**Condition Monitoring and lifing**

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Comments from the PB meeting

Y. Li:

• Rename the subtitle CM for transient operation to Online/Real-time CM. Currently diagnostics are off-line, or with simple online solutions. Not a real online monitoring.

• Add section Prognostics

• Add section Life consumption monitoring. Indeed, Lifing is mentioned but not covered.

The share of renewable energy sources in electrical power generation increases, there is a need for more flexibly operating plants to maintain grid stability as well as meeting peaks in demand and providing dispatchable power.

This plant cycling together with quick start-ups and rapid load changes, results in less predictable effects of aging and degradation than in continuous operating conditions. Significantly changed operational profiles affect also reliability, availability and maintenance of plants. At the same time service and maintenance costs are a main focus area for many operators of grids and power plants. While grid operators mainly require information on the status of the plant (operational state and possibel ramp rates for starts, stops and load changes) erquire plant operators detailed informaion from conditon monitoring. For them condition monitoring is a central tool and base to estimate operating hours to next service, remaining lifetime as well as required service activities and spare parts. It contributes to avoiding unexpected outages and reducing outage durations by allowing in advance detailed resource planning and identification of required spare parts. For the use of advanced alloys and coatings, for GTs and HRSGs, condition monitoring supports the early detection of TBC spalling/blade hot-spots and the need for repair/refurbishment. Condition monitoring is therefore a necessary tool to ensure and support increased reliability, availability and maintenance planning of GT plants.

The following list of proposed research and development activities represents a collection of ideas which might result in further / future projects.

**Processing of measured signals from sensors and data storage**

Signals from sensors, which are the base for condition monitoring activities (combined with routine process operating data), need to be processed and often stored before any further activity. This time consuming process is usually done by the operator and often based on manual interactions. An R&D activity could therefore target to automate the process, for example removal of bad data while, at the same time, avoiding loss of information. Additionally, the storage of important data and information is a critical topic; it is important not to lose information, which could be relevant for later usage in the frame of long term monitoring, and diagnostics often requiring multiple years of data. A project could therefore focus on identifying the needs of long term condition monitoring and develop the necessary methodologies for data storage and handling (e.g. event driven data collection, data compression and averaging etc.).

Sensor validation

Another interesting R&D topic to focus on is sensor validation, including differentiating between a failed sensor and a real event. This has the potential to avoid spurious gas turbine trips. Models can be developed and then tested in a first stage with physical net- works which simulate operating and fault conditions, and so can help understand sensor responses. Micro gas turbines could also be used as test beds, with sensor fault applied manually. This approach enables partial validation of approaches before testing on commercially operational plants, limiting the risk and allowing evaluation of different scenarios, e.g. the need for redundant sensors to back up a failed one.

**Monitoring systems where there is limited data available**

These systems are used to evaluate the condition of components and plants for which not all characteristics are available to the required detail, thus data driven models are used such as artificial neural networks. The data needed for generating such a model are the results of real measurements on the individual plant and need to cover a relatively long period of operation to achieve a sufficient level of accuracy. This disadvantage could possibly be overcome by the development of so called “grey box” models, based on general available characteristics which are derived from physical laws and further improved by combining these characteristics with a data driven/black box model. The application of the resulting model should result in a significantly shorter period for data collection while still achieving a high level of accuracy for the specific plant/component of interest. A possible R&D activity could target building and implementing such a method for a gas turbine or e.g. a small scale CHP as a base for further development steps.

**The inclusion of non-sensor based information**

The inclusion of non-sensor based information (e.g. from inspections etc.) and off-line monitoring (may be sensors or other measurement devices, e.g. to measure material condition) might significantly improve the interpretation of data from condition monitoring systems. However this information is usually not systematically implemented. A project might target development of routines and tools to close this gap to sharpen the picture resulting from condition monitoring systems and result in the improvement of the connection to asset management. This information could be ideally assigned to individual components and parts not to lose information on case components or parts are exchanged or repaired ones are implemeted into a different machine / plant.

**Condition monitoring for transient operation**

Condition monitoring during transient operation of the plant/ component is another area, which requires further R&D activities. It is also closely connected to advanced data analysis tools due to large amounts of data (high sampling rate) and required fast processing of them. Currently many maintenance systems rely on data from steady state operation as a base for analysis. Given the growing share of renewable energy sources, requiring balancing by conventional power generation technologies, the transient operation of GTs will increase. An R&D project may focus on developing improved condition monitoring tools for transient operating conditions. This should also include defining required sampling rates of measured data and their processing (e.g. to destinguish transientes from normal fluctuations of measured values) to achieve accurate and reliable results. Results of such a project could also be used to refine the de- termination of consumed & remaining lifetime of the plant and / or components. A target would be, for example, to replace standard penalties for a start up or shut down with algorithms using measured values. Transients of load change during operation might be also covered based on the magnitude of the change as well as of the gradient of the change.

