Minutes of Meeting

VGB-Technical Committee:	**Generation and Technology**
VGB-Working Panel:	**PGMON**
	Power Generation Maintenance Optimisation Network
	43rd Meeting on 6./7. 10. 2011 in Paris

Agenda

Welcome (Paul Thame)

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TOP 2:	Maintenance KPI´s Jason Bane, ESB
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TOP 12:	Place and date of next venue

TOP 1: Industrial Risk Management Department of EDF R&D
Philippe Klein, EDF

To be inserted later

TOP 2: Maintenance KPI´s
Jason Bane, ESB

To be inserted later

TOP 3: Gas turbine life time extension-an operators view
Willy Vanderelst, Laborelec

1. Context

Operators want to extend the life time of their assets for financial benefits and this is often not the scope of an OEM. How to handle than the life time extension of a GT in this case?
This question will be answered for the hot gas path component of a gas turbine.

2. Hot gas path component management

There are different Gas Turbine types in the fleet and the different OEM's apply different maintenance strategies with one thing in common: tendency to be conservative towards live time extension

3. Life extension incentives for an operator

- maximize the value of expensive gas turbine components, beyond OEM recommendations
- reduce total life maintenance costs
- extend outage intervals to suit operational requirements
- handle unexpected plant damage

4. Evidence-based Life Extension decisions

To extend the life of a component there the following requirements:

- A good knowledge of materials properties and component behavior
- Effective & Efficient NDT techniques
- A good understanding of OEM design principles

To acquire this it involves significant expenditure in both time and capital

Some useful sources of information that can help to make decisions are:

- Return of Fleet Experiences (users group information, destructive examinations…)

This tells you what you (or others) have experienced so far, <u>but is not predictive</u>

- Inspections (NDT…)

Tells you where you are now, <u>but extrapolating introduces a risk</u>

- Models (CAD,CFD,FEM…)

Predicts where you will be, <u>but must be validated</u>

Ideally, you should combine these 3 sources

5. Blade Life Modelling principles

Turbine blades are part of the hot gas path

The modeling is a 3 steps process:

- Modeling geometry, temperature, stresses, damages…
- Validation against service run components
- Extrapolation towards longer service exposure

6. Difficulties and pitfalls

There are four important issues:

- Access to components
- To know about design changes (coating, cooling flow, …)
- To have access to ‘design’ information
- To know the material properties

7. Direct and indirect benefits of the live extension investigations

7.1. Direct Benefits

- Extension of component lifetime beyond the OEM recommendation

7.2. Spin off Benefits

- Understanding the component behaviour
- Enabling informed discussions with OEM or any third parties on replacement, refurbishment, …
- Understanding impact of different operating regimes on the life of the components (ex. two-shifting, base load, …)
- Understanding abnormal behavior or components failures

8. Conclusions

Life extension studies require time and money, but the benefits are multiple:

➔ possible O&M cost reduction

➔ improved counterweight towards OEM and 3rd parties

➔ better understanding behavior of machines

➔ gaining strategic knowledge on life limited components

➔ improved assessment of unexpected damage

TOP 4: Long term maintenance optimization related to decommission/dismantling/demolition of old power units
Henning Lundstrom, Vattenfall

The presentation focused on the optimization of maintenance for old power units taken out of operation.

The examples were based at two Vattenfall units in Denmark which will have to stay for many years without activities, until the future plans have been decided.

<u>OBJECTIVE for the maintenance</u>
The units must be brought into safe conditions with a minimum of conservation scheme, suitable to stay in many years without activities.
Thus the risks for personal, environmental risks and technical installations must be minimized, further working environment aspects must be taken into account.

As the units are out of operation, operational and maintenance expenditures (OPEX) must be reduced to an absolute minimum.

The presentation has a number of examples of the process equipment to be disconnected to minimize maintenance. Examples of equipment and systems to stay into operation are surveillance systems and ventilation/heating systems to avoid corrosion.

Financing of the projects can partly be pay by selling the easy removable large equipments like transformers, generators, steam turbine, etc.

TOP 5: Coal fired power stations portfolio ČEZ - present and future
Miroslav Stecher, CEZ

Context:

Approach to the maintenance of coal-fired units in portfolio CEZ under the influence of new threats, in particular the new emission limits in accordance with EU directive.

Content:

- CEZ group introduction
- Supply chain from lignite mining to electricity supply

- CEZ group installed capacity and generation
- Major threats for coal fired power station (EU directive 2010/75/EU,…)
- Portfolio assessment concept
- Coal fired units – life management
- Maintenance approach and utilization, rules for maintenance planning
- Next steps in the future

TOP 6: Investment Portfolio Optimal Planning
Jérôme Lonchampt

IPOP software is a decision support tool for long term operation of industrial assets for power station. Its three main features are:
The measure of the profitability of an investments portfolio synthesised in the Net Present Value indicator. The NPV is the sum of the differences of discounted cash flows (direct costs, outages, power generation…) between the situations with and without a given investment, that is to say losses avoided by the investments or profits created. These cash flows are calculated through a pseudo-markov reliability model representing independently the components of the industrial asset and the spare parts inventories. This model, referred as the NPV function, takes for input an investments portfolio and gives its average NPV.

The selection and planning of an optimal set of investments, if all investments were independent, this optimization would be an easy calculation, unfortunately there are two sources of correlation. The first one is introduced by the spare part model, as if the components are indeed independent in their reliability model, the fact that several components use the same spare parts induces a dependency. The second dependency comes from economic, technical or logistic constraints, such as a global maintenance budget limit or a precedence constraint between two investments, making the aggregation of individual optimums not necessary feasible. The algorithm used to solve such a difficult optimization problem is a genetic algorithm, a classic meta-heuristic used in Operational Research for solving difficult optimization problems.

The measure of the risk of a portfolio of investments: Major components are often characterized by a low probability of failure and high consequences of its failure (plant long forced outage, safety issue…). Therefore making decisions based only on average values could lead to risky situations. This is why it is fundamental to be able to calculate risk indicators such as the probabilities of failure of the components according to a major maintenance program, the probabilistic distribution of all technical and economical indicators, the probability to regret a set of investments (probability of a negative NPV)… These calculations are done through a Monte-Carlo simulation of an events model.

After a presentation of these features, the presentation describes a study carried out on a group of transformers

TOP 7: System of supply of maintenance service in CEZ
Miroslav Krpec, CEZ

Current market situation in the area of maintenance contractors in the Czech Republic, CEZ company forced changes in attitudes to suppliers. The aim was to establish long-term contracts with strong companies, with its own know-how in maintenance of energy facilities.
The presentation describes the basic rules of long-term contract and is a motivational tool for both sides that lead to convenient long-term partnership for both parties.

TOP 8: Maintenance modelling to assess systems' availability and maintenance costs
Antoine Despujols

In the field of maintenance, the challenge nowadays is to make decisions to control risks and to increase competitiveness on the basis of information more and more quantitative. For this we need to use simulation to assess the performances of different maintenance strategies taking into account operating and environmental conditions.

A general modelling which represents the causal chain leading to the malfunctioning of a system is proposed to estimate the downtime and the maintenance costs over a given period of time.

This modelling establishes relationships between :

- the failure modes of the system’s components, i.e. the functional manner of their failure (e.g., refuse to start a pump, inadvertent closing of a valve, external leakage of a heat exchanger, ...) that will result in the complete or partial unavailability of the system;
- the degradation of the components (degree of wear, deep of cracks, degree of corrosion, etc.) which can lead to failures;
- the symptoms (e.g., vibrations, odours, noises, ...) which are inputs for predictive maintenance tasks;
- the failure mechanisms that lead to degradation (e.g. wear, corrosion, fatigue, etc.);
- the influencing factors (i.e. operating conditions, environment, failures of other components, …) that are responsible for the start of a mechanism or/and its kinetics;
- the maintenance tasks (preventive and corrective) to avoid or to repair failures;
- the logistic support and especially the availability of the spare parts, tools and personnel to perform maintenance tasks;
- maintenance rules that lead grouping of tasks in order to minimize downtime and costs (e.g. "opportunistic maintenance").

Unlike a performance model that can somehow "bases judgement on evidence" a fault modelling will be credible only if its construction correctly reflects knowledge of the experts without excessive simplifying assumptions. This is the objective of the suggested model for which it remains to adapt and to implement effective techniques for dealing with qualitative information. Developments are underway to find suitable solutions to outstanding problems especially to take into account expert opinion when data are missing or too expensive to obtain.

TOP 9: Use of advanced techniques for diagnosis and simulation of maintenance
Enrico Zio, University of Milan

The ultimate goal of Condition Monitoring (CM) is to timely plan appropriate maintenance actions, based on information on the health state of the components. Such information can be of different forms (in-service data, sensor measurements, expert opinions, physical models) and requires different modeling techniques and methods of analysis. The successful resolution of the modeling and methodological issues associated to the task of CM is strongly beneficial for establishing effective condition-based maintenance (CBM) strategies capable of optimally coping with the production availability targets and the safety requirements of Power Plants (PP).

In the presentation, by way of real examples statistical models and Advanced Pattern Recognition (APR) methods have been presented for the establishment of effective CBM of components, including:

- the timely detection of abnormal operation conditions (fault detection);
- the identification of the causes of abnormality (fault identification or diagnosis);
- the prediction of the remaining useful life in the given abnormal conditions (fault prognosis);
- the informed decision on the proper time and type of maintenance to be performed in order to recover normal operation.

TOP 10: Asset management
Mohammad Raza, Alstom

Overview

The dynamic swings of the market, environmental and safety laws, financial crises, wars and terrorism are impacting on industrial working methods. Efficient and safe ways of operating a productive industry and reaching target goals, whether on environment, profitability or safety of products and people, is becoming more and more complex. In such an environment, organizations continue to serve societies in delivering technology and maintaining it through their services. Asset management is of primiary importance for capitial intensive assets. Especially when the cash availiability is scare and optimisation has to be carried out within restricted budgets. This lead to the formation of this project group . The main aim is to

- Understand the asset owner’s priorities.
- Assess the asset owner’s understanding of RAMS impact to his asset.

- Study the gap between the understanding and the application
- Priortize and bridge the gap through a series of well connceted chapters
- Ultimately release a book which will act like a guide and partically useful for an asset owner.

Currently (as of Oct. 11) we are in phase of consolidating the feedback and also consolidate with other European partners with the same quest. This will be ongoing till end of this year. As next steps, the group shall Involve all relevant members or associations into the group with the aim is to involve all relevant partners in this task (like EFNMS, ETN, ESRA,VGB) and proceed further with comprehensive guideline for the Industry. The results of the Project group will be consolidated into a book, which shall be published by International publications. Each contributor will be part of co-author’s list. The copyright remains with ESReDA (European Safety Reliability Data Association, which is the sponsor of this project) and the publisher with author’s work clearly stated. This shall mean the end of the activity and it is planned to happen by Dec 2012. Hence a period of 3 years (2010-2012) is planned. But depending on the work, it can be extended by a year. In case the readers find the work proposed as interesting and could be able to contribute on any of the topics which is part of their daily work, then kindly contact mohammad.raza@power.alstom.com and inform. As the work is under progress, a response to this call will be considered till end of Dec 2011. For more details, refer to www.esreda.org

TOP 11: Degradation trajectories for components in power plants
Henk Wels, KEMA

For components in E-production units the optimum time for overhaul is ill known. With a quantitative model the planned unavailability in relation to unplanned unavailability can be optimized as a function of operating conditions. Such a quantitative model should answer the question how much more or less failures are to be expected when the overhaul interval is lengthened. It can be expected that mechanical components show a degradation trajectory to failure. Therefore failure mechanisms and influence factors have been charted for such components. Use is made of FMECA results as well as KEMA failure investigations. The failure investigations have been used to obtain quantitative information for failure and degradation trajectories.
The failure investigations of power plants show that in practice there is a large amount of uncertainty in times to failure and degradation times. Even a failure database with 745 damages in some 30 types of components shows that there is still insufficient material to precisely estimate time to failure and degradation trajectories per failure mechanism. An uncertainty of a factor 2 in time to failure is not uncommon. Therefore expert judgment has been used to assess the probability of occurrence of a failure mechanism, the average time to failure and the degradation speed.
Degradation trajectories have been simulated with Monte Carlo analysis. The combination of expert judgment, FMECA, quantitative information from failure investigations and simulation is sufficient to calculate the optimum time between overhauls using Markov modeling of degradation trajectories.
Such modeling is easy to understand and elegant.