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Heat Rate Analysis in a Cyclical Environment

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White Paper

Background

Thermal Power plants are facing competition from new and clean sources of energy, because of which they are now required to operate the plant in a cyclical manner, often in low plf. In such a scenario, when the revenue is not in our control, survival strategy mandates us to improve productivity by looking into costs.

Heat Rate is an important KPI that captures productivity in a Thermal Power plant. Any activity or costs that does not improve heat rate needs to be re-looked in the current environment.

Thermodynamic model to calculate Heat Rate

About 10 years ago, most thermal plants were operating near full load and major operating conditions were nearly constant. When operating conditions are nearly constant, curve-based approach for Heat Rate calculation is enough to understand the plant condition.

In a cycling environment, the operating condition changes every day, even many times in a day. In this scenario, the curve-based approach does not convey an accurate picture of the plant. It is important for the plant engineers to adopt thermodynamic models to accurately calculate heat rates and other equipment KPIs, which operate under a wide range of operating parameters due to the cyclical operation of the plant.

The classical “Heat Rate vs Load curve” can be taken as an example to explain the inadequacy of the curve-based method in a cyclical environment.

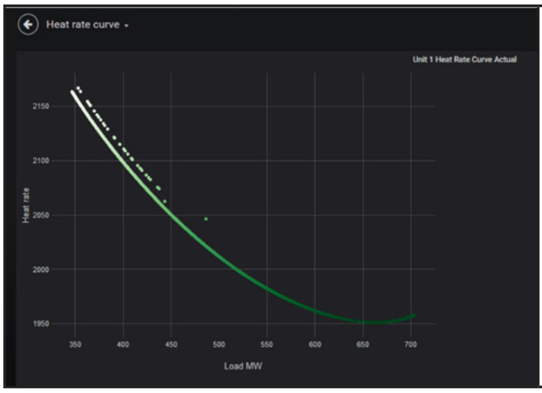

Figure 1: Heat Rate Vs Load assuming all other operating conditions are constant

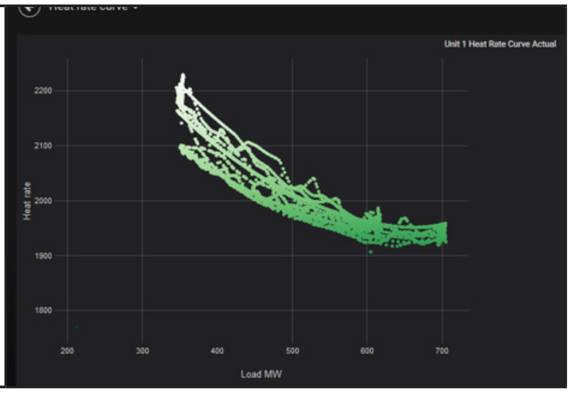

Figure 2: Heat Rate Vs Load under any current operating condition

Figure 1 depicts Heat Rate Vs Load assuming all other operating conditions are constant. Such a scenario is theoretical and cannot be expected when the plant is cycling. Figure 2 is the same Heat Rate Vs Load for the plant, calculated at different operating condition. Figure 2 is derived from a thermodynamic model using first principles and is clearly more realistic and accurate when we want to know the impact on Heat Rate due to load changes for any operating conditions.

Hence, use of Thermodynamic models is recommended for calculating various plant KPI’s.

Importance of Expected and Corrected Value in a cyclical plant operation

In a cyclical environment, we need to understand the impact of equipment degradation and operating condition on the heat rate. This means, we need to know if the change in Heat rate in a plant is due to the equipment degradation or due to the operating conditions (Load, CW temp, MST, etc.) or both.

Rated Value (+) Equipment degradation (±) Operating Condition Deviation = Actual Value

– Equation ❶

As defined in equation ❶, we need to calculate the equipment degradation and the impact of Operating condition separately. In order to calculate Equipment Degradation and impact of Operating condition separately, we need to derive the Expected Value and Corrected Value from the Actual value, at that operating condition. This can be done in Kalkitech’s Eltrix platform using its advance Thermodynamic model.

Corrected and Rated value is used to quantify the degradation in the turbine cycle.

Actual and Expected Value is used to understand the impact of Current Operating conditions on the plant. The definition is summarized in Figure 3 and further explained below.

	New and Clean Plant e.g. at the time of PG test say 01-04-2005,07:00:00:00	**Current Plant (which is degraded)** say 31-01-2020, 18:00:00:00	**Comment**
Current Operating condition (Load, MST, CW Temp ,etc.) as on say 31-01-2020, 18:00:00:00	Expected Value	Actual Value	Comparison of Expected and Actual is useful for optimizing the current operations
Design Condition (Design Load, Rated CW Temp, etc.) @ 01-04-2005,07:00:00:00	Rated Value	Corrected Value	Comparison of Corrected and Rated is useful for understanding degradation

Figure 3: Rated, Actual, Corrected, Expected Definition

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Rated Value: This represents the performance of the non-degraded equipment and the unit at reference/ rated operating conditions. Unit at 100% load is taken as reference condition which acts as the benchmark to compare and analyse performances over time.

Actual Value: This represents the current performance of the unit and equipment based on the real time process parameters received from the plant.

Expected Value: This predicts the performance of new and clean (non-degraded) equipment under current/real-time operating conditions. Actual and expected models are under same operating conditions. The difference between expected and actual performance yields relative degradation at that operating condition. Since the operating conditions changes over time, the difference between actual and expected performance is not relevant for evaluating the degradation over time. Here comes the importance of corrected performance.

Corrected Value: The corrected performance is the predicted performance of current (degraded) equipment when operated at reference or rated conditions. Comparing performance over time is justified only when actual performance is corrected to reference condition. Degradation is defined as the difference between rated and corrected performance. To correct the performance means to account for the performance variations that would be expected due to changes in environmental conditions and control set points.

Eltrix Plant Performance Management

ELTRIX Plant Performance Management (PPM) software module enables power plant operators to understand the plant performance in a cyclical environment. One can break down the causes of Heat Rate deviation into Operating condition (Load, CW temp, etc.) and Equipment Degradation (turbines, condenser, heater).

Sample screen shots from Eltrix are shown below:

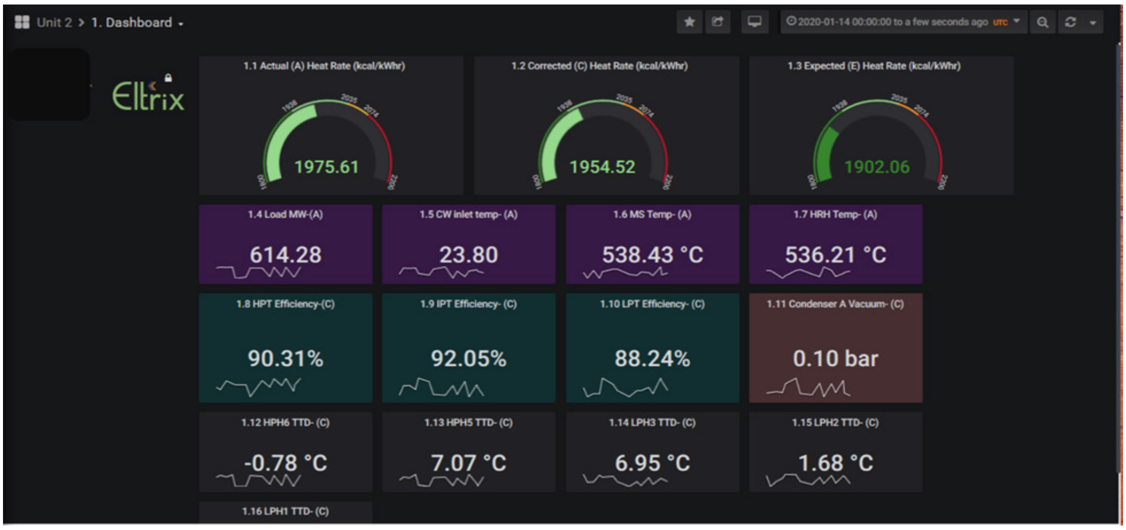

Figure 4: Dashboard

Figure 5: Turbine Cycle details

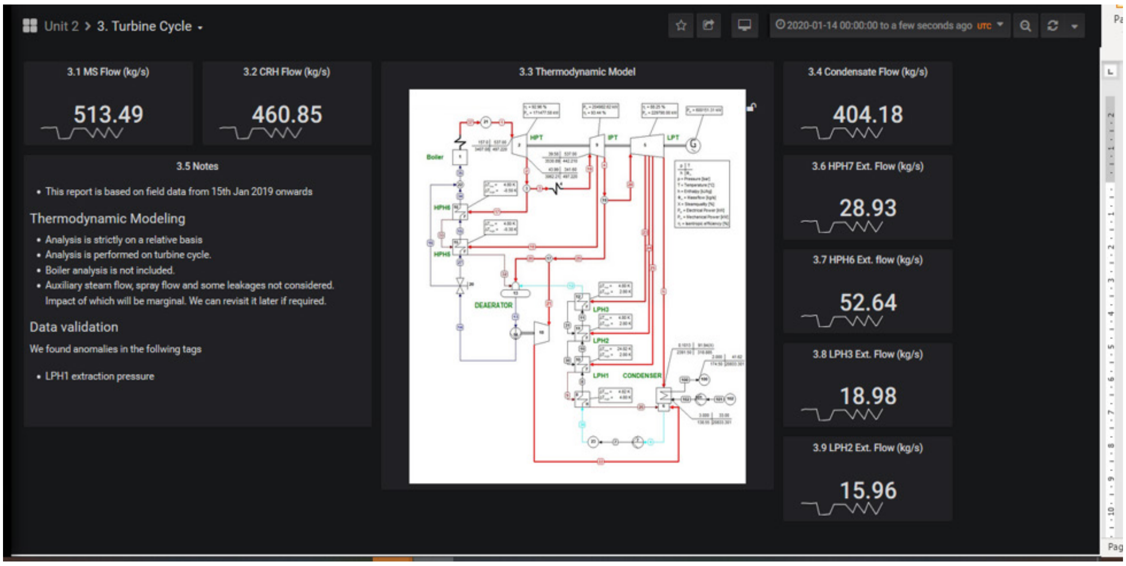

Figure 6: Flow Calculation

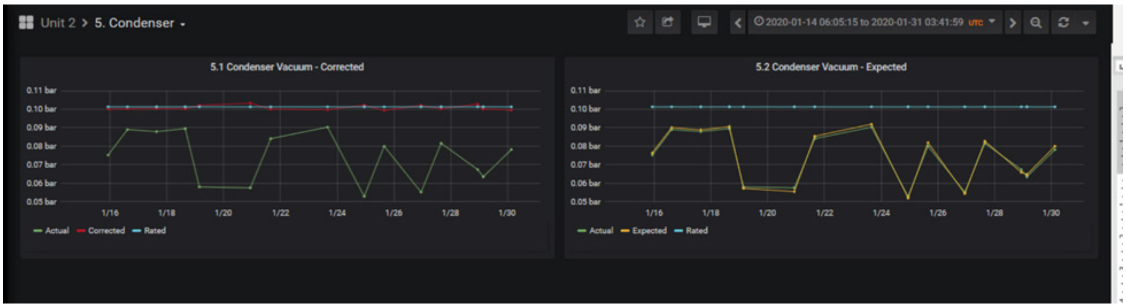

Figure 7: Condenser performance

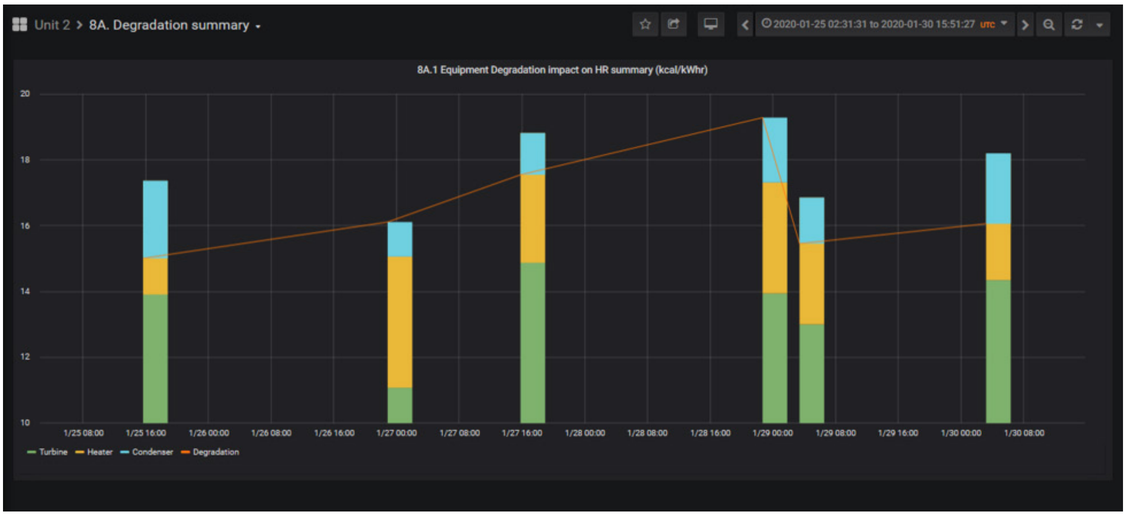

Figure 8: Degradation Summary

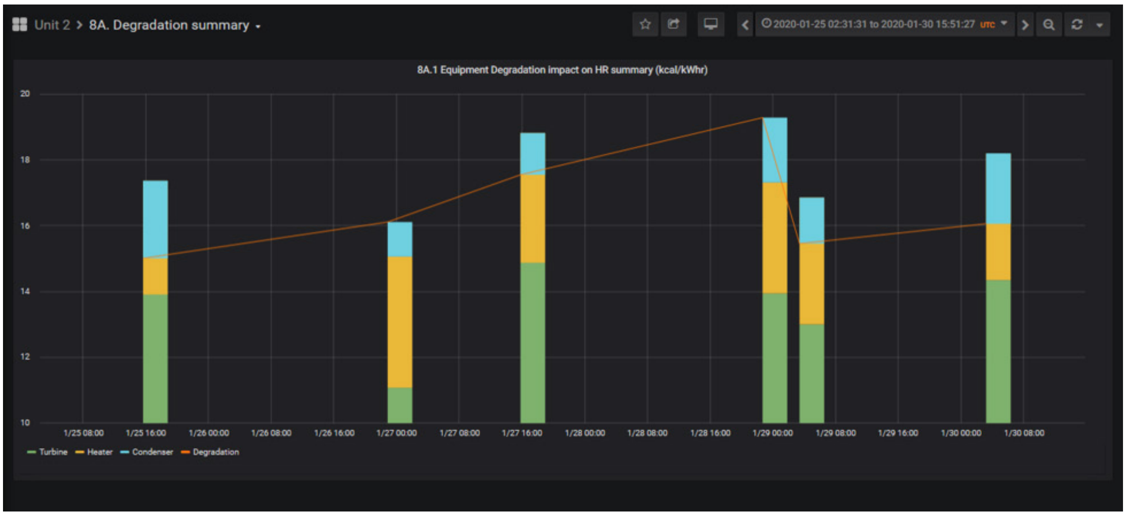

Figure 9: Impact of Operating condition

From the above dashboards, we can clearly calculate the following,

- Turbine Cycle degradation and individual equipment degradation (difference of Corrected and Rated values in Figure 4, Figure 5, Figure 7, Figure 8)
- Heat Rate impact due to operating conditions (Figure 9)
- In the current operating condition, what should be the ideal performance, (Expected value in Figure 5, Figure 7)
- ROI of overhaul, before and after impact of overhaul (slope of the corrected curve in Figure 4, Figure 5, Figure 7, Figure 8)
- Comparison of similar Units (Corrected values of the compared units as shown in Figure 4, Figure 5, Figure 7, Figure 8)
- Shift monitoring (Figure 9)

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About Kalkitech

Kalkitech helps energy utilities around the globe in enabling and transforming grid communications, improving reliability and energy efficiency. Its solutions enable customers to implement mission-critical applications ranging from advanced metering and distribution automation to wide area monitoring, substation automation and power plant optimization. Kalkitech invests extensively in research and development in areas such as power systems engineering, thermal engineering, control theory and communication and information technology. By building expertise, the company creates robust standards-based communication and optimization solutions and products for modernization of utilities, helping them to harness the power of grid data.

Kalkitech has been implementing strategies for optimising the efficiency of thermal plants to improve heat rates using Eltrix, which is its advance power plant analytics and optimisation software. Eltrix, with over 25,000MW experience in power plant calculation and optimisation, has been implemented in several power stations in India as well as across Middle East, and South East Asia.

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