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STRAP – A New Risk-Based Analysis Tool for Steam Turbine Decision Making Part 1

By John Latcovich, The Hartford Steam Boiler Inspection and Insurance Company

Introduction

Hartford Steam Boiler's second major risk-based analysis tool — the Steam Turbine Risk Assessment Program (STRAP) — has completed beta testing and is now available as a commercial fee-based service. STRAP, which applies to steam turbines heavily integrated into manufacturing operations, builds on the experience HSB has accumulated with its first risk-based analysis tool: TOOP (the Turbine Outage Assessment Program). TOOP uses risk to determine the optimum time between major outages for power generation industry steam turbine generators.

Methodology

As with TOOP, development of STRAP followed the Risk-Based Inspection Guidelines of the American Society of Mechanical Engineers (ASME). To understand what goes into the risk-based model, it is important to understand the methodology. For HSB risk-based models, the following steps are followed:

1. System definition
2. Qualitative risk assessment
3. System assessment ranking
4. Inspection program development
5. Economic optimization

The first part of the process is to define the overall system and pertinent lower-level subsystems. After system boundaries and appropriate subsystems have been defined, applicable failure modes and probabilities of failure must be established. Last, the failure mode consequences (repair/replacement costs, lost production time, or as otherwise defined) for each subsystem component must be defined.

Once the subsystems, failure modes, failure rates, and consequences have been defined, the risk values are calculated by subsystem component, subsystem and the total system. From these results, risk levels are ranked to identify the highest risk subsystem components and subsystems. The system total risk is used to benchmark or risk rank with comparable systems. From the risk rankings, it is relatively easy to prioritize and justify maintenance decisions, and develop inspection plans to more effectively use company resources.

A number of approaches can be used to establish failure rates and consequences. Failure probability and consequence data may be obtained from company failure data, manufacturers' data, industry data and traditional reliability analyses. Those would include Failure Mode Effects and Criticality Analyses, Fault Tree Analyses, Event

1866
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Tree Analyses and Hazard and Operational Analyses. When such data is not available, a team of industry experts can be assembled to estimate the failure probabilities and consequences based on their experience.

In most risk assessments, only the correct orders of magnitude for failure rates and consequences are required to effectively calculate risk and to risk rank the system and subsystem results. For these types of analyses, the risk assessment is defined as a qualitative assessment. When there are detailed analyses and data to support the failure rates and consequences, the risk results are defined as a quantitative assessment. As a practical matter, there usually is not extensive data available, particularly for low probability and high consequence events, necessitating reliance on expert opinion and appropriate analyses.

Critical Process Industry Steam Turbines

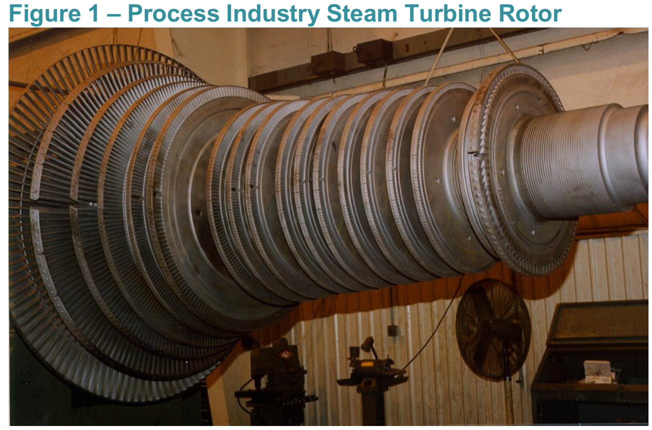
While the time interval between outages is the major concern for the power generation industry, the availability of steam turbine applications during production operation is the primary concern in the manufacturing and process industries. When steam turbines are heavily integrated into plant processes, loss of the steam turbine will shut down the process and result in substantial lost production and revenue.

Examples of this include boiler feed pumps, line shafts for the pulp and paper industry, blowers and generators for the iron and steel industry, and compressors for the refinery, petrochemical and chemical process industries. In these and other process industries, the cost of the steam turbine, on a relative basis, represents only a fraction of the process plant assets. However, each day of lost production attributable to the turbine can result in lost revenue reaching as high as $1 million per day. This is the critical factor to consider when developing a risk-based analysis tool for the process industries.

A Team Of Specialists

To quantify the risks associated with steam turbines in critical process service and assist maintenance staffs in making decisions for these critical turbines, HSB assembled a team of manufacturing, process (refinery, petrochemical), turbine repair, consulting engineering and insurance industry specialists to develop STRAP. The team included rotating equipment experts from The Dow Chemical (www.dow.com), Equilon Enter-prises LLC (www.equilon.com) CF Industries, Stone Container Corporation (www.smurfit-stone.com) , Hickham Industries, Revak Turbomachinery (www.revak.com) , Mechanical and Materials Engineering (M&ME) (www.mmengineering.com) and HSB (www.hsb.com).

Figure 1 – Process Industry Steam Turbine Rotor



A system with the associated components and subcomponents was established for the steam turbine. Figure 1 shows a typical process steam turbine rotor. Figure 2 shows the STRAP system, which includes the turbine, control valves and supporting systems. Because of the wide variation of steam turbine configurations used in the different process industries, the steam turbines were broken out into five different size and speed classes and four different operating regimes. Failure probabilities and consequences were established for each of the different turbine classes, operating regimes, subcomponents, and applicable failure modes.

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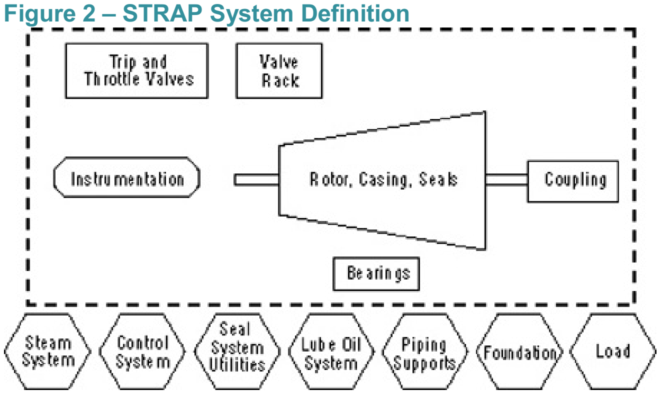
Figure 2 – STRAP System Definition



Risk consequence for this model is lost production time expressed in terms of days or in equivalent lost revenue and/or added expense per day. This approach was used because the cost of the equipment is considered to be inconsequential as compared to lost production revenue.

To account for the differences in service between units, the STRAP model also uses a detailed questionnaire which uses the responses to modify (raise or lower) the baseline subcomponent failure probabilities and consequences based on the specifics of the unit being analyzed.

[Editors Note: STRAP risk ranking, program testing and conclusions follow in Part 2 of this article.]

About the Author

John Latcovich is Hartford Steam Boiler's Fleet Manager for Rotating Equipment. He has more than 27 years experience with rotating machinery and works with HSB inspection specialists and clients on rotating equipment technical, operational and maintenance issues.

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