GE Oil&Gas
On line Condition Based Maintenance

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Imagination at work.
Online Condition Based Maintenance

- **Scope of work**: An online cockpit that, getting input from lifing models, analytics and advanced sensors, provides a combined picture of part/unit degradation, unit maintenance planning and SoW forecasting.

- **Accurate Life Odometers**: Models dedicated to estimate residual life of the machine, based on how it is operating. They can be used to inform customers about maintenance outage distance or to optimize the operation increasing maintenance intervals. Life odometers consider the overall machine life and operate locally influencing the operation behavior.

- **Risk Management**: CBM online continuously computes the risk @ Failure Modes, section and unit level and provides a picture on how the unit is approaching the maintenance period, evaluating if it can be postponed based on runtime risk calculation.

- **Maintenance Optimizer**: A tool that allows to move from a fixed intervals maintenance to dynamic intervals one. Based on risk output the maintenance optimizer represents an instrument to compare different and potential scenarios guiding the maintenance strategy decisions.

On Line CBM is a Customer value...
On line CBM..how it works – General Overview

Inputs:
- Running Unit
- RMD
- Asset Configuration and Part Life Tracking
- Failure and damage experience

Outputs:
- Performance & Lifing Kernels
- Hybrid Physics Based Model
- Lifting Model
- M&D data

Risk Management:
- Unit Risk
- Combustion Section
- Hot Gas Path Section

Maintenance Planning:

Continuously the on line tool computes the risk @ FM, section and unit level and provides a picture how the unit is approaching to the maintenance and so evaluating if it can be postponed if the relevant risk is acceptable.

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On line CBM
A Real case application
BACKGROUND

GT Model Type: 120MW ISO rating (5 units considered)
Combustion Type: Dry Low NOx 1 (25 ppm NOx)
Fuel Gas: Natural gas (100%)
Maximal expected load: 80%
Service Type: Power generation
ISO rating: 120 MW
Environment: Marine (salty), onshore
Other: simple cycle, IBH available, RM&D available

The 2nd stage turbine blade installed into the units are old design and need to be inspected at 24000 hours to keep under control shrouded tip deformation.

- 2nd stage turbine blade tip deformation is due to creep and so mainly impacted by GT Power, Speed and hot gas flow temperatures.
- The creep failure mechanism is consistent at full speed and full load conditions
- The #5 units will be operated max at 80% of Load and so the 2nd stage turbine blade tip creep deformation is expected to be limited

CUSTOMER IMPACT
The Hot Gas Inspection at 24000 hours is required to inspect the 2nd stage turbine blade ..... IMPACT on AVAILABILITY

TARGET
Hot Gas Inspection removal at 24000 hours with 2nd stage turbine blade inspection interval extension from 24khrs to 48khrs.
2\textsuperscript{nd} stage turbine blade – Tip creep deflection model

\[ T_{\text{rel temp}} = f(RM&D \text{ data}) \]

\[ T_{\text{m}} = f(T_{\text{rel temp}}, T_{\text{CD}}, \phi) \]

\[ \sigma = f(\text{speed}, T_{\text{m}}) \]

- **Bulk metal temp**
  - From transfer function

- **Reference metal temp**
  - From FEA analysis

- **Reference stress**
  - From FEA analysis

- **Bulk stress**
  - Physics based transfer function

**Material Properties**

**Time to failure/no failure**

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2\textsuperscript{nd} stage turbine blade – Tip creep deflection model OUTCOMES

The 2\textsuperscript{nd} stage turbine blade risk model has been created using as input:
- GT operating parameters acquired by RM&D system that have used to estimate the 2\textsuperscript{nd} stg turbine blade metal temperature
- Stresses and creep strain/deformation as outcome of structural model and material properties
- 2\textsuperscript{nd} stage turbine blade tip deformation measures

Figure 1 shows the correlation between the 2\textsuperscript{nd} stg turbine blade Risk and the Power of the gas turbine. It is clear how is it important to know the operating conditions and how it is powerful the model connected to RM&D system in order to monitor the Risk and to really customize the gas turbine maintenance.

Considering the target to remove the Hot Gas Path inspection at 24000 hours and so extending the inspection interval of the 2\textsuperscript{nd} stg turbine blade from 24khrs up to 48khrs, the 2\textsuperscript{nd} stage turbine blade incremental risk has been considered. Figure 2 shows the incremental risk for the max and expected power level of 80%.

The $\Delta$Risk\textsubscript{48k-24k} has been considered technically acceptable.

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Gas Turbine OVERALL Risk Outcomes

Following as reference it is shown the INCREMENTAL RISK = RISK@48 - RISK@24 for the 80% Load operating profile.

For the #5 units operated at 80% of Load the overall unit Risk has been considered acceptable and so the request to remove the Hot Gas Path inspection at 24000 hours approved.

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Thank you!

Imagination at work.