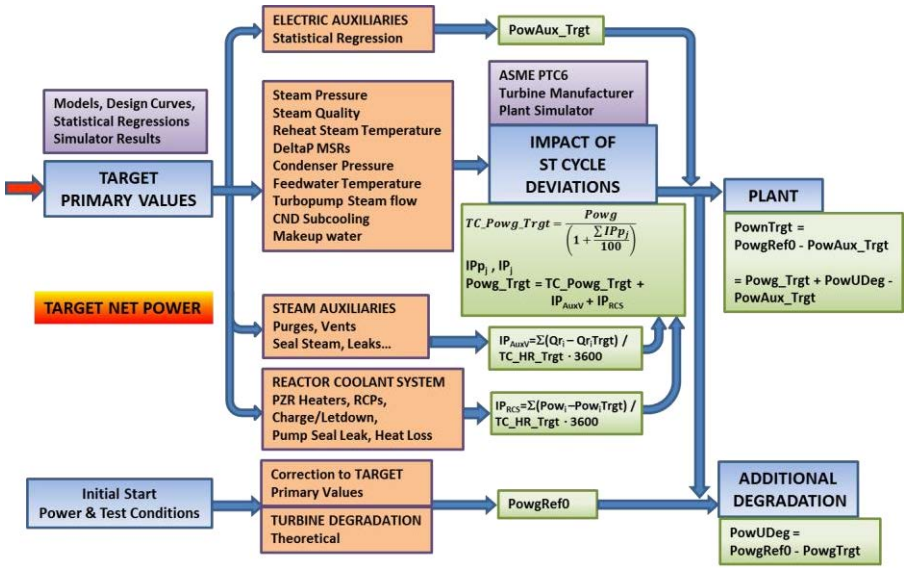

Figure 2. Individual Targets and Net Power Target Calculation.

And the third aim is to calculate the contribution of each system, component and operational parameter, to the deviation of heat rate and maximum power. This constitutes the main set of values for BbM. The impact of deviations is expressed in energy units for heat rate, in MW for power, and in monetary units for both. Figure 2 shows all the primary parameters considered in a generic model.

The impact of a single deviation on heat rate and power is obtained mainly from the steam turbine vendor technical documentation. Nevertheless, this is not the only source as extensively validated (against real plant behavior and transients) simulators are preferred to obtain impact functions.

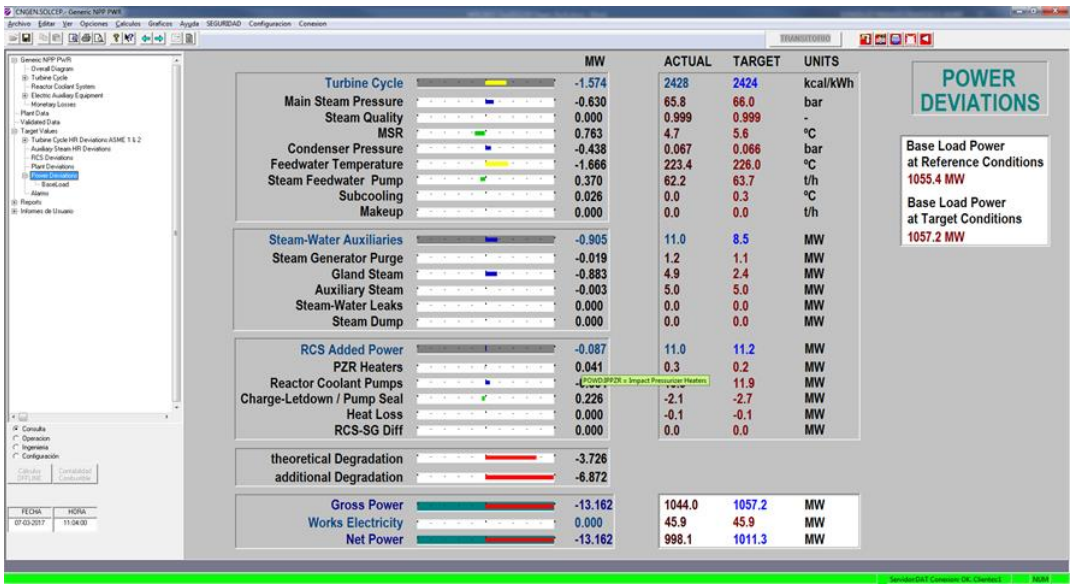

Figure 3. Bar-Screen: Contributions to Power Deviations.

TecSOLCEP results are collected on screens for on-line visualization and on reports for average and accumulated results. Figure 3 shows the main screen for power deviations.

2.2 TecSOLCEP Technical Characteristics

TecSOLCEP, as a modern software, has many characteristics that follow tendencies in the digital world and user preferences:

- Core programmed in C++ to run fast and assure portability through MS Windows versions.
- Client-Server Architecture, using TCP/IP Protocol for data transfer.
- Quick access to Historical data base, structured by time records.
- Two options for input data: Real-time data obtained from a Plant Data Server or historical data read from a file extracted from Plant Data Storage can be selected to be read (complying with cyber security requirements).
- Data acquisition interfaces to PI, WDPF, XU, OPC standard and other multiple sources
- Excel add-in to extract data simultaneously from multiple TecSOLCEP servers.
- DLL for on-line data publication on Web sites.
- User hierarchy with different privileges regarding access to information and tools.
- Multilanguage.
- Advanced Graphic with filtering
- Information is collected and shown on bar screens, process screens, alarms and reports.
- Off-line Client for analysis and diagnosis of past time periods.

Models developed for different generation technologies share the following general characteristics:

- Model fitted perfectly to each plant.
- Modular structure.
- Nomenclature of variables follows ASME standards.
- Data Validation by an expert module.
- Model transparent to the users. Model Explorer.
- Performance test reports.
- Uncertainty calculations

  Final User freedom and capacity to enhance models and visualization: adding new modules or screens, modifying calculations, constructing new reports, or simply adapt targets to plant changes and ageing.

3 POWER PLANT IMPROVEMENTS

TecSOLCEP is a more-than-15-years proven technology which is currently installed in 54 power plants. These plants use the tool to detect and quantify overall plant performance losses, power losses and single equipment losses. The results from the tool are used to take decisions on operation and maintenance strategies. The tool is used for continuous monitoring and for supporting for specific tests or audits.

Tecnatom expert engineers provide local or remote support to plants to get the most from the tool. TecSOLCEP helps in the root-cause diagnosis of individual equipment performance deviations which, without going into details, cover the following:

- Instruments status and influence on results through uncertainty calculations
- Steam Generator degradation
- Steam Turbine and Seal System degradation
- Turbo-Pumps degradation
- Heaters degradation
- MSRs degradation
- Condenser, Vacuum equipment, Circulating Water Pumps degradation
- Cooling Tower degradation
- Electric Auxiliaries high consumption
- Unwanted Leaks
- Unwanted recirculation flows
- Heat losses and credits in the RCS

Once deviations are identified, operation and maintenance strategies recommendations are proposed to plant engineers to maximize the economic results, production or residual life. Some examples of these recommendations are condenser cleaning to reduce pressure deviation or optimum number of cooling tower cells in operation.

The use of this system in a fleet allow benchmarking and identifying best practices among the different plants.

The tool has been used in nuclear power plants to detect the reasons of power losses. The return-on-investment time for this type of software and consultancy services could be a few months per some recent experiences in power plants.

Figure 4 shows an example of the diagnostic screen for a high-pressure heater. Along with performance indicators, alerts are implemented for the possibility of tube leaks, emergency drain leaks and bypass leaks.

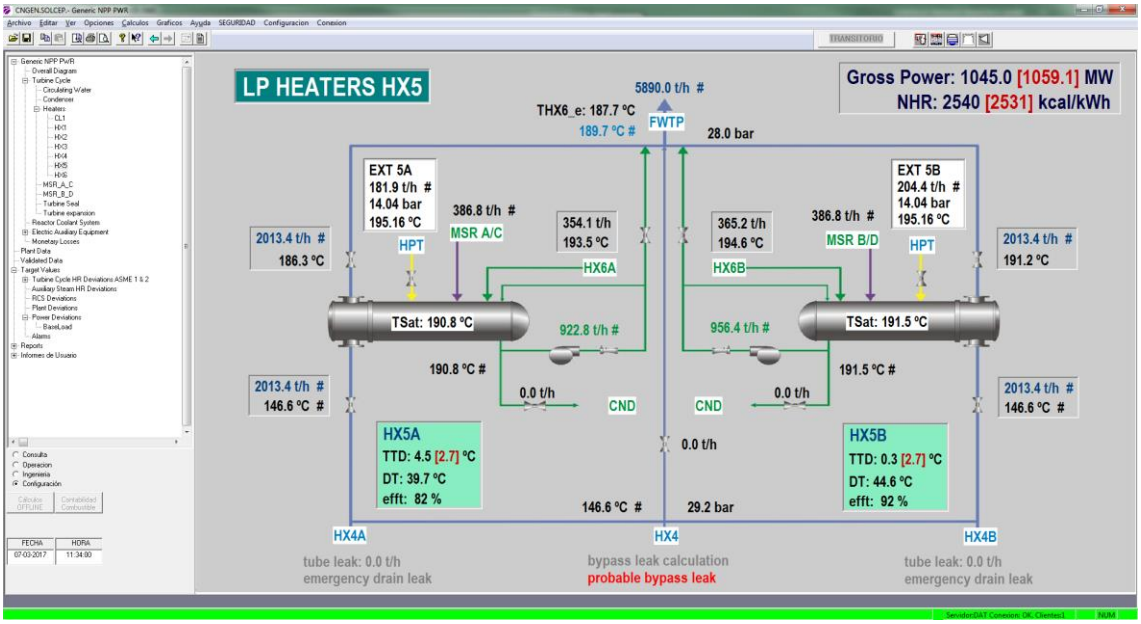

Figure 4. Process and Diagnostic Screen: High-Pressure Heater.

4 CONCLUSIONS

Online Optimization and Energy Accounting software tool, TecSOLCEP, detects and quantifies overall plant performance losses, power losses and single equipment losses. TecSOLCEP supports the short-term and long-term decision making, and the strategies regarding maintenance, repair or substitution of equipment from an economic and technical perspective. It helps to increase the plant efficiency and the plant production and helps in minimizing the maintenance costs. The impact of any actuation on performance deviations can be evaluated with the tool.

This kind of proven technology will help plants to reach the Nuclear Promise objectives by maximizing the plant production and equipment residual life. What can't be measured can't be improved!

5 REFERENCES

1. ASME PTC PM-2010, Performance Monitoring Guidelines for Power Plants.
2. Nuclear Energy Institute, Delivering the Nuclear Promise Strategic Plan (2016)